PROJECT MANAGEMENT MATURITY IN PUBLIC SECTOR ORGANISATIONS: THE CASE OF BOTSWANA

Emmanuel Tembo
University of Botswana, Department of Civil Engineering, P Bag 0061, Gaborone, Botswana
Tembo@mopipi.ub.bw

P M D Rwelamila
Graduate School of Business Leadership, University of South Africa (UNISA), P.O. Box 392, UNIS 003, Pretoria, South Africa
rwelapmd@unisa.ac.za

Public sector organizations responsible for infrastructure development in most developing countries are project oriented organizations (POO). There are strong indications to suggest that a number of public project failures in Botswana are symptoms of PM immaturity of public sector infrastructure organizations. This paper reports on a case study that was carried out in one of the large public sector infrastructure department in Botswana *–referred to as BUS in order to maintain its anonymity.* A questionnaire was administered through a cross section of 20 randomly selected employees involved in project management at various capacities and also administered to another randomly selected sample of private project management practitioners who normally conduct business with BUS who formed some form of check on the level of project management maturity. Follow-up interviews on some of the aspects that were answered in the questionnaire were also done. The findings strongly suggest that an average maturity of 2.3 (*on a scale of 5, where level 1 is the lowest level of maturity*) being across all PM knowledge areas. Generally the results reveal serious inadequacies in project risk management maturity. Recommendations are made that project management capacity building through training should be strengthened and the process need to start from identification of PM training needs in the organization.

KEYWORDS: Project management maturity, public sector, infrastructure organizations, Botswana.

INTRODUCTION

Project management as a formal managerial discipline is said to have evolved in the middle of the 20th century, when the first Program Evaluation and Review Technique (PERT) marked the beginning of a new discipline. Hamilton (2004), states that modern project management has really come to the ascendancy and has been developing over the past 40-50 years. Initially project management developed in a limited number of engineering based industries during the 1950s, 1960s and 1970s (Morris, 1994). With time, tools, techniques, and methods became standard across industries and businesses as more and more organisations began witnessing the benefits of organising work around projects. Garies (1990) indicates projects are becoming a way in which organisations (especially project oriented organisations) fulfil their business plans. In recent years, therefore, there has been a focus at not only looking at project management from the perspective of studying projects but also from the perspective of looking at the way organisations are using projects to achieve their goals (Andersen & Jessen, 2003). Management by projects is definitely here to stay but mechanisms to monitor the capability of public organisation in managing projects are yet to be established. It is recognised that projects and their management involve a complex environment brought about by the nature of the projects themselves and the environment in which these projects are executed.

Rwelamila (2007), notes that management by projects is an organisational strategy of organisations dealing with an increasingly complex environment. He further states that this environment is affected by a number of forces originating from the project itself, the organisation sponsoring the project, and the organisations involved in project implementation, the sector or industry relevant to the service or product resulting from the project, forces from the country/economy and forces coming from the world environment on economics, politics and other social pressures. Garies & Huemann (2000) state that to sail through the forces indicated, an organisation must pursue the following objectives: 1) Organisational differentiation and decentralisation of management responsibility; 2) Quality planning, control and assurance by project team work and holistic project definitions; 3) Goal orientation and personnel development; 4) Organisation of organisational learning by projects.

So, while projects are now recognised as a means to achieve competitive advantage, project management competences are not being monitored in public organisations. Successful delivery of projects is dependent on organisational capability in project management. In the budget speech of 2007 the Government of Botswana recognised the poor delivery of projects across the public sector and proposed strengthening this aspect of the public sector. However, you can only strengthen that which you know its strength. There has been no research conducted in Botswana to show the level of public organisation competency in project management.

This paper aims to fill this gap by presenting results from a study conducted on one public sector infrastructure department. The survey conducted between February and March 2007 focussed on project management maturity with respect to nine knowledge areas espoused by the Project Management Institute (PMI).

PROJECT MANAGEMENT MATURITY-THEORY AND PRACTICE

According to Kerzner(2003), maturity in project management is the implementation of a standard methodology and accompanying processes such that there existed a high likelihood of repeated success. Andersen & Jessen (2003) refer to maturity as “a state where an organisation is in perfect condition to achieve its objectives. Project maturity would then mean that the organisation is perfectly conditioned to deal with its projects.”

Through the widely adopted capability maturity model developed by Software Engineering Institute (SEI) of Carnegie-Mellon in 1986 and 1993 for software organisations (Skulmoski, 2001), the concept of process maturity migrated to a measure of organisational process maturity. Integral to the model is the concept that organisations advance through a series of five stages of maturity: ***initial*** level- No formal methodology, no project portfolio management, the score is from 0 to 1; ***repeatable*** level- Systemic Planning and control with a standard methodology, the score is from 1.1 to 2.0; ***defined*** level- Merging of product and PM processes, the score is between 2.1 and 3.0; ***managed*** level - Integrated PM and business systems with a score between 3.1 and 4.0; ***optimising*** level- Continuous PM process improvement with a score between 4.1 and 5.0.

Maturity Models

One can identify the following prominent models, Project Management Process Maturity (PM^2) model also known as Ibbs model which emphasise the aspect of financial return on investment, the Kerzner model (Kerzner, 2005), Organisational Project Management Maturity Model (OPM3) by PMI, and the Garies model (Garies,2003) which views maturity in the form of a spiral rather than a stepwise process.

According to Powell (2003) all the models inherently have some of the following characteristics: An assessment of project management practices, processes and people competencies; A benchmark with other organisations within the sector and with industry in general; A review of the average performance of projects in terms of cost, time, quality, scope (or other measures such as user satisfaction, Safety Health Environment etc.) against others in the sector or general industry.

Maturity Studies elsewhere

Various studies have been done on project maturity assessment in organisations e.g. Ibbs & Kwak, 2000. In their studies of different types of industry i.e. *Information Systems*, *Information Management and movement, High tech manufacturing* in the United States of America, they found that High tech manufacturing had the highest knowledge maturity of **3.4** while the level of maturity for Engineering Construction companies was **3.3**. The lowest was Information Systems with **3.0**. In this study Ibbs & Kwak compared maturity level with project performance and showed that it was possible to correlate project maturity with project performance.

A major study of project management maturity at a global level was conducted by PriceWaterHouseCoopers in 2004 in which two hundred responses were gathered from a balanced group of companies from thirty different countries across the globe. Some of the relevant key findings for the study were as follows: That there was a positive correlation between project maturity and project performance. A higher project management level would most likely deliver superior performance in terms of overall project delivery and business benefits; that the current level of maturity is 2.5 indicating that the current state of project management in organisations is at the level of informal processes; that many of the project failures are due to an imbalanced organisation; Organisational structure has a big influence in overall project performance. Organisation structure influences the performance and outcome of projects.

RESEARCH DESIGN, METHOD AND RESULTS

Design and Methods

In this study the researchers adopted a version of the Organisation Project Management Model (OPM3) of the PMI to investigate BUS- a public sector infrastructure department. BUS is involved in the design and construction of public civil engineering infrastructure. The study was done through administering a questionnaire to staff involved in projects in the organisation. The data collection tool i.e. the questionnaire, used an affective test using the LIKERT scale and consisted of 90 questions with 10 questions in each of the nine project management body of knowledge (PMBoK) areas. The questionnaire was adapted from

Bolles(2002) in which project management maturity knowledge levels are measured through affective tests. The study is informed by other studies of project management maturity which tend to measure organisations through the use of such tests. For example Kwaks & Ibbs(2000) and Andersen and Jessen(2003) have used similar test to determine project management maturity in organisations.

The organisation's members of staff targeted were involved at various levels of project management from initiation to project monitoring and evaluation. A total number of 20 participants were targeted in the organisation and 11 **(55%)** responded. The respondent consisted of **eight Engineers** and **three Technicians**. Although the ideal would have been to have respondents from across all levels of the organisation, it was not possible to get responses from other staff not involved in the conceptualisation, supervision and monitoring of projects in BUS. The questionnaire survey was followed by interviews on some of the aspects that were answered in the questionnaire with the view of addressing any gaps between responses and fundamentals. As a check the questionnaire was administered to project staff in different organisations who interact with the BUS.

Research results

The findings of the study were focused on determining maturity levels of the organisation being investigated in the following knowledge areas:

> Project integration, Scope Management, Time Management, Cost Management, Quality Management, Human Resources Management, Communication Management, Risk Management and Procurement

On the basis of maturity of each knowledge area the final maturity level was then determined as an average of the 9 areas. A scale of knowledge levels was used from 1 to 5- 5 being the highest level.

Project Integration

Project integration involves coordinating project activities and integrates all efforts into a project plan. The study sought to find the level of project integration in BUS. The respondents were asked 10 questions in this category and were to fill in a questionnaire and on a scale of 1 to 5 where 1(never) and 5 (always). A higher score reflected a higher maturity. The overall maturity for project integration was **1.52** indicating that on an overall basis the organisation did not have a proper project integration management process in place.

Scope Management

Under scope management the research sought to find out how scope was managed and whether respondents rated the way in which scope was managed in their organisation highly. This was again done through a set of 10 questions. The overall score for scope management was **2.08**. This was better than the project integration management. However compared to time and cost management scope management was scored lowly as shown in Figure 1.

Time Management

Questions on Time Management centred on issues around the use of Work Breakdown Structures and the use of scheduling. The overall score in this category was **2.39** which indicated a reasonably high mature project management style in as far as time management was concerned. However, when asked whether this meant that projects came in on time because of the maturity level in time management it became apparent that almost 100% of the jobs never finished on time. This was attributed to issues of inclement weather, and initial wrong estimations. Respondents indicated therefore that in almost all cases contractors were given extensions of time. The respondents when interviewed explained that they use the tools for scheduling as well as they could and failure by contractors to complete projects in time although scoping had been done properly.

Cost Management

Cost Management maturity seems to have been the highest in the organisation with a maturity score of **3.23**. This signifies the fact that the organisation focuses on cost management to ensure that projects do not go beyond the estimated cost. However, empirical evidence shows that most projects have serious cost overruns. The high maturity in cost management is consistent with findings in a study by Ibbs & Kwak (2000) in which they found that cost management maturity in the construction industry in America. Typically, the same can be said about cost in public sector infrastructure departments and therefore stringent measures are put in place to ensure that cost controls are in place. However, the study also reveals that most of respondents felt that very few project team members had any training in cost management i.e. on financial standards and procedures.

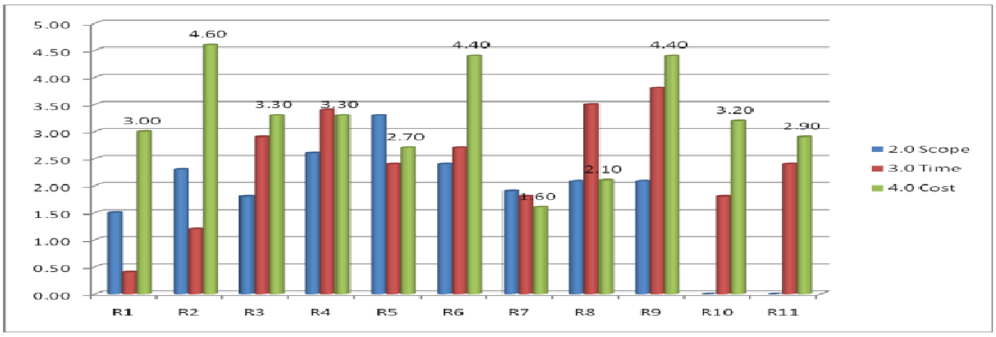


Figure 1: Comparing scope, time and cost management scores

Quality Management

Quality management involves both quality control and quality assurance procedures in an organisation. The overall score for quality management was **2.25**. Quality Assurance is a means by which an institution satisfies itself that standards and quality of its service provision can be maintained and enhanced while Quality Control involves the operational techniques and activities that are used to fulfil requirements of quality. Although respondents scored highly on Quality Assurance Plans (QAPs) being available for each project further interviews seemed to have contradicted this because the respondents indicated that they relied mostly on documented processes and had no QAPs because these were considered expensive. BUS had not attempted to start the process of accreditation to ISO9002.

Human Resource Management

The average maturity with respect to Human Resources Management is **3.06**. Despite this good value there is glaring lack of staff to manage most of their projects. In one respect the respondents state that there were indeed organisational plans in respect of the projects BUS undertook although they were guided mostly by the consultant who also normally worked as project managers. BUS would appoint a staff member to a project while the bulk of the project activities were done by the consultant.

Communication Management

Findings on communication management involved determining among others, whether there was a communication plan, project information was updated and was readily accessible and whether any variance in schedule, budget was communicated on a regular basis. Respondents scored communication management highly with an overall score of **3.64** which was the highest rating of maturity for the organisation.

Risk Management

Risk management assessment sought to find out if there were any risk mitigation plans and whether there were reviews on regular basis on risks in a project life cycle. The overall maturity with respect to risk management was **1.76** which was the lowest in all the knowledge areas.

Procurement Management

Assessment of procurement management involved determining whether BUS had standard contracts and whether the organisation had a procurement plan for each project start. It also sought to understand whether contract administration formed an integral part of the project management organisation. The organisation uses traditional procurement methods as all public organisations in Botswana. The overall maturity for this knowledge area was **2.58.**

SYNTHESIS AND ANALYSIS OF RESULTS

Overall Maturity of the organisation

An analysis of the overall maturity of BUS was done based on the components of the knowledge areas hitherto highlighted. A summary of the scores were entered in Table 1 and calculation of the overall maturity of the organisation was then done. The overall maturity of organisation A was found to be 2.5. This represents a maturity of level of 3.

Table 1: Summary table of maturity in knowledge area

Maturity Level	**L1**	**L2**	**L3**	**L4**	**L5**
Knowledge Area	**0-1.0**	**1.1-2.0**	**2.1-3.0**	**3.1-4.0**	**4.1-5.0**
1.0 Integration		1.52			
2.0 Scope			2.08		
3.0 Time			2.39		
4.0 Cost				3.23	
5.0 Quality			2.25		
6.0 Human Resource				3.06	
7.0 Communication				3.64	
8.0 Risk		1.76			
9.0 Procurement			2.58		

Comparison across industry

A comparison with other responses taken during the testing of the questionnaire revealed a small difference and can be seen in Figure 2. It is seen in the figure that there is a similar pattern in which cost and communication management are rated highly while risk and quality management are rated lowly. The overall maturity for the combined responses, which provided a check, was **2.3**. This signifies a level 3 maturity according to the standard set. This falls in this same category as the one found from the respondents from BUS.

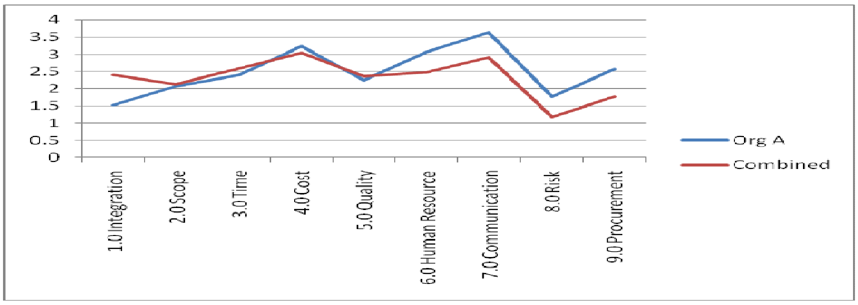


Figure 2: Comparison of Rating of Maturity between BUS respondents (Org A) and Clients

The revelation of maturity in organisation A of 2.5 suggests that the organisation is at level 3 in the maturity scale. Level 3 is a managed level. However, it is important to observe that some knowledge areas scored highly because respondents did not think that they had any problems with them in the organisations. For example communication management was perceived to be matured in this functional organisation because as a public organisation any project information must be readily available for scrutiny by the political system as and when it is needed. However, there was no evidence of communication plans specifically set up for projects.

Knowledge areas versus Project life cycle

An analysis was done based on process groups versus knowledge areas to understand the strength of BUS with respect to the whole project life cycle. Figure 4 shows that most of the maturity of the organisation is derived from the planning process where human resources, cost and time management maturities contribute a significant amount towards the maturity of the organisation. The average maturity with respect to planning is **1.34**. Under the execution process communication management has a high maturity according to the respondents although the average maturity was found to be **0.70**. A similar average of **0.70** was found for the monitoring and control process with the highest maturity coming as a result of the cost control process. Initiation and closing did not seem to pre-occupy the minds of the respondents and scored an average of **0.30** and **0.18** respectively.

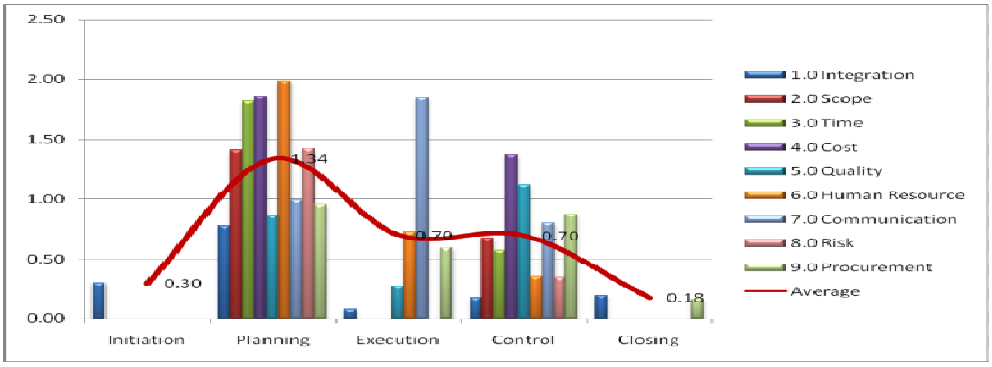


Figure 4: Maturity within the project life cycle

CONCLUSIONS AND RECOMMENDATIONS

The project management maturity level in the public sector organisation was found to be **2.5** which seem to indicate that there are a good number of project management practices in the organisation. Comparison with other responses from the same sector revealed a score of **2.3.** It would therefore appear that maturity in the civil engineering sector of the construction industry in Botswana is at **level 3**. While a level 3 maturity would be considered very good this study puts a caveat that a broader sample will have to be undertaken in the organisation to validate the findings obtained from those who are directly involved in projects in BUS.

It can be said that the organisational dilemma faced by most of project managers in public sector organisations in Botswana are similar in that most of them work within the framework of a functional government structure with its reporting and control systems. Project managers are not given enough latitude to make decisions on projects because of the nature of the organisation. Some government departments have created Project Implementation Units (PIUs) with a view to enhance project management practices in the departments and assigning teams to be responsible for different projects. This is seen to be a step in the right direction but more still needs to be done with respect to ensuring that project management practices become embedded in these PIUs. The transformation of these PIUs into Project Management Offices will be a starting point in ensuring that Project Management Methodology Guidelines (PMMG) begin to be introduced in the public sector organisations. In the public sector Civil Engineering infrastructure industry the general observation is that there is an over- reliance of consultants in managing projects and most public sector organisations tend to merely get reports and "oversee" the process of construction.

Recommendations

Improving project maturity level

Having established that the organisation is at level 3, it is recommended that if it needs to advance to the next level the organisation will need to establish a project office or a centre of excellence. It must also begin to think at how best it can begin the process of benchmarking itself with similar organisations. Benchmarking will involve both quantitative and qualitative benchmarking.

Improving project integration

It is recommended that the organisation endeavour to establish Project Management Information Systems for its projects either through an established project office or on individual projects. The recommendation is to establish a configuration management process for managing projects in the organisation.

Project Scope Management

The organisation's management of scope revealed the need for improvement in developing Work Breakdown Structure Dictionaries. It is recommended therefore that change control documentation be implemented and that work breakdown structure dictionaries be created for all the projects through a central project office which will act as the knowledge base for the organisation.

Project Time Management

The study recommends that the organisation should consider improving identifying schedule constraints on each project evaluation. Further, it is recommended that the organisation should consider adopting methodologies such as critical-chain methodology when devising project time management strategies.

Project Cost Management

The recommendation therefore is that project staff should be introduced to financial standards and procedures in the organisation irrespective of whether they are accountants or not.

Project Quality Management

It is recommended that change control processes for each project must be established and followed to minimize the erosion of quality of projects. This would protect the contractor as well as the client when this is strictly observed. It is further recommends that quality control procedures be put in place.

Project Human Resources Management

The major deficiency cited by the respondents was the lack of documentation of training and developmental needs of team members of a project. It is therefore recommended that each project team members' training needs should be documented and training developed to match the training needs. Team members should also be encouraged to take up professional project management qualifications in order to help develop an effective project team that can deliver consistently. Most members of staff are "seconded" to a project because they have been involved in similar projects and are perhaps qualified in a technical area. Following the observation by Toney (2002) that the project manager has about 34 to 47% direct influence of project success BUS should try and maximise the probability of consistently attaining project goals by recruiting, developing, nurturing and retaining well qualified project managers.

Project Communication Management

No specific recommendation can be cited with respect to communication management although it was not clear whether indeed there were communication plans drawn up specifically for each project. The organisation is however advised to document project successes in order for these to be used in close down announcements of projects.

Project Risk Management

It is recommended that the organisation should prepare risk management plans for each project and carryout risk identification and analysis together with a risk response plan for each project. Further it is recommended that the organisation should carry out risk monitoring and control based on the plans that are established at the beginning of the project. It is little wonder that most of the projects that fall under the ambit of BUS are not completed on time and are above budget. While the blame can be placed on the contractors for their failures it is apparent that BUS should implement realistic risk assessment strategies before awarding work to contractors.

Project Procurement Management

It is recommended that the organisation should formalise an evaluation process for reviewing and accepting proposals. This involves setting up proper evaluation criteria for the assessment of the project proposals from consultants in a manner that will reflect true costs and schedules. While it is accepted that the organisation is guided by the Public Procurement and Asset Disposable Board Act in terms of procurement, it appears that there is a general tendency for the least cost method of evaluation of tenders which at times do not achieve the necessary savings for the organisation.

Introduction of project management methodology guidelines

The observation in this study is that the organisation which was studied has no formal project management methodology in place. It relies a great deal on the experience of “project managers” assigned to specific projects and also on consultants who did the initial designs. It is however being proposed that for any organisation to move towards more proficiency and increased efficiency there is need to be consistent in applying procedures or standards. Consistency in applying standards can be achieved if an organisation establishes a project office which will set up guidelines for which each project team will follow. The first step in establishing project management methodology guidelines, therefore, is to establish dedicated project management offices. These offices will be responsible for the evaluation of project management in the organisation from a strategic point of view.

As Bolles (2002) has suggested education and training should firmly anchor the introduction of project management methodology guides.

Acknowledgements

The authors would like to thank the respondents who found time to fill in the questionnaire and answer some of the subsequent questions.

References

1. Andersen E & Jessen S, 2003, *Project maturity in organisations. International Journal of Project Management*; 21:457-461

2. Bolles, 2002, *Building Project Management Centers of Excellence*, AMACOM, NY

3. Garies, R, 2003, *Competences of Project-oriented companies: A process-based Maturity Model,* ProjektManagement Group, Vienna

4. Garies, R. & Huemann, M. (2000) *Project Management competencies in the project oriented organisation,* in Turner, J.R. and Simister, S.J. (eds) Gower Handbook of Project Management, Gower Publishing, Hampshire, pp. 709-21.

5. Hamilton A, 2004, *Handbook of Project Management Procedures*, Thomas Telford, London

6. Kerzner H, 2003, *Project Management-A Systems Approach to Planning, Scheduling, and Controlling*, John Wiley & Sons
7. Kerzner, H. 2005, *Using Project Management Maturity Models- strategic Planning for Project Management*, John Wiley & Sons

8. Kwak Y.H & Ibbs W.C, 2002, July, *Project Management Process Maturity Model* $(PM)^2$, Journal of Management in Engineering, pp150-155

9. Morris, P, 1994, *Management of projects*, Telford Thomas, London

10. Powell, M., 2001, *Using a maturity assessment tool to benchmark project management capabilities across the organisation-Getting value for money*?

11. PriceWaterHouseCoopers Report, 2004, *Boosting Business Performance through Programme and Project Management-A first global survey on the current state of project management maturity in organisations across the world*

12. Rwelamila. P. 2007. *Project Management Competence in public sector infrastructure organisations, Construction Management and Economics*, 25:1, pp55-66

13. Skulmoski, G, 2001, *Project Maturity and competence interface. Cost Engineering, 43(6*), pp11-18

14. Toney, F. 2002. *The Superior Project Organisation (Global Competency Standards and Best practice),* Marcel Dekker, NY

TALENT MANAGEMENT FRAMEWORK FOR THE CONSTRUCTION INDUSTRY

Deborah Phillips
Georgia Institute of Technology, Atlanta, Georgia, USA
Deborah.phillips@coa.gatech.edu

In today's competitive marketplace, talent management is a critical element in organizational success. Companies within the construction industry are now recognizing the value in attracting and retaining the best and the brightest employees, in order to achieve higher than average market share and elevated profits. In the Era of the Knowledge Worker, "talent" – narrowly defined as a core group of leaders, technical experts and other key contributors – are quickly becoming a company's most important asset. As the construction industry continues to grow, this search for top-tier talent has intensified into a full-scale "talent war" with important financial implications. This paper focuses on strategic systems and processes to attract and retain talent in an increasingly competitive market. This paper presents a framework with practical, useful strategies specifically for small construction firms looking to improve and manage their pool of knowledge workers.

KEYWORDS: talent management, employee engagement, framework.

INTRODUCTION

In the competitive marketplace that exists today, talent management is a primary driver for organizational success. Our society has moved from the Industrial Age to the Age of Intellectual Capital (Dychtwald, Erickson, & Morison, 2006). Many experts refer to this as the Era of the Knowledge Worker. Companies are now competing on the basis of the skills and talents of their employees and are discovering that, by attracting and retaining the best and the brightest employees, the company can achieve higher than average market share and elevated profits (Smith, 2007). These "knowledge assets" are not the same as those that were sought after in the Industrial Age, such as plants, equipment, and inventory. The intellectual capital consists of the knowledge and experience of every employee in the organization (Sommer, 2000). The word "talent" is now being more narrowly defined as a core group of leaders, technical experts and key contributors who can drive their businesses forward (Society for Human Resource Management, 2007). A management consulting firm for the construction industry, FMI, claims that "organizations that strategically address the need to develop talent through recruiting and hiring, training, development, performance management, career pathing and evaluation will maintain a competitive advantage and win the talent wars" (FMI, 2007).

Economic and demographic changes in today's workforce have turned the competition for talented employees into a strategic imperative. Companies are vying for top employees for many reasons. The primary reasons are demographic shifts, increased turnover, economic growth and globalization. The U.S. Department of Labor (DOL) has identified construction as one of the top industries in terms of projected job growth. In 2004, the Bureau of Labor Statistics (BLS) reported that the industry provided nearly seven million jobs, or more than 30% of the "goods-producing sector", which also included manufacturing natural resources and mining. Over the next decade, the BLS is forecasting the industry – the only non-services industry with a projected increase in jobs – to grow at an average of 11.4% creating close to a million new jobs" (Ireland, 2008).

This paper proposes a talent management framework for industry practitioners to use as they address the complex issues that exists within the construction industry. In this conceptual framework, there are five key elements: attracting, selecting, engaging, developing and retaining employees. At the core of the framework is a company's core values and competencies. These elements are connected through a continual process which includes the strategy, execution and evaluation. The framework is intended to be used specifically for small construction firms as part of an ongoing strategy of talent management.

Employment Trends

A recent survey reported that roughly two-thirds of U.S. employers do not have a process for planning for their talent needs (Johnson & Brown, 2004). For such organizations, every new need for talent presents a serious disruption. Every employee who quits represents a calamity, and every new demand for skills represents a crisis (Cappelli, 2008). A company that does no planning, and thus does not manage its talent, basically waits for a need to develop or current employees to leave and then hunts for a new solution. Another reason for concern lies with the impending retirement of the baby boom generation which will add to the dearth of highly skilled employees (Dychtwald, Erickson, and Morison, 2006). It is important to note that as baby boomers leave the workplace, they are also taking the depth of their experiences with them, so there is not only a decline in the number of workers, but there is also a shortage of skilled workers.

However, it is not as simple as replacing a vacant position with a person who fits the job description – it is much more complex due to the most significant group of new employees representing the generation of younger workers (those born between 1980-2000) known as Generation Y. This group enters the workplace with a new set of expectations. This generation has been raised to be independent thinkers by their Baby Boomer parents and have received enormous amounts of praise and recognition. They have also watched their parents work long hours only to end up suffering from burn-out and fatigue (Lancaster & Stillman, 2002). Generation Y craves a more-balanced life with flexible work hours and feedback on demand, rather than the annual performance review that their parents once talked about.

Another trend that is impacting the workplace is a shorter tenure among workers. The average length of employment in all age groups has been declining gradually for the past several decades. For workers under age 35, the average is less than three years. Eighty percent of the younger cohort has tenure of five years or less, and fully one-third are in their first year with the employer (Dychtwald, Erickson & Morison, 2006). Each time an employee leaves the company, profits go with them. The time, energy and money are lost; in addition, time, energy and money are spent to bring another person on board and get them adequately trained. These employees enter the process at the bottom of the quality and productivity curves (Galbreath, 2000).

To summarize these shifts, the construction industry will have too few workers entering the workforce to replace the labor, skills and talent of boomer retirees. This talent shortage will impact a company in many ways; for example, it will take a longer time to fill positions, increased costs to fill positions, increased expectations in regard to salary, benefits (including work/life balance) and increased turnover.

Values and Competencies

There is a body of research that clearly demonstrates the extraordinary impact of a shared vision or core ideology on long-term financial performance (Blanchard, 2007). In this framework, the nucleus from which to begin a talent management process can be developed. High performing organizations are known for having a strong and distinct culture and, therefore, can often reflect the organization's DNA. Culture consists of the values, attitudes, behaviors and practices of the organizational members (Blanchard, 2007). These members come to associate their company's style and personality around central themes or core beliefs commonly called values. The behaviors associated with a particular performance can be defined as a competency. A competency then can be thought of as an underlying characteristic of an individual that is causally related to effective or superior performance in a job (Boyatzis, 1982). Competencies can also be built from content knowledge and cognitive or behavioral skills (Hunt & Weintraub, 2002). In this framework, a competency model provides focus and, together with shared values, should lie at the core of an organization. From this model, all actions regarding talent management can be derived. In this framework, there are five key elements: attracting, selecting, engaging, developing, and retaining employees. The model is shown in Figure 1.

Figure 1: Values and Competencies Model

Attracting

The responsibility to recruit top-tier talent is often left up to the recruiter's ability to source and screen for the bright talent. This task not only takes time, but also requires money, especially if an executive search firm is used. A company needs to be creative when developing a recruitment strategy and should avoid the more traditional methods of recruiting when attracting Generation Y. Recommended strategies for this generation include interactive networking sites, Open Houses (for prospects and their parents), referral programs, internships, and job boards, such as Career Builder.

Selecting

As small construction firms find themselves struggling to identify a "niche" that can set their firm apart from larger more established companies, the area of selection can become equally as challenging. Traditional hiring practices include examining resumes, checking references and conducting interviews. The subjective nature of evaluating resumes and answers to interview questions makes these practices less reliable and the legal ramifications for employers providing references have made these methods less useful. Including an objective measure of performance, such as psychological assessment, in combination with other recruitment tools can greatly improve a company's chances of matching the right person to the job. Behavioral interviews, personality assessments and job knowledge tests can serve as valuable selection, promotion and placement tools (FMI, 2007).

Engaging

Attracting and selecting the talent can appear to be the simplest of the phases. Although pay and benefits may initially attract employees, top-tier organizations have now realized the importance of employee engagement. Engagement is much different than satisfaction. A satisfied employee is happy with current pay, benefits and atmosphere. This contentment may cause hesitation to show any extra initiative or achievement; thus, it creates a worker who is comfortable with the status quo. Alternatively, engaged employees demonstrate virtuous qualities like: innovation and creativity; taking personal responsibility to make things happen; authentic desire to make the company successful as well as the team; and having an emotional bond to the organization and its mission and vision. Engaged employees are not difficult to spot in an organization. They are high-impact people—the "go-to" people in a company. They are willing to go the extra mile to help the customer and usually understand how this effort makes a difference on the bottom line (Gostick & Elton, 2007).

However, one should not misunderstand or devalue satisfaction. Both satisfied and engaged employees are valuable to an organization. A survey conducted by The Jackson Organization of 200,000 employees found that only 40 percent were identified as being both highly engaged and highly satisfied. It is critical for organizations to address low engagement scores such as the 46% of employees that are described in this survey. These are workers that actually interface with the customer. Often times, it is the employees who can increase or decrease market share through the level of customer care. This sentiment was reinforced by a 2006 survey of 14,000 workers which shows 65 percent of employees are currently looking for work. This equates to two-thirds of employees who are looking for greener pastures, and who are thus not satisfied or engaged (Gostick & Elton, 2007).

When HR managers measure their own company's engagement, they immediately want to find ways to improve engagement among all ranks. In fact, many find themselves hoping that engagement will automatically improve, and hope that the disengaged employee will switch gears and become engaged. This transformation is not likely. In many instances, employee engagement is a product of strong leadership. The opportunity and challenge for HR, working with senior management, is to increase the strength of employee engagement. This engagement can best be accomplished by recognizing that there are four different generations that are working in companies. These generations include: the traditionalist born between

1900-1945; (10% of the workforce); boomers born between 1946-1964 (45% of the workforce); Gen-Xers born between 1965-1980 (30% of the workforce); and Millennials born between 1981-2000 (15% of workforce).

With each generation comes a separate and distinct protocol for increasing engagement. For example, the traditionalists are the most satisfied and often the most engaged because they are not dealing with the challenges of child care, are retired and more apt to be working for the "fun of it." Baby boomers are in need of energizing; they are commonly referred to as "work-a-holics" and are commonly "stressed-out." This group is also the one that express the lowest satisfaction with their immediate manager or supervisor.

Young workers are uneasy on the job, not because of inexperience or difficulty adjusting, but because of their expectations. They seek a different kind of workplace/employment balance. From day one, this group has watched their parents struggle in corporate America and decided early on to count on having multiple careers. This age group is searching for a robust and engaging workplace that encourages collegiality, teamwork and fun. They are looking for ample opportunities to learn and grow, including assignments that are challenging and involve flexibility and leeway. They are also looking for immediate feedback from their supervisor or mentor. They are looking to work for someone who appreciates an individual employee's point-of-view and encourages their development. At SEI Investments, 46 percent of the workforce is under 35-years-old, and 19 percent is under age 27. The company believes that an open dialogue and free exchange of ideas among junior and senior staff alike drives creativity and innovation (Dychtwald, Erickson, & Morison, 2006).

Developing

Because of the unique characteristics that exist within each generation, strategies should be tailored specifically for each in order to engage them. There are, however, common threads that increase retention. Gostick and Elton (2007) report that employees will stay where there is: a quality relationship with his or her manager; opportunities for personal growth and professional development; work-life balance; a feeling of making a difference; meaningful work; and adequate training.

In a nationwide survey of workers and their preferences, "the opportunity to learn and grow and try new things" ranked third among 10 basic elements. It ranked higher than more pay, more vacation, flexible schedule, flexible workplace, work that is personally stimulating, and even by a slight margin, a workplace that was enjoyable (Dychtwald, Erickson, Morison, 2006). Employees at all job levels value learning; however, people in small companies value learning more than those in larger ones and those employees who work more than 50 hours per week show above-average preference for learning. People in professional and business services, information and technology, and construction show a significantly above-average preference to learn and grow than workers in other industries. Therefore, these findings support the value of companies becoming what David Garvin of the Harvard Business School refers to as a "learning organization" which is "skilled at creating, acquiring, interpreting, transferring, and retaining knowledge and then modifying its behavior purposefully to reflect new knowledge and insights" (Dychtwald, Erickson, Morison, 2006, p. 164).

Retaining

The likely question for most practitioners becomes, "Now that we've trained them, how do we keep them?" Employee retention is closely linked to a company's performance management system. It is recommended that a compensation package clearly articulates clear expectations of performance, skills, experience, and behavior. This system should be designed to drive top performance at every skill level within the organization. It is recommended that compensation and benefits support the organization's overall goals not just in recruiting and retention, but also in business performance, commonly referred to as the HR Scorecard, in which people and strategy are linked with performance (Beckler, Huselid, Ulrich, 2001). Performance management systems should also address how the different generations in the workplace view feedback and the drivers of employee retention. While Boomers generally assume they'd spend one to five years in a position before being promoted, Generation Y want to know where they are going to be next month (Dychtwald, Erickson, & Morison, 2006). Seventy-one percent of top performers who received regular feedback were likely to stay on the job versus 43% who didn't receive it. These statistics indicate that even among peak performers, feedback plays a vital role in an employee's decision to stay in a job (Cappelli, 2008).

Among the most important factors driving employee retention, especially in the United States and Europe, are opportunities to develop and advance in their careers. According to a recent study, one of the best predictors of turnover is whether an employee had recently received training (Cohn, Khurana & Reeves, 2005). Other studies confirm that executives who feel they have been made to wait longer for promotions are more likely to become disenchanted and quit. A survey of Generation Y would wait only an average of 10 months for an opportunity to develop before concluding that advancement was blocked and they should move on (Fairis, 2004). In this case, it's more than simply having a deep bench of ready and available talent should the person decide to move on: it involves having a succession planning process focused on long-term organizational implications.

Most traditional succession plans simply focus on which individuals should advance to the next position in a hierarchy of jobs, commonly referred to as a job ladder. Today, succession planning should focus more specifically on talent assessment and force human resource professionals to ask, "Who's ready for the job?" The difference is that the determinations are made well in advance of the vacancy. Therefore, the purpose of a succession plan becomes two-fold: to identify which jobs will come vacant at what time, and which individuals will be in the pipeline with the necessary skills, talent and expertise to fill them. More elaborate plans attempt to ascertain which individuals at each level are equipped with the right attributes to become candidates for promotion to senior positions later in their careers. As the number of skilled workers decrease and the Generation Y seek out positions that promote more "work/life balance," the number of executives ready for advancement will decrease.

CONCLUSIONS

Many years ago, management guru, Tom Peters introduced the phrase "moments of truth" that suggested that any time customers came in touch with a product or service, there was an opportunity for them to want to use the product or service again, thereby increasing repeat business. In today's environment, every time an employee has the opportunity to create a meaningful relationship with the customer or client, they are forming an important bond. There is also the chance that if handled poorly, that bond will reflect negatively on the company and cause the customer to choose an alternative solution. Companies are now starting to realize that employees are becoming a “brand” unto itself.

According to recent data on employee engagement by The Gallup Organization, just 29% of employees are energized and committed at work. Another 54 percent are effectively neutral. They show up and do what is expected but little more. The remaining employees, almost two out of 10, are disengaged and are estimated to cost companies $300 billion per year in lost productivity in the U.S. alone (Wagner & Harter, 2006). These issues when compounded with the shortage of talent, the generational divide, and ordinary turnover present surmountable challenges for companies. Employees who are positively engaged have higher levels of productivity and profitability, better safety and attendance records, and higher levels of retention. In addition, they are more effective with customers which, in turn, drives higher customer satisfaction. The most obvious solution is to combat these challenges with proactive strategies. The strategies recommended in the proposed talent management framework presented in this paper measures performance on all fronts. Recognizing the problem, and using a framework to address the issue is often times the easier part: the toughest part lies in the execution.

REFERENCES

Becker, B.E, Huselid, & Ulrich, D. (2001) The HR scorecard. Boston, MA: Harvard Business School Press.

Boyatzis, R. (1982) The competent manager: A model for effective performance. New York: Wiley-Interscience.

Blanchard, K. (2007) Leading at a higher level. Upper Saddle River, New Jersey: Prentice Hall.

Cappelli, P. (2008) Talent on demand. Boston, MA: Harvard Business School Publishing.

Cohn, J., Khurana, R., & Reeves, L. (2005) Growing talent as if your business depended on it. Harvard Business Review, 83(10), 62-70.

Dychtwald, K., Erickson, T.J., & Morison, R. (2006) Workforce crisis: How to beat the coming shortage of skills and talent. Boston, MA: Harvard Business School Press.

Fairis, D. (2004) Internal labor markets and worker quits. Industrial Relations, 43 (3): 573-594.

Galbreath, R. (2000) Employee turnover hurts small and large company profitability. Society for Human Resource Management White Paper. Alexandria, VA: SHRM.

Gostick & Elton. (2007) A carrot principle: how the best managers use recognition to engage their employees, retain talent, and drive performance. New York, NY: Free Press.

Ireland, B. (2008), EC&M Electrical Construction & Maintenance. Available at http://goliath.ecnext.com/coms2/gi_0198-453112/waging-the-war-fortalent.html.

FMI. (2007) The 2007 U.S. construction industry talent development report. Raleigh, NC.

Hunt, J.M and Weintraub, J.R. (2002) The coaching manager. Thousand Oaks, CA: Sage Publications.

Johnson, G.L, and Brown, J (2004) Workforce planning not a common practice, IPMA HR study finds. Public Personnel Management, 33(4), 379-389.

Society for Human Resource Management. (2007), Human Resources Glossary. Available at http://www.shrm.org/hrresources/hrglossary_published/t.asp.

Smith, J.J. (2007) China faces 'talent paradox,' high employee turnover. Society for Human Resource Management Headline News.

Sommer, R.D. (2000) Retaining intellectual capital in the 21st century. Society of Human Resource Management.

Wagner, R. & Harter, J.K. (2006) Twelve: The elements of great managing. Washington, DC: The Gallup Organization.

VALUE-ADDING KNOWLEDGE MANAGEMENT (KM) FRAMEWORK: *'AN AEC INDUSTRY PERSPECTIVE'*

A. Weippert
Queensland University of Technology, Brisbane, Australia
a.weippert@qut.com

S.L. Kajewski
Queensland University of Technology, Brisbane, Australia
s.kajewski@qut.edu.au

The '*need'* for an Architectural, Engineering, and Contractor (AEC) industry-specific '*Knowledge Management (KM) Framework*' is clearly evident. KM has been growing in importance and popularity over the last few decades and AEC industry organisations and project teams are constantly being advised to fully embrace a new *'knowledge-based philosophy*' to help redefine tomorrow's international AEC industry markets – i.e.: one that realises KM is as much a '*social'* (cultural) challenge, as it is a '*scientific'* (technical) one. This paper provides a summary of an extensive literature investigation into the current state of play of innovative KM applications and initiatives in both public and private AEC and other leading industry practices. This is the first major deliverable of an ongoing research investigation into developing an innovative AEC industry-specific, value-adding and sustainable *'KM Framework'*. Research activities include (a) testing, field trialling and evaluating international best-practice KM frameworks, models and processes, and (b) examining the cultural (social) '*dynamics'* (values, assumptions, beliefs, etc) and surrounding '*influences'* (drivers, barriers, etc.) that tend to challenge today's AEC industry organisations and project teams. Finally, in an attempt to meet the aims and objectives of this research project, the authors provide a preliminary response to three KM related research questions.

KEY WORDS: Knowledge Management; Leadership; Value-adding; Framework; AEC Industry

INTRODUCTION

In today's highly competitive market, research shows that AEC industry organisations and consultants have been actively practicing Knowledge Management (KM) for some time and have identified and/or customised various KM solutions to meet their individual project needs and business objectives. Some have done so successfully others not. Increased amounts of managers and project leaders are starting to realise the importance of KM, but are still '*confused'* by the mystifying array of KM solutions made available to them - referring to KM as being highly '*controversial'*, '*hard to pin down*' and '*meaning different things to different people*'. It is these managers, project leaders, and industry stakeholders that seek guidance on various KM issues and search for answers to questions of when, how, where, who, what, and why they need to become involved with innovative KM initiatives. According to a recent investigation by (Amin, Bargach et al. 2001), approximately eighty percent of the world's largest corporations have either a basic or a highly sophisticated KM initiative underway. KM has superseded management trends such as '*total quality management'* and '*business process management'* as the dominant research field within the area of management. This is based on the significant decline in the number of publications that focus on the afore mentioned management trends since 1995, and an increase in KM publications - rising from three in 1995 to more than three hundred in 2002 (Christensen 2003).

Based on the outcomes of an extensive literature investigation into the current state of play of innovative KM applications and initiatives in both public and private AEC (and other leading industry practices) and is the first major deliverable of an ongoing research investigation into developing an innovative AEC industry-specific, value-adding and sustainable '*KM Framework*', this paper provides the following review:

- Reasons as to why there is an urgent need to better manage AEC industry related knowledge
- A brief history on the study of human knowledge is provided
- KM benefits and twenty first century challenges are discussed
- A working / operational definition for the term 'KM' is proposed by the authors – underpinning the development of the proposed innovative AEC industry-specific, value-adding and sustainable '*KM Framework*'
- Preliminary responses to the following three KM related research questions are proposed:
  i. How do we develop a value-adding and sustainable KM framework that will help prepare today's AEC industry organisations to compete in tomorrow's highly competitive global arena?
  ii. What sustainable KM implementation strategy is best suited for temporary and highly fragmented AEC projects – i.e.: one that can be 'seamlessly' integrated into (or enhance) an AEC organisation's existing business strategy?
  iii. What sustainable leadership and resource management strategy is best suited when implementing an innovative KM framework – i.e.: one that is based on trust and respect (as opposed to the old 'command-and-control' model)?
- Finally future research activities are suggested and conclusions are made

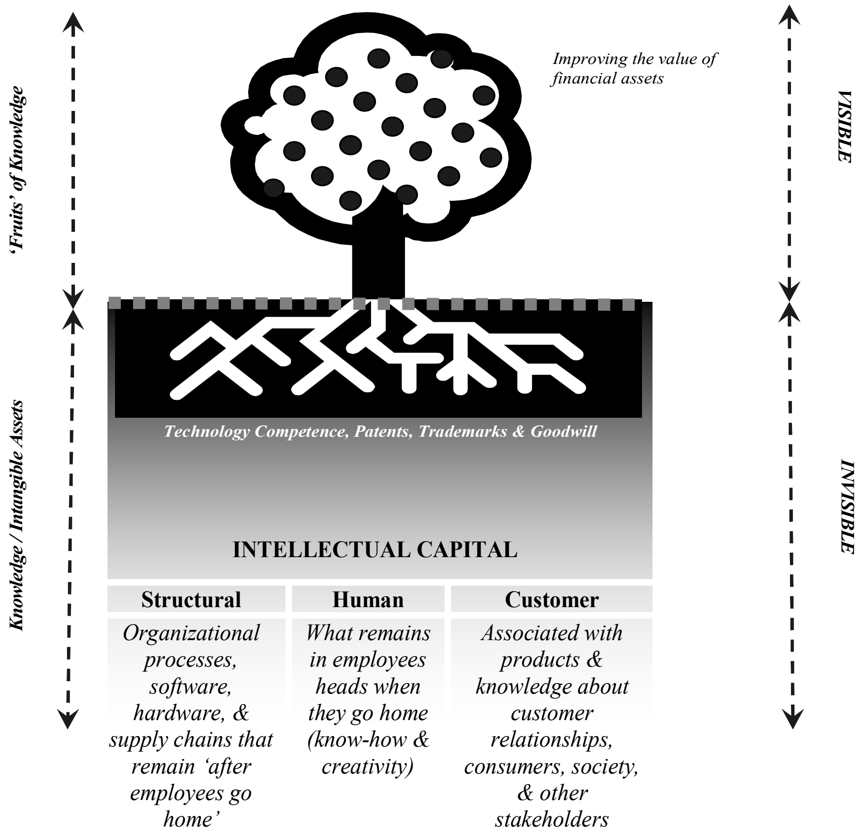
WHY MANAGE KNOWLEDGE?

"…knowledge is rapidly becoming more important to organisations than financial resources, market positions, technology and other tangible assets [hence] *what is needed is to be able to concentrate knowledge creation and conversation at a certain space and time in order to render it useful"*
(Kululanga and McCaffer 2001) p346 and (RICS and Salford-University 2007) p5

Research concurs that knowledge is the '*source of the highest quality power'*, that it is the key to the '*power shift'* of the future, and the '*ultimate'* replacement of other resources (Nonaka and Takeuchi 1995). According to (Keyes 2006), the effective management of valuable knowledge needs to be undertaken based on the following rationale:

- ***To provide some degree of protection for current intellectual property or assets*** – i.e.: a '*survival strategy*' - by concentrating more on turning tacit knowledge into explicit knowledge, also referred to as '*knowledge harvesting*'
- ***To provide a source for future or continuing competitive advantage*** – i.e.: an '*advancement strategy'* - by focusing on the creation of new knowledge or on new way of exploiting existing knowledge via collaboration.

Research further indicates that a change in today's business logic has caused a '*shift'* from industry leaders focusing on '*short-term harvesting of the fruits of success'* (profitability and increased shareholder value), to '*nurturing the roots*' (building knowledge assets and stakeholder value) for '*long-term trust, improved governance and sustainability'* (Robinson, Anumba et al. 2006). Like the root of a tree (Figure 1), knowledge (an intangible asset) is described as *'invisible parts*' of an organisation, which have to be '*nurtured'* in order to *'harvest the fruits*' of (a) improved financial asset value, and (b) better access to financial capital (through debt and equity investors). In this case the '*assets*' within an organisation or project team are made-up of '*intellectual capital'* and property (such as technology competence, patents, trademarks, and goodwill) - defined as the *'economic value'* associated with structural, customer and human factors in organisations. Bringing the intangible assets (knowledge, intellect, experience) to the forefront of an organisation's business strategy, will have a significant impact on the future wealth and competitiveness of the organisation as a whole (Robinson, Anumba et al. 2006)



Adapted from (Robinson, Anumba et al. 2006)

Figure 1: 'Knowledge Tree'

SO WHAT IS KM?

To help put things in perspective, the second question we need to ask ourselves is '*what is KM?*' *"First and foremost* [KM] *is a way of thinking"* (Rollett 2003) and identified as one of the highly critical areas of contemporary management that addresses issues particular to a business or project – i.e.: whether it is a business creating and delivering innovative products or services; managing and enhancing customer/partner/supplier relationships; or implementing, administering and improving work practices and processes (Cecez-Kecmanovic, et al. in (Hasan and Handzic 2003) and (Tiwana 2000). Unfortunately, the better understanding of KM is further hindered by there not being a single definition that has (or even can be) universally agreed upon – e.g.: KM…:

"…comprises the identification and analysis of available and required knowledge, and the subsequent planning and control of actions to develop knowledge assets so as to fulfil individual and/or organisational objectives" (Sensky 2002)

"…aims to help organisations learn and adapt to a constantly changing, complex environment by acquiring, developing and applying the knowledge that is unique to the organisation more effectively and efficiently" (Bishop and Business-Excellence-Australia 2002) p3

"… is processes and technologies for capturing, sharing and applying collective knowledge to make optimal decisions in real time" (Amin, Bargach et al. 2001) p51

"…is a multifunctional approach to achieving organisational objectives by making best use of knowledge…it focuses on processes such as acquiring, creating and sharing knowledge and the cultural and technical foundations that support them…aiming to align knowledge processes with organisational objectives" (Standards Australia 2001) p7

"…is the management of organisational knowledge for creating business value and generating a competitive advantage[by] *combining people, processes and technology to deliver to business and client requirements"* (SAI-Global 2004, c2003) p2 and (Tiwana 2000) p5

"…is the process of selectively applying knowledge from previous experiences of decision-making to current and future decision-making initiatives with the express purpose of improving the organisation's effectiveness" (Jennex 2005) p. viii

KM HISTORY

The study of human knowledge has been a central subject matter of philosophy and epistemology since the early Greek period and since seen as the process of searching for an answer to the eternal question – '*what is knowledge*' (Nonaka and Takeuchi 1995). Individual knowledge, collective knowledge and the general pursuit of '*knowledge'* are not new '*fads'* of management. Arguably the overwhelming need to manage the twenty first century's copious knowledge is evermore present for organisations to survive in tomorrows competitive arena (Hasan and Handzic 2003). The science of epistemology has also evolved over the last two millennia, generating categorisations and generalisations about what defines '*knowledge'* (Knight and Howes 2003). Epistemology is mainly concerned with the analysis of what is meant by the term '*knowledge'* – i.e.: seeking to provide knowledge about knowledge (Bukh, Christensen et al. 2005). Arguably, the availability of inexpensive desktop tools and emergence of the Internet allows today's '*ordinary'* employees to create and publish vast amounts of information any time anywhere. Consequently, as large generators and consumers of information, the AEC industry became more and more aware of '*information overload*' and that corporate information assets are no longer under central control – i.e.: it is not always clear how authoritative or legitimate the information is. In response to these challenges, certain industry leaders established that a productive solution would be to better '*access'* and '*manage'* the great amounts of knowledge created within the boundaries of their organisations.

KM BENEFITS

The term '*Knowledge Management*', although poorly defined, is '*officially'* (and increasingly) introduced to the various industry sectors of the globe (KMSciences 2006) – driven by the following potential benefits:

- **KM** *'…**both makes and saves money'***
    - Research indicates that the sums of money saved are significant – i.e.: hundreds of millions of Pounds, Dollars or Euros every year.
- **KM** *'…**puts technology into perspective'***

  - It allows individuals and organisations to develop innovative systems and processes that are meaningful and relevant.
- **KM** *'…**is about people'***
  - Establishing itself as the '*management discipline of the decade*' – "*…drawing attention to aspects which previously have often been neglected"*
  - Employees benefit from these innovative business processes - by enjoying work more, they contribute more, as well as learn and understand more – *"… where a knowledge-friendly culture increasingly determines the success of the company as a whole*" (Bahra 2001) and (Rollett 2003)

TWENTY FIRST CENTURY CHALLENGE

Numerous '*solutions'* have materialised in attempts to resolve the myriad of knowledge and information related '*problems'* AEC industry members have encountered over the last three decades (KMSciences 2006). The main challenge for organisational leaders and project managers in the twenty first century business settings is to add value to their focus on the '*bottom line*' by becoming more '*knowledge focused*'. Today's work environment is more complex than ever before, with organisations and project team members having to '*think on their feet*' within highly competitive arenas that are '*unforgiving'* due to shortened business cycles and rapid technological change (Dalkir 2005) (Bishop and Business-Excellence-Australia 2002). While the '*bottom line*' is justified by the financial resources and structural assets of an organisation / project team, being '*knowledge focused'* requires paying increased attention to the '*intangible'* intellectual resources that are unique to an organisation / project team and how these form a competitive edge. The unique knowledge and intellectual resources of employees and project team members in this case includes their: innovative ideas, experiences, expertise, values, norms, behaviours, relationships and alliances they develop with clients, customers, competitors, etc., as well as the products, processes and services that are developed as a result of the aforementioned attributes (Bishop and Business-Excellence-Australia 2002). (Hasan and Handzic 2003) refers to earlier research by Stewart, where industry organisations are strongly urged to consider '*intellectual'* forms of capital versus *'bricks and mortar'* when measuring their '*worth'*. Further stating that companies that master this '*knowledge agenda*' are those that will succeed in the twenty first century, based on three '*knowledge economy pillars*' (a) knowledge has become what we buy, sell and do; (b) knowledge assets (intellectual capital) are increasingly more important to companies than financial and physical assets; and (c) to prosper in today's new *'knowledge-based economy*', businesses need new vocabularies, management and measuring techniques, technologies, and strategies.

"…KM is not an end in itself and is of limited value if it is not geared towards improved business performance…construction organisations need to better manage their knowledge assets if they are to remain competitive in the new Millennium" (Carrillo, Anumba et al. 2000)

WORKING / OPERATIONAL DEFINITION FOR THE TERM 'KM

Based on the afore mentioned findings of the in-depth literature investigation of this PhD study, the authors propose the following working / operational definition for the term 'KM' – underpinning the development of the proposed innovative AEC industry-specific, value-adding and sustainable '*KM Framework*':

Knowledge Management is a multifunctional approach in achieving business objectives, creating business value and generating an enhanced competitive advantage, by (a) making best use of

knowledge and experience (know-how), (b) focusing on innovative processes of acquiring, creating and sharing knowledge(in real time), whilst (c) considering and aligning unique social (cultural) and technical dynamics more effectively and efficiently

INITIAL RESEARCH QUESTIONS

Based on the extensive literature investigation into the current state of play of innovative KM applications and initiatives in both public and private AEC and other leading industry sectors, and as the first major deliverable of an ongoing research investigation into developing an innovative AEC industry-specific, value-adding and sustainable '*KM Framework*', the authors offer a preliminary response to the following three questions:

i. How do we develop a value-adding and sustainable KM framework that will help prepare today's AEC industry organisations to compete in tomorrow's highly competitive global arena?

Literature investigations describe knowledge as being today's new competitive resource, which has '*hit'* the various industry sectors '*like lightning*', further portraying the '*contemporary global arena*' as being more competitive than ever before (Nonaka and Takeuchi 1995) and (Von Krogh, Nonaka et al. 2000). From an international business perspective, organisational knowledge is recognised as a *'...significant source of competitive advantage* [and] *the key battleground for competition'* (Davies, Studer et al. 2005) p175 and (Shukla and Srinivasan 2002.). This competitive form of '*management thinking'* or *quantitative* and/or *qualitative* measurement of an organisations business processes, has become a '*natural component'* for promoting tomorrow's efficiencies (Kululanga and McCaffer 2001). It is therefore no surprise that AEC industry organisations *"...may need to flip some of that cut-throat attitude on its head in order to remain competitive over the long haul"* (Von Krogh, Nonaka et al. 2000). This change in attitude is essential for industry organisations to achieve and maintain a competitive advantage, as employees and project team members (knowledge workers) can not be '*bullied'* into creativity or knowledge sharing (Von Krogh, Nonaka et al. 2000). In order to gain a competitive advantage within today's AEC arena, organisational leaders need to integrate the knowledge and expertise of their employees and project team members with the assistance of innovative information, communication technology (ICT) solutions (whilst considering the cultural and sub-cultural dynamics), and then '*align'* these with the organisation's overall business strategy, procedures, and objectives (Walker 2004). Embracing this unique *'knowledge-based philosophy'* inturn will help AEC industry organisations experience a highly competitive and dynamic business environment, fuelled by enhanced project performances and value-adding benefits. AEC industry organisations are therefore expected to not only embrace the innovative and sustainable concept of developing and implementing a value-adding KM framework, but also to apply its relevant and interdependent principles as a way of '*doing business*' and managing of assets (knowledge and experiences) to facilitate continuous improvement and organisational performance (competitiveness) (Robinson, Anumba et al. 2006).

> *"...project-based industries, especially the construction industry, are under growing pressure to compete in new ways* [hence] *the development of measuring techniques capable of helping construction organisations move towards a knowledge culture is vital for today's knowledge economy"* (Egbu 2004) p308 and (Kululanga and McCaffer 2001) p353

From a cultural perspective, there is also a desperate need of a KM framework that incorporates and promotes the essential and complex undertaking of forging a sustainable change in culture – i.e.: transforming an existing resistive culture to one that has common beliefs, positive attitudes, and values strong enough to encourage everyone within the organisation and project team to willingly participate, adapt and contribute towards the new way of '*doing things*'. Unfortunately, present realities show a completely different picture requiring much needed attention:

> *"…we build cultures on values that are vague and counter-productive, we try to manipulate our culture in order to achieve better financial results, but we ignore the need for consistent and shared values…using culture as a weapon to increase productivity has failed, and it has resulted in fear and resentment towards quick-fix solutions"* (Von Krogh, Roos et al. 1998) p13

ii. What sustainable KM implementation strategy is best suited for temporary and highly fragmented AEC projects – i.e.: one that can be 'seamlessly' integrated into (or enhance) an AEC organisation's existing business strategy?

The AEC industry is rapidly becoming a '*multidisciplinary, multinational and multibillion-dollar economy*', involving large number of participants working together at widely dispersed locations (Rezgui Y., Cooper G. et al. 1998). Developing and employing an AEC industry-specific process for implementing a value-adding KM initiative will inevitably enable organisations and project teams to (a) learn from their '*corporate memory'*, (b) freely share their invaluable knowledge and experiences, and (c) help source unique and sought-after competencies in order to become forward thinking and well respected competitors in tomorrows business arena (Robinson, Anumba et al. 2005). Yet, one of the practical '*problems'* in developing and implementing a value-adding KM initiative into existing and well established business and project environments, is the complex nature and diverse (sometimes conflicting) interpretation of KM itself (Revenaugh D. L. 1994). As a result, one of today's many challenges is for the AEC industry and its stakeholders to better understand and manage the immense wealth of their combined knowledge and experiences and how these can be efficiently communicated and applied within a unique project-based business environment. Suggestions in developing a sustainable KM implementation strategy for the dispersed and unique nature of today's AEC industry and its participants, include (a) drawing on past implementation experiences (successes and failures) and '*know-how*' (historic knowledge), (b) setting out clear goals, aims and objectives, and (c) readily include all employees and openly promote how this unique approach, expected benefits, and allocation of resources are to be realised within a specified timeframe. Considerations to take on board during the implementation process of an AEC industry-specific KM Framework should therefore include the following:

- Appoint knowledge leader(s) / champion(s) to promote the importance of utilising and managing existing knowledge resources whilst considering the impact KM may have on existing organisational structures / working practices
- Prepare a business case that clearly articulates the introduction of the KM initiative -
- Map the organisation's business or construction processes to help identify areas that could bring recognisable benefit to the end-users of the proposed KM initiative - start with a small problem (pilot project) which relies on managing in-house knowledge before moving onto large projects involving the entire supply chain
- Compile a KM implementation strategy that is proactive and has integrated means and measures to (a) ensure improved business performance, and (b) help overcome any social (culture) or environmental challenges towards the implementation of a KM initiative - e.g.: one that incorporates an incentive / reward program that encourages employees to share knowledge
- Allocate adequate resources (financial, non-financial, expertise, infrastructure, etc.)
- Clearly chart a methodology for managing the lifecycle of knowledge - from knowledge inception to retirement - whilst dealing with obstacles, such as limited time and validation
- Implement an appropriate training and support programme that continuously educates employees and project team members on the benefits in using the proposed KM initiative

- Continuously evaluate the implementation strategy / progress (for possible revision) – by obtaining feedback from '*front-line*' staff (end users) (*what* information they need *where* / *when*)
- Learn from others who are at a more advanced stage of implementing similar KM initiatives

"…KM will have to become an integral part of the way individuals work if it is to succeed"
(Carrillo, Anumba et al. 2000)

iii. What sustainable leadership and resource management strategy is best suited when implementing an innovative KM framework – i.e.: one that is based on trust and respect (as opposed to the old 'command-and-control' model)?

The actual sustainability of a KM initiative is largely reliant on various levels and forms of human intervention, ones that require extensive skills and effort by those who lead and manage this process, and who provide and promote a mutual assurance that the implementation of a new way of *'doing things*' within an organisation or project team environment will be successful. "*Leadership is the art of getting things done through others",* therefore, leaders can be considered to be successful when they accomplish certain tasks, goals or objectives. However, a leader's actions are not limited to simply providing verbal or written directives. Instead, a leader's accumulated wealth in experience, knowledge and skills is used to encourage others to contribute their individual levels of expertise, knowledge and skills in order to achieve the required results. Echoing the preliminary response given to question (ii), organisations identified as successfully managing the implementation of a new process or initiative (e.g. KM initiative) tend to have clearly identified leaders and dedicated champions who are committed to the following common leadership activities:

- Assess the strengths / weaknesses of existing resources and management approaches / strategies
- Establish separate funds, dedicate staff, and secure essential resources
- Set realistic expectations, priorities and milestones - providing clear direction on expected progress and follow-ups required
- Undertake periodic reviews of informal proposals / suggestions from all employees
- Promote extensive '*boundary-spanning*' activities – break down '*invisible'* communication, hierarchy, and learning barriers traditionally entrenched between management and employees
- Develop a supportive environment that encourages innovative thinking, explores variations, takes risks, recognises advantages, and builds on potential opportunities
- Encourage everyone to "*...savour every victory and learn from every failure"*
- Understand that *'Reward = Success*,' where innovative motivational programs, unique incentives, and effective reward schemes (also identified as '*critical success factors*') are developed and employed to encourage the mutual '*acceptance'* of a newly proposed KM initiative (Robinson, Anumba et al. 2005) and (White M.A. and Bruton G.D. 2007)

FUTURE RESEARCH: THE NEXT STEP

"…the future belongs to those endowed with knowledge" (Nonaka and Takeuchi 1995) p7

In an attempt to demonstrate leadership in facilitating the use of innovative KM initiatives within the highly fragmented public and private AEC industry organisations and projects, future research undertakings in developing a value-adding KM framework include:

- *Further identify and examine appropriate / best practice KM initiatives (frameworks, processes, systems, etc)*
- *Establish case study projects to test, field trial and/or evaluate the use of innovative KM solutions and demonstrate the benefits and efficiencies (if any) obtained*

- *Further examine the AEC industry's most valuable knowledge resource – i.e.: people and the complex dynamics of organisational and project team cultures and sub-cultures*

CONCLUSION

Due to the project-based nature of the AEC industry delivering large, expensive, custom-built facilities (Carrillo and Anumba 2002), involving large numbers of geographically dispersed organisations and individuals, project related activities are inevitably complex. It is therefore no surprise that there are those that argue whether an innovative KM framework or strategy can be applied to the AEC sector, especially with its often-quoted '*stereotypes'* of '*Machismo'* and '*technophobia'* (SAI-Global 2004, c2003). Project team members working on construction sites often have to move around a great deal and work within a multitude of ever changing team environments. Failure to capture and transfer knowledge and experiences generated within these dynamic environments lead to wasted activities and impaired performances (Carrillo, Anumba et al. 2000). The AEC industry (viewed as one of the most '*labour intensive sectors of the economy'*) is placing greater emphasis on their members as being '*knowledge workers*'. There is also sufficient evidence of an emerging level of interest and recognised value being placed on the '*people factor*' (culture and sub-cultures). Yet, the associated efforts in '*aligning'* an organisation's or project team's culture with the implementation and application process of an AEC industry specific '*KM Framework*' is still considered to be '*under-chartered territory*'(Pathirage, Amaratunga et al. 2007).

Despite the myriad of challenges facing today's AEC industry, the authors argue developing and implementing a well-managed, value-adding and sustainable '*KM Framework*' that fully embraces and effectively manages this '*untapped resource*' of relevant knowledge and experiences throughout project lifecycles, is invaluable to all AEC industry stakeholders - consequently enhancing client satisfaction, meeting governing expectations, and increasing overall project team efficiencies (triple bottom line). This paper further emphasises the need for AEC industry stakeholders to support the proposed development of a value-adding and sustainable KM framework that incorporates (a) a sustainable implementation strategy and (b) a leadership and resource management strategy to help better prepare today's highly fragmented AEC industry organisations to compete in tomorrow's highly competitive global arena.

Finally, to meet the aims and objectives of this research project, and in line with the afore mentioned future research direction, the authors will continue to (a) explore the relevant KM '*dynamics'* associated to the AEC industry sector, and (b) promote a new *'knowledge-based philosophy*' as an integral part of developing an innovative AEC industry-specific, value-adding and sustainable '*KM Framework*' that will arguably help (a) redefine tomorrow's international AEC industry markets, (b) increase their opportunity to internationalise and (c) inevitably reduce the continuation of international firms entering local markets.

REFERENCES

Amin, A., S. Bargach, et al. (2001) "Building a Knowledge Sharing Culture", from www.slb.com (white paper)

Bahra, N. (2001) "Competitive knowledge management", Basingstoke Palgrave

Bishop, K. and Business-Excellence-Australia (2002) "New Roles, Skills and Capabilities for the Knowledge-Focused Organisation", Sydney Standards Australia International

Bukh, P. N. D., K. S. Christensen, et al. (2005) “Knowledge Management and Intellectual Capital: Establishing A Field Of Practice” Houndmills, [England], New York Palgrave Macmillan

Carrillo, P. M. and C. J. Anumba (2002) "Knowledge Management in the AEC Sector: An Exploration of the Mergers and Acquisitions Context" Knowledge and Process Management (Jul/Sep) 9(5): 149-161

Carrillo, P. M., C. J. Anumba, et al. (2000) "Knowledge Management Strategy for Construction: Key IT and Contextual Issues" Construction Information Technology 2000, Taking the construction industry into the 21st century (June 28 - 30)

Christensen, P. H. (2003) “Knowledge Management: Perspectives and Pitfalls”, Copenhagen, Copenhagen Business School Press

Dalkir, K. (2005) “Knowledge Management in Theory and Practice”, Amsterdam; Boston Elsevier/Butterworth Heinemann

Davies, J., R. Studer, et al. (2005) "Next Generation Knowledge Management" BT Technology Journal 23(3)

Egbu, C. (2004) "Managing Knowledge and Intellectual Capital for Improved Organizational innovations in the Construction Industry" Engineering, Construction and Architectural Management 11(5): 301

Hasan, H. and M. Handzic (2003) “Australian Studies in Knowledge Management”, Wollongong, N.S.W., University of Wollongong Press

Jennex, M. E. (2005) “Case Studies in Knowledge Management”, Hershey PA Idea Group Pub

Keyes, J. (2006) “Knowledge Management, Business Intelligence, and Content Management: The IT Practitioner's Guide”. Boca Raton, FL, Auerbach Publications

KMSciences. (2006) "Knowledge and Collaboration for Project Managers" from http://www.findwhitepapers.com/ and www.kmsciences.com

Knight, T. and T. Howes (2003) Knowledge Management - A Blueprint for Delivery: A Programme for Mobilizing Knowledge and Building the Learning Organization, Oxford, Butterworth-Heinemann

Kululanga, G. K. and R. McCaffer (2001) "Measuring Knowledge Management for Construction Organizations" Engineering Construction and Architectural Management 8 (5-6): 346-354

Nonaka, I. and H. Takeuchi (1995) “The Knowledge-Creating Company: How Japanese Companies Create the Dynamics of Innovation”, New York Oxford University Press

Pathirage, C. P., D. G. Amaratunga, et al. (2007) "Tacit Knowledge and Organizational performance: Construction Industry Perspective" Journal of Knowledge Management 11(1): 115-126

Revenaugh D. L. (1994) "Business Process Re-Engineering: The Unavoidable Challenge" Management Decision 32(7)

Rezgui Y., Cooper G., et al. (1998) "Information Management in a Collaborative Multiactor Environment: The COMMIT Approach" Journal of Computing in Civil Engineering (July)

RICS and Salford-University (2007) “Drinking at the Knowledge Ba: Innovation in Small Construction Knowledge Intensive Professional Service Firms” RICS

Robinson, H. S., C. J. Anumba, et al. (2005) "Knowledge Management Practices in Large Construction Organizations" Engineering, Construction and Architectural Management 12(5): 431-445

Robinson, H. S., C. J. Anumba, et al. (2006). "STEPS: A Knowledge Management Maturity Roadmap for Corporate Sustainability." Business Process Management Journal 12(6): 793-808

Rollett, H. (2003) “Knowledge Management: Processes and Technologies”, Boston Kluwer Academic Publishers

SAI-Global (2004, c2003) “Introduction to Knowledge Management in Construction”, Sydney, Standards Australia International

Sensky, T. (2002) "Knowledge Management" Advances in Psychiatric Treatment 8: 387-396

Shukla, A. and R. Srinivasan (2002) “Designing Knowledge Management Architecture: How to Implement Successful Knowledge Management Programs”, New Delhi, Thousand Oaks, CA Response Books

Standards Australia, I. (2001) “Knowledge Management: A Framework for Succeeding in the Knowledge Era”, Sydney Standards Australia International

Tiwana, A. (2000) “The Knowledge Management Toolkit: practical Techniques for Building a Knowledge Management System”, Upper Saddle River, NJ, Prentice Hall PTR

Von Krogh, G., I. Nonaka, et al. (2000) “Enabling Knowledge Creation: How to Unlock the Mystery of Tacit Knowledge and Release the Power of Innovation”, New York Oxford University Press

Von Krogh, G., J. Roos, et al. (1998) “Knowing in Firms: Understanding, Managing and Measuring Knowledge”, London Sage

Walker, D. H. T. (2004) “The Knowledge Advantage (K-Adv): Unleashing Creativity and Innovation”, Australian Cooperative Research Centre for Construction Innovation (CRC-CI)

White M.A. and Bruton G.D. (2007) “The Management of Technology and Innovation: A Strategic Approach”, Canada, Thomson South-Western

BOX CONSTRUCTION SYSTEMS APPLICATION PRINCIPLES

Ass.Prof.Dr.Ozlem Eren
Mimar Sinan Fine Arts University, Istanbul, Turkey
essiz@msu.edu.tr

As industrialized construction systems, box systems are employed in structures containing a high degree of service units, such as hotels, public housing blocks, student dorms, educational buildings, commercial structures, hospitals, and elevator shafts. In terms of material, box systems are manufactured as reinforced concrete, steel, or wooden units, and in terms of the construction system as closed or as open units.

The purpose of this study is to examine the applicability of box systems, which meet the changing requirements of users, can be scaled up or down, exchanged, or can be adapted to different functions in different places, to housing structures. Box systems have the potential to prevent the natural resources of our earth from being wasted, and, whilst being environmentally friendly, provide comfortable conditions to building users. Particularly for our country, which is located in an active earthquake belt, short construction times are another big plus of this system.

KEYWORDS: Box Systems, Industrialized Building

INTRODUCTION

Following the destructions of World War II, the rising demand for housing brought the concept of mass production to the foreground. Consequently, Le Corbusier designed housing that was standardized both in term of function and aesthetics, and Buckminster Fuller responded to this new building culture with his “Dymaxion House”. Fuller’s house was a factory-manufactured product with an orthogonal layout, in which the building shell was suspended from a central vertical post, and technologies from the aircraft and automobile industries were utilized. Fuller continued his work with the idea of a mobile house complete with contents.

The idea of factory-manufactured housing was first promoted by Peter Behrens and Walter Gropius in Germany, and by Richard Neutra and Buckminster Fuller in the United States in the late 1920s and the 1930s. Research was started to quickly overcome the housing deficit that had arisen in the aftermath of WW II. A connection was established between the functions of cars and those of dwellings labeled mobile homes. With demand booming in the 1950s, many new companies were founded in the U.S. While in 1959 there were 268 manufacturers of prefabricated housing in the U.S., this number has now dropped to 34 for various reasons.

The first bathroom cell application was the prefabricated steel Dymaxion bathroom, developed in 1937 by the American engineer Buckminster Fuller. 30 years later, Nicholas

Grimshaw developed bathroom pods in a circular tower attached to a student hostel in London. Much later, possibly influenced by Grimshaw's concept, Sir Norman Foster used steel toilet cells in the HSBC Building. The use of service modules in this office building shortened construction time and improved the construction quality of modular building techniques.

Following these first steps taken by the Americans, European architects put forward a host of new ideas on housing structures between the 1930s and the 1970s. In particular the work of Jean Prouvé in this field has helped to promote modular unit design. In 1950, at the request of the French government, Prouvé carried out a study of 14 variations of two different construction types suitable for mass production based on a metal skeleton to develop various housing schemes. Featuring comparatively rich façades for its time, this mass housing catered to middle- and high-income families. At present Richard Rogers is one of the foremost architects working on functionally appealing, aesthetic, and easy-to-maintain housing modules. The focus in mass-produced housing has now begun to shift from functional flexibility and ease of construction to energy conservation. Rogers' futuristic "Zip Up" program represents the concept of sustainable architecture. In this system beams can be selected from within numerous elements to enable personalized homebuilding. Rogers' aim was to promote his idea of "autonomous human settlements"; his design included a proposal for a small ecosystem with independent wastewater and refuse removal and self-sufficient energy production.

Around the same time, the Austrian architect Leo Kaufmann developed a modular system highly suitable for housing functions. The "FRED" system designed by Johannes Kaufmann could be compared with Lego bricks. By placing modules sized 5 x 5 m side by side and one above the other, 10 different façades can be implemented. For another system called "SU-SI", very similar to the "FRED" system, a transportable prototype has been developed; the entire structure can be assembled on site in just 5 hours. In recent times Leo Kaufmann and the Swedish architect Johannes Norlander have been working on this topic. Their research regards various functions and form variations tuned to client specifications, such as garden sheds, toilets, hospitals or campsites, universities, etc.

Box Unit Systems

As with carcass construction or prefabricated structures with load-bearing wall panels, modular box unit systems are composed of a combination of rods or surface load-bearing elements. The basic problem in the modular box unit construction system is how to join the individual box together. The tolerances between the individual box units are essential. Box units systems are highly advanced as to the industrialization of building construction, in other words, they are systems with a high level of industrialization. Box units are three-dimensional spatial elements formed by the combination of wall panels and floor units. These systems, constituting an advancement of heavy and light-weight panel systems, are being preferred to achieve a high degree of completion through factory manufacture of the product, i.e. the building. The development of the box unit system makes it possible to manufacture an entire completed product in the factory.

"Box-module structures" are buildings with a fireproof and permanent design in steel and concrete construction. Here the entire structure is factory-built, then split into modules, and transported to the construction site. The features and advantages of cell-module systems can be summarized as follows:

- The units' structure consists of steel and concrete building materials and elements. Therefore these systems offer better durability and higher flexibility than conventional constructions.

- 60-98 percent of the work can be carried out in the factory.
- With the mechanization-based construction method it is possible to achieve the same quality as manpower-based workmanship.
- Prefabricated modular structures can reach the same service life as buildings constructed with traditional techniques.
- The most important advantage of cell-module constructions is that they are time-saving. Factory building enables production in a controlled environment unaffected by weather conditions.
- In box-module constructions, only the foundation and infrastructure elements are built on site.
- It only takes around 50 percent of traditional construction time to complete such structures. These constructions can be split into sections and rearranged within the building site or on a different plot; they can even be resold for use at another location.
- Realization of single- or multi-story structures (up to 7 stories) is possible, both as self-supporting structures and as additions to existing buildings.
- The dimensions of factory-built units are assigned in accordance with statutory restrictions on transport.
- These structures are built from fire-resistant materials and allow employment of a variety of materials, e.g. brick cladding, concrete floor elements, and masonry-concrete walls.
- Mechanical systems such as systems for gas, electrical power, fuel, and hot water are combined and factory-assembled as module units, and can be transported to the site without sustaining damage.
- Installation and testing of mechanical systems and the creation of a controlled space is easier in these structures as compared to conventional systems. Thus an entire school can be completed without having to rely on different gangs of workmen.
- Modular units can be applied to structures with a wide variety of functions, from residential homes to fast food restaurants.
- On-site construction is expedited. Speedy construction translates into shorter construction times, faster return of investment cost, and more benefits to the client.

Figure 1: Office Building (Detail, 2001-4)

- Disruptions during construction are avoided, and no damage to neighboring buildings caused during construction.
- This method is suitable for buildings containing a high degree of service units.
- Factory-built uniform or repetitive units provide ease of transport and ensure scale economy in production.
- Construction is not affected by weather conditions.
- Quality assurance at a high level is best achieved through off-site production and controls carried out prior to installation.
- Construction is safe due to the use of modular units, allowing inspections at the manufacturing stage.

In addition to this, construction with cell systems also provides the following features of industrialized structures:

- Structures are highly durable and can be planned flexibly to meet changing requirements.
- The construction elements are being standardized without restrictions to design. So it becomes possible to compose structures by choosing from a catalogue of ready-made elements, and to replace elements whenever required (Figure 1) (Eşsiz, Koman, 2004, Eşsiz, Koman, 2005; Gras, Armer Clarke,1994).

Classification of Box Systems

As with carcass construction or prefabricated structures with load-bearing wall panels, modular box-units are composed of a combination of rods or surface load-bearing elements. The basic problem in the modular box construction system is how to join the individual boxes together. The tolerances between the individual boxes are essential. Box systems are highly advanced as to the industrialization of building construction, in other words, they are systems with a high level of industrialization. Boxes are three-dimensional spatial elements formed by the combination of wall panels and floor units. These systems, constituting an advancement of heavy and light-weight panel systems, are being preferred to achieve a high degree of completion through factory manufacture of the product, i.e. the building (Figure 2).

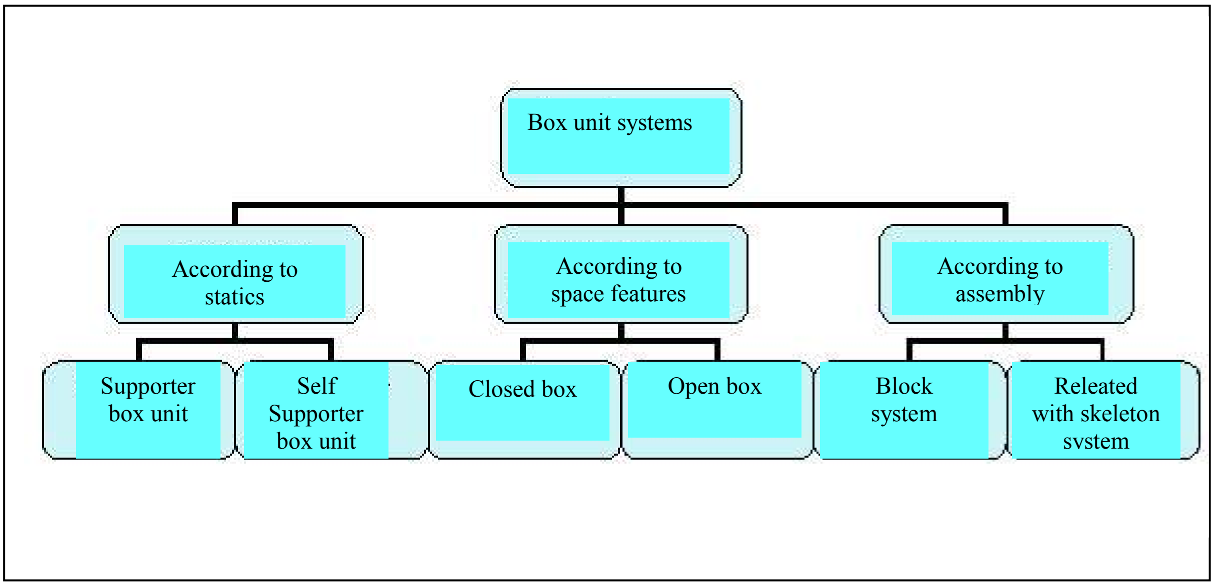


Figure 2: Classification of box unit systems (Eşsiz , Koman, 2005)

The development of the box system makes it possible to manufacture an entire completed product in the factory. “box-module structures" are buildings with a fireproof and permanent design in steel and concrete construction. Here the entire structure is factory-built, then split into modules, and transported to the construction site. Today, box systems find application in increasingly diverse fields, since the employment of such systems in construction is associated with advantages such as cost reduction, quick mounting, timely completion of works, and minimization of material losses, thus serving to create higher-quality physical spaces.

Over time, the requirements of building users are likely to change. At the same time, certain construction elements tend to wear out faster than the remainder of the structure. Therefore, the economic and ecological approach in developing countries is to extend the service life of existing buildings through whatever subsequent improvements are deemed appropriate. In developed countries, however, one feels the need to adopt buildings in order to preserve city skylines and to keep pace with technological developments. Apart from all this, buildings that become dysfunctional are liable to become environmental hazards. In the light of economic and ecological conditions, one of the principal factors to be taken into account at the design stage of present-day structures, for the reasons stated, is adaptability. Designs that facilitate potentially necessary adaptations serve to extend the functional life of buildings in the long run.

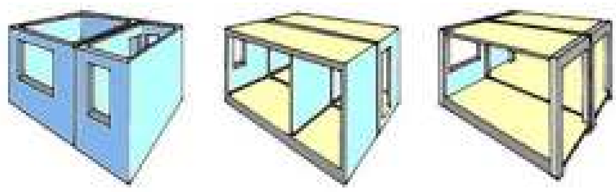


Figure 3: Classification of box unit systems

The size of the three-dimensional modules is determined by transportation and erection considerations. Accordingly, they are mostly of one- storey height (2.80m-3.00m) and 3.50m-

4.00m width, which is the maximum permitted in various countries by traffic regulations. Their length is limited due to weight constraints to 6.00m-10.00m. The resulting weight of 300-400 KN is within the limit of what heavy mobile cranes can handle at the minimum reach required for erection, namely, 10m-15m. Modules produced from lightweight concrete can be slightly larger. The three-dimensional modules can contain more finish works than other prefabrication forms. The systems that employ them can therefore fulfill, better than others, the ultimate objective of industrialization a maximum saving of human labor onsite. However, they also suffer from several limitations. A 'friendly' building layout, which can be effectively partitioned into three-dimensional blocks of required dimensions, is an essential for their employment. In this respect three dimensional units are much less flexible then linear or even planar elements, which can be used in almost any architectural layout with relatively minor adaptations. Another limitation of these units is their considerable weight and bulkiness, which make transportation and erection rather involved and costly process. Finally, the use of three dimensional units in buildings in excess of three or four stories requires special structural adaptations, which again make them less competitive with conventional or other prefabricated methods (Waszawskı, 1999).

With Respect to the Production of Box Units

These systems can be categorized as follows (Figure 3).

Systems with Partioned Box-Units

The prefabricated box units are transported to the building site, the assembled to form the box-unit. Box unit components are prefabricated and assembled to form the box unit in the factory. All necessary finishes are applied and thus prepared ready for use units are delivered to the site for erection.

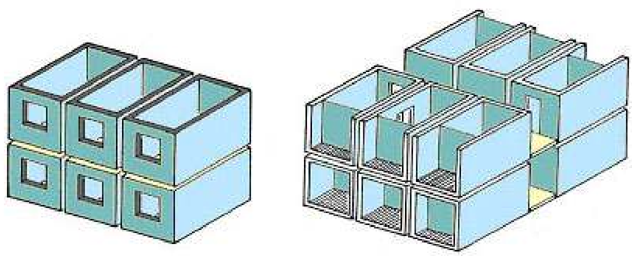


Figure 4: Box systems (Eşsiz , Koman, 2005)

Systems with Monolithic Box-Units

The box-units are is cast as a whole the delivered to the site.

With Respect to the Design of Box Units (Figure 4)

Systems with Opened Box-Units

According to Koşaner, the box units consist of load bearing cross walls or load bearing wall longitudinal walls. The opposite walls are left open. In the case where the module is left open in the longitudinal direction," considerable advantages can be obtained. The spans are shorter and the structural stability of the building is ensured by the cross walls. Good stability in the longitudinal direction is also provided by interconnection of the units to form a closed portal frame like assembly. Also cross walls serve as separate party walls which are instrumental in increasing the degree of insulation between adjacent dwellings. Alternatively the modules may be so arranged that the dividing walls each comprise a single leaf only. In the instance where the module is left open in the longtional direction, the span of the floor imposes constraints on the structural design. For this reason, the method has not been widely used (Koşaner,1991).

Systems with Closed Box-Units

In the closed-box system a space with defined dimensions, delimited by its walls and floor, is determined. These boxes have no potential for expansion (Garas, Armer Clarke,1994). They are being produced in three types: fully closed, with open façades, and with open top. Closed boxes are completely factory-manufactured units ready for installation. Buildings constructed with closed box do not offer flexibility in terms of planning. These systems very much resemble "cross-like" systems implemented in systems with large panels, where all walls are load-bearing or "transverse" systems where the load-bearing walls are arranged orthogonally to the façade (Eşsiz, Ö., 2002a, 2002b). Closed modules permit the free combination of modules. The best known example is Habitat Montreal 67.

In closed modular box unit systems, all sides of the unit are completely delimited, thus determining the size of the space. The cell size is restricted by transportability. For road transport, the width of the cells must comply with the traffic laws. Consequently, the modules' length in either direction must not exceed 2.40 m and 3.30 m respectively. Since the size of the space depends on its dimensions, these cells are more suitable for housing. Closed box units form a rigid structure within themselves. They are joined together just like masonry structures. By placing differently sized cells on top of each other in different ways, a number of variations become possible.

Modular Cells Independent from Structures

Modular cell elements may also be used as system complements within prefabricated or non-prefabricated load-bearing structures like frames, cores, tubular, load-bearing wall panels or hybrid systems. Here the cells are not load-bearing, but rather borne by the load-bearing structure. Those cells are elements such as kitchens, bathrooms, elevator shafts and stairwells. Since they contain the entire equipment and all workmanship is completed in the factory, they are the units with the highest degree of industrialization.

Figure 5: Green Modular Building.(http:// Schools benefit from green modular construction.htm)

Ecological Box Systems

A green home uses less energy, water and natural resources; creates less waste and is healthier for people living inside. Green Building also means a more resource efficient building process. There is reduced exposure to mold, mildew and other indoor toxins, reduced waste streams, conservation and restoration of natural resources along with enhancing and protecting ecosystems. In addition there are the economical benefits like lower operating cost, enhanced durability, less maintenance and optimized life cycle economic performance.

Building a home using modular construction is a very effective way to make the best use of materials, manufacturing efficiencies and protects the framing process from the elements. Keeping all materials dry and away from the elements helps to reduce the chance of mold and other toxins from later contaminating the indoor air quality. Local communities are looking for ways to minimize the impact of construction on local infrastructure at the building site. By building with modular construction you can reduce the traffic to a building site by delivering a house that is 80% complete in one day as opposed to having trucks delivering materials day after day. Modular construction minimizes the disturbance at the site and will reduce neighborhood traffic (http://www. sustainable environmentally friendly Modular Home Construction.htm).

Modular construction can sometimes be greener than site-built construction, due in part to reduced site disturbance, decreased on-site construction time, and less waste production as a result of factory-based material recycling(Figure 5) (http:// Schools benefit from green modular construction.htm).

Prefabrication and Modularity are new eco-buzzwords on the menu this year. From homes to furniture, designers are beginning to employ new methods of construction and transportation to cut waste and energy consumption, cut production costs, ensure safety, and achieve greater overall methods of sustainability. Consistency in dimensions and design makes modularity and prefabrication.

Figure 6: Otel-Bezau-Avusturya, Mimar; Heopold Kaufman, 1996. (Detail, 2001-4)

Prefabrication: (often relating to large scale production such as homes) is the practice of assembling parts in a factory, then transporting the complete or partial moduler to the construction site. Prefabrication also relates to small scale design such as furniture- i.e. parts of a desk are cut, stamped, drilled, and prepared in the factory then sent, with all its components, to be assembled on site. On the left site you see an example of box unit system. The hotel consist of a heterogeneous accumulation of buildings of different dates. It was to be extended by a further bedroom tract with a half for various events. Since the hotel is in use almost year round, a very short construction period was necessary. The solution was found in a series of prefabricated containers that could be stacked on top of each other. The 7.50x4.99m boxes aare self supporting, so that no primary structure or additional bracing were required.Services were laid in the voids between the cells. Only the glass bathroom walls and the wood furnishings had to be installed subsequently.The boxes and roof were erected in two days and after only a month, the extention was ready to receive quests (Figure 6) (Detail 2001-4).

Modularity: In design pertains to separate modules of the whole that can be used interchangeably. When pertaining to a home, it means that a general design is created so that modules within the exterior dimensions of a home can be moved around. In general, modular design benefits the consumer because the interchangeable components can be moved around to better accommodate your space, style, and needs. Since the modules are constructed in a factory, a higher quality of construction can be ensured than on-site, stick-built homes. The fasteners are accurately applied, materials are cut with more exactness, and since they have to withstand transport, everything is tighter and more secure. This extends the lifespan and cuts on upkeep. Modular prefabrication also saves significant amounts on their waste. While 30-40% of the material from a standart home construction site is carted off to the dump, modular homes generate only about 2% waste. That is a pretty large gap. Additionally, since the duration of construction is shorter, the cost is lower. This concept improves efficiency and ability, meanwhile achieving all of the modular prefabrication benefits.(www.Ecolect - A Sustainable Materials Community.htm)

It is faster: The construction period is reduced to three days;service installations are prefabricated and incorporated more swiftly; and building firms are less dependent on the weather and time of year.

It is more economical: The shorter assembly period represent a big potential cost savings and life-cycle costs are redued as a result of the simple method of removal and disposal.

It ensures a higher level quality: All componenets and services are installed at works to a constant quality level and with comprehensive quality controls, and the risk of accident on site is reduced.

It is environmentally friendly: Building sites are cleaner; waste products are avoid on site, and the reuse of components is simplified by the scope provided for a damage free dismantling and removal of elements (Prochiner, 2001)

CONCLUSIONS

Today, scientific and technological developments are taking place at a great pace. New technologies outdating the earlier ones are constantly introduced. As a result of these developments, the use of industrialized systems in construction has become topical. The following are the most sought features of industrialized construction systems:

- Structures must be highly durable and modifiable to be able to meet changing requirements.

-It must be possible to standardize the construction elements without restrictions to design, to compose structures by choosing from a catalogue of ready-made elements, and to replace these elements whenever required.

As industrialized construction systems, box systems are employed in structures containing a high degree of service units, such as hotels, public housing blocks, student hostels, educational buildings, commercial structures, hospitals, and elevator shafts. In terms of material, box systems are manufactured as reinforced concrete, steel, or wooden units, and in terms of the construction system as closed or as open units. Today, box unit systems find application in increasingly diverse fields, since the employment of such systems in construction is associated with advantages such as cost reduction, quick mounting, timely completion of works, and minimization of material losses, thus serving to create higher-quality physical spaces.

REFERENCES

Gras, Armer Clarke,(1994), Building in the Future, Innovation in Design Materials and Construction, E&FN Spon, Londra.

Anon, (2004), An Introduction to Modular Construction, http://www. corusconstruction. com/page_2372.htm

Eşsiz,Ö.,(2002a), High Tech Buildings Sub System Integration, Doctoral Thesis, MSU,Istanbul

Eşsiz,Ö.,(2002b), Prefabricated Modular Building Components in Modern Architecture, BIMB, 17th International Congress of the Precast Concrete Industry, Lütfi Kırdar Convention&Exhibition Center, Istanbul.

Koncz,T., (1975), Handbuch der Fertigbauweise/Band 3, Bauverlag GmbH, Wiesbaden.

Eşsiz,Ö., Koman,İ., (2004), Prefabricated Concrete Box Systems Applications, 11. Beton Prefabrication Symposium, İzmir.

Eşsiz,Ö., Koman,İ.,(2005), Box Construction Systems, YEM

Koşaner, Y (1991) Introduction to Industialised Housing Systems. Eskişehir: Univesity of Anadolu Faculty and Architecture Department of Architecture

Prochiner, F (2001-4), Innovative Plug in Connection the Key Technolgy for Prefabriacted Housing, Detail

Hotelbau in Bezau, Detail 2001-4

Ecolect-A Sustainable Materials Community, Available at: http://www.Ecolect - A Sustainable Materials Community.htm

Sustainable Environmentally Friendly Modular Home Construction, available at: http://www. sustainable environmentally friendly Modular Home Construction.htm

Warszawskı, A. (1999), Industrialized and Automated Building Systems, E&FN Spon,London

Green-Classrooms-To-Go Green-Classrooms-To-Go ,available at: http:// Schools benefit from green modular construction.htm

A REGULATORY APPROACH TO FOSTER INTEROPERABILITY: HOW IT TRENDS CAN HELP TO INNOVATE THE AEC SECTOR PROCESS

Claudio Benghi
Centre for Construction Innovation Research, University of Teesside, Middlesbrough, UK
c.benghi@tees.ac.uk

Nashwan Dawood
Centre for Construction Innovation Research, University of Teesside, Middlesbrough, UK
n.n.dawood@tees.ac.uk

In the last decade Information Technology (IT) development has been major innovation factor across the AEC (Architecture, Engineering and Construction) industry and several other sectors. The increase in pure computational resources, the ease of global network access and the development of mobile computing allow an unprecedented amount of digital activities in the procurement process. As richer data models, handled by Building Information Modelling (BIM) applications, become available it's recognized that data interoperability becomes a central issue in allowing further development in the diverse environment of the procurement process. The aim of this paper is to outline the state-of-the-art in interoperability, to identify effective IT strategies that could overcome the reported flaws and to describe a mid term certification strategy to foster the suggested solutions. In the last decade the efforts of International Alliance for Interoperability have brought to the development of a set of file formats aimed at overcoming this issue; although some results have been achieved we believe that the current IAI approach presents an important flaw neglecting the relevance of automated network access to the information through Service Oriented Architecture (SOA). Leveraging market needs and the consensus gathered around IAI, the software certification procedure proposed in the present paper aims to achieve a flexible and vibrant interoperable AEC IT environment.

KEYWORDS: Interoperability; IAI; Service oriented architecture; BIM.

INTRODUCTION

In the last decade the increase in pure computational power, the ease of global network access, the development of mobile computing and the evolution of a large number of software applications are among the reasons that improved the effectiveness and efficiency of IT in the construction procurement process while impacting the form of architecture itself (Barrow, 2004).

Powerful tools are available to perform traditional tasks such as finite element structural analysis and innovative activities as the 3D algorithmic determination of architectural form that defined the design of the new Beijing Olympic stadium. Nevertheless in the whole AEC industry the majority of the applications currently in use are information islands. We are - from an ICT (Information and Communication Technology) standpoint - in the early stages of their development and not taking advantage of important available technologies.

This lack of interoperability is partly due to the structural complexity of the AEC supply chain (well known to be fragmented and heterogeneous) and to a number of technical limitations that the market is progressively tackling (Gallaher et alt. 2004).

The present paper will report on technological trends emerging from the Information and Communication Technology (ICT) sector and then evaluate the state-of-the-art and ongoing efforts in AEC sector; it will envisions a development scenario for the construction industry and propose a certification procedure that is supposed to play as a key enabler in accelerating the vision to become reality.

The suggested Service Oriented Architecture Certification procedure is expected to combine with current certifications released by the International Alliance for Interoperability (IAI) encouraging fully interoperable vertical and middleware software platforms to fill the gaps between the biggest market players ultimately improving the quality of IT infrastructures for the AEC procurement process.

ICT TRENDS

In this paragraph we report on a series of ongoing trends observed in the last few years in the ICT Industry characterized by a high impact on society and economy. As it happens with high innovation-rate markets it’s not just that technological evolution affects the market and society but also (and most importantly) the other way around: emerging companies and users introduce new ways of using existing technologies generating new business models, as recently the case with the so called “Web 2.0”.

Like many recent concepts, Web 2.0 is not yet crystallized in a formal definition and doesn't have a hard boundary. In is a widespread term that refers to the set of principles and practices of successful internet businesses launched in the past few years; it represents the evolutionary edge of internet companies as opposed to the simple content hyper-linking approach of the initial exploitation of the Word Wide Web. The term was initially introduced at the first Web 2.0 conference as reported by O’Reilly (2005); the main business principles identified in the occasion of the conference are reported in the following paragraphs.

Service versus software

The first characteristic of a web 2.0 business is the business model itself. As envisioned in Rifkin’s (2000) “The age of Access” It is based on the access to a service rather than a traditional sale.

Netscape and Google may very well respectively represent the characteristics of web 1.0 and 2.0 business models in the IT sector. Netscape’s flagship product was the web browser, a desktop application, and their strategy was to leverage the dominance in the browser market to control the market of high-priced server products for content providers in the hope to reproduce in the web industry what Microsoft had done for the desktop environment. Eventually both web browsers and web servers turned out to be commodities, and value moved "up the stack" to services delivered over the web platform just where Google (a small start-up in those days) was exploiting its data mining skills to provide mediation services between people searching for information and the servers.

Harnessing the community

Google's competitive edge over its competitors was in fact not only in programming skills but in the ability to perceive the Internet as a social network and gathering knowledge from users behaviour: Google's breakthrough in search, which quickly made it the undisputed search market leader, was PageRank, a method of using the link structure created by web authors across online documents rather than just the words contained in the documents to provide better search results (Brin, Page 1999).

The initial business model that allowed Google to generate income from the visitors of their site was initially to sell advertisement space on their pages, only this time they tried to provide it as part of the service rather than the price-to-pay for the search service: they displayed unobtrusive sponsored ads related the search keywords typed by the users and thus potentially interesting, making profit from a practice that users might perceive as a feature and in fact they charged (the publishers) only for those ads that actually got clicked-on. This is the opposite of what happened with previous advertisement models: usually displayed with great evidence and occupying big portions of the screen. The natural behaviours of the community both when linking across pages and clicking on advertisement were central to the business model.

Participation or "the long tail"

Another effective way to harness the community is to set up system in such to expand participation to every potential user. The ability of online services to help consumers locate, evaluate and purchase a far wider range of services than via the traditional channels usually results in a high number of micro-transactions on the services producing relevant income streams (Brynjolfsson et alt 2006).

This generally involves making things simple for small businesses or even single users. In the online advertise market Overture and Google figured out how to enable web developers to achieve advertisement placement on any web page just reading a simple guide and via an automatic registration process. Every little content producer could place ads on his pages and share the revenues with the advertisement company. The implementation of such system produced in a small period an income comparable and sometimes bigger of the centralized advertisement method with the further result of tightening the community around the service provider. This kind of functionality was implemented using a technology called "web service".

Web services

Web Services should not be confused with the concept of getting served via the World Wide Web using a browser. Web Services are more about ways of coordinating data and procedures (services) to provide other services; they refers to a modular application architecture that can be invoked through the Internet. Often consumers of Web services are other computer applications that communicate, using XML standards, allowing application integration.

In the example of the previous paragraph a "web service" provides a set of advertisement links depending on the information contained in the page hosting them and is invoked automatically by the calling page. The called service may in turn call a geo-localization service to provide advertisement appropriate to the area of the viewer, semantic analysis servers to suggest appropriate subjects or similar functions. This service chain of calls are invoked dynamically by the original page and do not need any complex human intervention to configure the specific embedding in one page.

Light programming models

Once the model of web services became popular, large companies started developing complex web services stacks designed to create highly reliable programming environments for mission critical distributed applications. Success stories in their development though teach us that to engage effectively with a wide community the complexity of technical requirements should be compatible with the economic values at stake.

Amazon.com's web services, for instance, are provided in two forms: one adheres to the formalisms and complexity of fault tolerant web services stacks while the second simply working on XML data over HTTP. With this two methods Amazon has means to manage high value Business-to-Business connections with established retail partners and low profile relations through the lightweight HTTP service having the chance to engage with a wider number of partners that cannot afford to spend several man-months in developing high-level data management systems.

IT AND THE CONSTRUCTION INDUSTRY

The current AEC IT market is very diverse ranging from CAD applications to cost and engineering management tools; many of them saw a rapid improvement in the user experience and in the quality of interfaces over the last few years as the increase in computational power and the availability of accelerated 3D graphic adapters allowed more responsive, effective and consistent interaction with the applications; however they still do not take full advantage of the network revolution.

Due to the large number of different professions and firms involved in the process it was impossible for the IT market to produce a unique environment capable of handling the extremely diverse tasks involved. General purpose CAD applications and Spreadsheets have therefore been widely adopted to take advantage of increased drafting speed and computational power across many of the supply chain stakeholders from the mid ’80s. While CAD applications exposed the same interfaces and functions throughout the whole industry to architects, engineers, interior designers and urban planners some degree of customization has been available from the early stages through the development of specialized templates (e.g. for cost, thermal or simplified structural analysis) for spreadsheet users.

Soon after CAD applications implemented dedicated API (Application Programming Interfaces) a number of small and medium software companies started developing so called *vertical applications* to extend the available functions for the benefit of specific trades often storing semantic-rich information. When integrated into other systems these vertical applications used two approaches to store relevant data: meta-data technologies to embed it in the drawings or external files in case of more complex requirements. This marked the beginning of the end for seamless interoperability; editing that information without the vertical extensions could generate inconsistent or corrupted meta-data.

Building Information Modelling (BIM) commonly refers to the use of object-oriented, parametric solid-modelling systems for buildings; although the definition of this class of applications has emerged only in the last few years, the ability to manage semantic-rich building information goes back as mentioned more than 20 years at least for the construction industry and 30 or more for plant management systems. The real break-through we are experiencing lately is the maturity of effective integrated solutions that bring together, thanks to the complexity of the underlying common semantic model, data interfaces that were previously available in isolated vertical applications.

Once rich models are defined the next problem is to effectively distribute information. Chan (2005) mentions three different ways to coordinate data exchange across the different stakeholders in a procurement process: the fee-based project management service; the build-it-yourself solutions; and the web-enabled software. He then recommends the use of fee-based project management service "because it facilitates inter-organizational information sharing with affordable price and professional services, which sets the trend for Web-based project management".

We do not dispute that fee-based systems are to be preferred over a build-it-yourself solution but we see a serious limit in the definition he provides of Web-based software as "whole-set bought and maintained by construction companies". According to the winning strategies identified earlier for Web 2.0 the next paragraphs will provide identification of areas in which proper "web-based" applications could easily outperform the current status of the AEC IT.

Online Information Storage

Information sharing is now commonly obtained through file sharing. Access to company and project information is achieved, in most cases, via a File System on the Local Area Network (LANs); Internet access to the same information relies – when available - on file upload and downloads procedures, file attachments to e-mail or in rare cases Virtual Private Networks (VPNs).

Project management intranet or extranet services usually include a service-bases web approach limited to project meta-data such as discussions, revision statuses and calendars, while project documents, drawings, and spreadsheets are still linked as files. This approach requires complex coordination systems and human operation is required to perform common tasks such accessing actual drawings, compare changes and similar activities.

In a service oriented approach information would be stored in potentially distributed database servers and accessed through semantic queries rather than through file sets, allowing automated version comparison of design parts, financial analysis, quantity extraction and others.

Information format and interoperability

In projects of relevant complexity time is spent before contractual agreements are signed to determine the methods to allow data exchange between different applications and companies. File formats and application versions are checked to guarantee interoperability. As semantic richness of the managed files increases firms are more reluctant to rely on low semantic value interchange files and the solution is often to agree on common software vendors or platforms to override the interoperability issue.

In the vision of an interoperable service oriented approach this issue would be surpassed and each firm could maintain familiar applications, only defining proper data translation methods or acquiring them on the market. To harness the community simple methods should be made available to interrogate the system for specific information and programmatically modify it.

This kind of feature could provide ways to expand the functions of the system where needed with dedicated features surpassing current sub-optimization of information re-usage. As a consequence (ideally) contractual practice should change to reflect the increased flexibility in data management and mining. Through adequate web services the whole tendering process, or trade integration (for instance) could be extremely accelerated and in some case automatically calculated in real time making formal paper revisions meaningless.

Corporate an business knowledge

Knowledge and experience emerging from business practice is currently stored in the drawings and documents of personal and departmental archives.

Nowadays the effectiveness of company-wide knowledge bases - when available – is sub-optimal due to their lack of integration with the working user interfaces and to the limited scale of the available data; thus only a few large companies are investing in the systematic extraction of knowledge from their process. Past experience is only in people's memory and solutions are regularly re-invented and common mistakes repeated.

Information Technologies have a huge potential in providing the right information at the right moment in time, but appropriate data mining techniques require specific skills and large datasets in order to be effective. Service oriented architecture could provide the framework for business opportunity in knowledge mining services to emerge.

INTEROPERABILITY

On the basic premise that firms are slower to produce innovations when in isolation we recognize - along with AEC development roadmaps such as ROADCON (Hannus M. et alt. 2003), e-Cognos and VTT's VERA - that interoperability may be the central issue to address in order to encourage innovation. The key factor that allowed the web to experience such an explosive growth in content and functionalities over the past years is in fact the very interoperable nature of text contents.

Obtaining the same levels of data interoperability in our widely disperse sector is quite a more complex challenge. In the past decade International Alliance for Interoperability (IAI) has worked at the specifications of "Industry Foundation Classes" (IFC), an open fully documented semantic-rich file format to allow BIM data interchange across different platforms.

In the last years IAI has formed a very rich consensus group and is now endorsed by some of the most prominent international standard-setting bodies including ISO. Their standard has been recognized in late 2005 as ISO/PAS 16739, and the Publicly Available Specification status should be removed soon making it a full-titled ISO standard. IAI has also succeeded involving most of the key players of the CAD/BIM market such as: Autodesk, Nemetschek, Graphisoft, Bentley, TEKLA and many other smaller companies.

IAI is pursuing interoperability through standardization of data interchange formats. Industry-wise recognized conformance to IFC is certified by IAI to applicants through a standardized procedure. In the next paragraphs we propose a complementary certification approach that could be effectively encouraging a service oriented open environment.

Standards and innovation

The reason to establish a technical standard among competing entities in a market is to bring clear, documented and agreed ways of achieving particular objectives encouraging competition. The clear potential drawback is of course hampering innovation as it's hardly possible to be better without being different.

Exploiting lessons learnt from the explosion of web 2.0 we recognize that being able to interpret information correctly provides only half of the requirements to establish a vibrant market. The other is the capability of having information flow on request, not depending on user operation of file import-export procedures. We need the equivalent for BIM data of the HTTP protocol for hypertexts.

IFC's layers are constituted of a closed set of elements with specific properties. They have been chosen to describe the core of AEC's market requirements as emerged in its 10 years of development; extensions and new properties will be added to this set as a common need for them will be recognized by IAI. For any property not currently provided in the data structure IFC provides a set of rules to add meta-data storage.

Applications that successfully perform a given set of tasks on sample IFC files being able to either read or write them obtain a compliance certification status. Different levels of certification are granted depending on the set of tasks successfully accomplished.

This approach has been chosen because it apparently meets the industry need for a known working set of features while allowing for extensibility. Meta-data layers are, in fact, often used to implement platform specific features. Unfortunately, though, the current certification process does not require metadata handling opening - by design - a breach in the whole interoperability process. A single application could in fact export its own format to IFC and than import it back with correct extended data handling, but being those structures proprietary, there's no guarantee that other applications will know hot to manage it, update them consistently, or even that they will prevent their deletion. This will make of IFC a mere vehicle to transport partial datasets as opposed to a vibrant and diffused data standard.

The proposed model

The new certification model we propose aims to fill the gap between the current IFC file based strategy and the need for a service oriented infrastructure. Applications undergoing the proposed certification scheme should be checked against software architecture rather than mere file conformance.

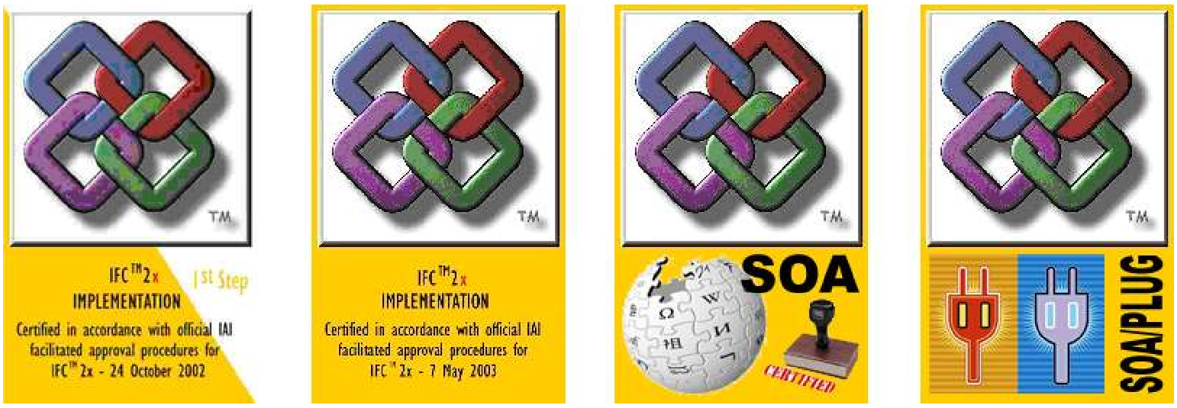


Figure 1: From left to right the current IAI Certification Logos for level 1 and 2 and two mock-ups of the Logo for the new proposed certification levels.

SOA Level Certification will be granted to an application capable of operating in a Service Oriented Architecture environment (i.e. enabling the automation of project data flows). Each vendor could decide to apply for certification of client applications, server applications or integrated systems.

Defining the technical details of this proposed certification process is beyond the scope of the present paper and is the subject of the next stage of the ongoing research at CCIR, but the core requirements for the certification architecture have already been identified and are based on two principles:

1) Isolation of the data repository

Any application capable of saving information to a storage system (data repositories) should not have a user interface and vice versa. Interaction with these isolated data repositories will be achieved consuming service calls over the TCP/IP protocol. Data travelling in both directions shall be encapsulated in XML. Technical documentation will be provided to describe the means of accessing the service trough recognized standards such as Web Service Definition Language (WSDL). A technical panel will evaluate the completeness of the documentation provided for the service request protocols and XML schemas for the response flow.

2) The data repository service import/export functionality

Application will be free to choose whether to comply or not with the ifcXML standard for data flow between clients and services but the data repository service will provide documented methods to export a compliant ifcXML data set or an IFC file and to import a IFC object definition either as a new object or to replace and existing one.

Expected outcomes

In principle this minimal set of requirements will guarantee that information stored in certified solutions will be available for interoperable processing at different levels:

1) Guarantee light programming models without hampering innovation

Requiring an automated function to import/export IFC data formats for partial models allows taking advantage of the interoperability levels already granted by file based IFC compliance to provide short term interoperability methods with current applications before they adhere to the new SOA model.

Allowing arbitrary XML data flows for will guarantee to vendors the possibility to optimize for performance and functionalities (with the burden of documentation).

2) providing an on-demand service model versus a traditional software model

The proposed certification will not make any request in the matter of data management capabilities of any service application. Services will perform as black boxes and no intellectual property will have to be shared or documented as to how internal computations are consumed.

In the case that the data repository for a project is available online vendors could decide to provide their core service without even licensing the software to the client but providing it through the internet.

3) Harnessing the community

As long as the service will be consumed online as suggested at the previous point the vendor could be able to perform useful data mining on the volume of available information generating useful bits of knowledge that could return to the community in the form of customized interfaces or contextual information thus generating competitive advantage over the competitors while innovating the market.

CONCLUSIONS

Communication and information technologies are changing the way for people to behave in everyday life and in their businesses. Relevant social and economic changes have derived from this and more are probably to come.

Architecture, Engineering and Constructions are of course influenced by technological changes constantly evolving around them, but most of the advantages they are obtaining from current IT, although in some circumstances impressive, still do not take full advantage of current automation practices. There is little or no doubt that service-oriented open data integration systems will eventually become available but the time-scale for this event might be widely influenced by the strategies that market leaders will decide to adopt in response to market request. The so called web 2.0 businesses represent the most advanced ways to harness the power of the internet and should then be of inspiration in the identification of winning strategies for a tightly interconnected AEC IT development.

The role of organisations such as IAI is to facilitate the adoption of interoperable platforms while protecting innovation. As we reckon that interoperability in an open and competitive market represents the key to unchain AEC process optimization and evolution we propose to leverage IAI’s regulatory influence introducing a complementary certification procedure finalised to accelerate the adoption of automated, flexible and modular Service Oriented Architecture. Main guidelines for the proposed certification strategy have already been defined and briefly detailed in the present paper; technical details for their implementation will have to be determined in further development of the research.

REFERENCES

Barrow, L. (2004) Elitism, IT and the modern architect opportunity or dilemma, Mississippi State University

Brin S., Page L. (1999) The anatomy of a large-scale hypertextual Web search engine, Stanford University

Brynjolfsson, Erik, Hu, Yu Jeffrey and Smith, Michael D., (2006) From Niches to Riches: Anatomy of the Long Tail. Sloan Management Review, Vol. 47, No. 4, pp. 67-71

Carter S. (2007) The New Language of Business: SOA & Web 2.0. IBM Press

Chan S., Leung N., (2005) Prototype Web-Based Construction Project Management System, Journal Constr. Engrg. and Mgmt., Volume 130, Issue 6,

Farrell J., Klemperer P. (2006) Coordination and Lock-In: Competition with Switching Costs And Network Effects. University of California, Berkeley

Fischer M. (2005) For BIM's Sake. American Institute of Architects Whitepaper. Available at http://www.aia.org/tap_a_200506_bim

Gallaher P., O'Connor A. C., Dettbarn J. L., Gilday L. T. (2004) Cost Analysis of Inadequate Interoperability in the U.S. Capital Facilities Industry. US NIST

Hannus M. et alt. (2003) Construction ICT Roadmap, Deliverable of IST project ROADCON. Available online at http://cic.vtt.fi/projects/roadcon/public.html

Iversen E. J. (2000) Raising Standards: Innovation and the emerging global standardization environment for ICT. Oslo ISSN 1501-0066

Lima, C. et alt. (2006) Towards a knowledge-based comprehensive approach for the management of (e) regulations in Costruction, in EWork and EBusiness in Architecture, Engineering and Construction, Taylor & Francis

O'Reilly T. (2005) What Is Web 2.0: Design Patterns and Business Models. Available at: http://www.oreillynet.com/pub/a/oreilly/tim/news/2005/09/30/what-is-web-20.html

Kolbitsch, J., Maurer H. (2006) The Transformation of the Web: How Emerging Communities Shape the Information we Consume, Journal of Universal Computer Science 12(2), 187-213

Kurzweil R. (2005) The Singularity Is Near: When Humans Transcend Biology, NY: Penguin

Rifkin J. (2000) The Age Of Access: The New Culture of Hypercapitalism, Where All of Life Is a Paid-For Experience, Putnam Publishing Group

Simonson K. (2006) Quick Facts about the Construction Industry. Associated General Contractors of America

UNDERSTANDINGS OF DESIGN QUALITY: THE CASE OF THE BUILDING SCHOOLS FOR THE FUTURE PROGRAMME

Paula Cardellino
University of Reading, UK
p.cardellino@reading.ac.uk

The Building Schools for the Future (BSF) programme represents the biggest single UK government investment in school buildings for over 50 years. The programme has been established to ensure that pupils learn in 21st-century facilities. A key goal for BSF is to ensure that schools are designed or redesigned to allow for educational transformation. This represents a major challenge to those involved in the design of educational buildings. The paper explores understandings of design quality within the programme based on the analysis of 40 reports on design quality by government organisations and on 14 semi-structured interviews with experienced professionals that represent key actors in the provision of schools. It describes the means by which design quality becomes defined and given importance within the programme through official documents and by articulating the multiple understandings of design quality that stakeholders have in practice. The preliminary findings suggest that a well designed school building is important to educational transformation; and that judgements of the quality of its design need to be made in the context of this wider context.

KEYWORDS: design quality; schools; educational transformation; innovation

INTRODUCTION

Design quality is central to a number of recent debates about the built environment (Gann and Whyte 2003; Thomson *et al.* 2003; Keniger 2004; Macmillan 2004). A high quality built environment provides a goal for the construction industry. In the context of education there is at present a growing recognition that the public sector must be provided with environments that provide children with good places to learn. These should be designed to the highest quality and the government has given the issue considerable attention (HM Government 2006). However, for those responsible for the delivery of such buildings the question still remains, what does design quality actually mean.

The recent initiative, Building Schools for the Future (BSF) programme, represents the biggest single government investment in improving school buildings for over 50 years. The BSF programme – worth £2.2 billion in its first year (2005-6) – has been established to ensure that pupils learn in 21st-century facilities (The Education and Skills Committee 2007). The aim of the programme is to drive reform in the organisation of schooling, teaching and learning, and in the procurement of school buildings. This is to be achieved by rebuilding or refurbishing every secondary school in England in the next 10-15 years (DfES 2004). The design of 21st century school buildings in the BSF programme aims to account for current and future developments in education and technology as well as the local and global environment. Ultimately, the programme's target is to achieve educational buildings that inspire new ways of learning and to provide 'excellent' facilities that benefit the whole community.

This initiative comes on the back of an increasingly widely held belief that older schools, as well as those more recently built or refurbished, are inadequate in their ability to cope with anticipated changes such as shifting pedagogy, curriculum and learning expectations (Audit Commission 2003). A key objective to the BSF programme has been the push to achieve ‘design quality’ in schools. Thus, the programme is a good context for studying the meaning of the term ‘design quality’ and the different ways in which this is being interpreted.

The paper explores understandings of the term ‘design quality’ in the educational context, in particular within the BSF programme. In the next section, the academic literatures and debates on design quality are considered. This is followed by the method section, where the data collection methods used in this research are described. The following section describes preliminary findings based on the analysis of reports and policy documents and 14 semi-structured interviews. The section illustrates some challenges associated with the understanding of the term design quality in the BSF context. Finally, the paper concludes that judgement of design needs to be contextualised and describes areas for future research.

LITERATURE ON DESIGN QUALITY

Over the past few decades, both academics and practitioners have devoted much effort to design quality research and there are a number of attempts to define the term ‘design quality’ in relation to the built environment (e.g. Macmillan 2004; Gann and Whyte 2003).

One dimension of research describes design quality as made up of, and divisible into, different aspects. This multifaceted nature of design has been recognised, at least, since late Antiquity, when Vitruvius (1999) described design as a tripartite division of *firmitas*, *utilitas* and *venustas*, terms translated by Wotton in 1624 as commodity, firmness and delight. Perhaps, one of the more clear applications of the tripartite concept is the conceptual framing of the Design Quality Indicators (DQIs), a tool developed to assess the design quality of a building. They are: function, build quality and impact (Gann *et al.* 2003). *Function* includes concepts such as the building use, access and space; *build quality* relates to the building performance and construction; and *impact* encompasses aspects of the building form and materials, internal and external environment and identity. This tripartite approach still seems appropriate to break down the design quality concept within the BSF context (CABE 2005).

Another dimension argues that design quality consists of both objective and subjective components. While the objective components, are easily quantifiable, and therefore assessed, other components result in ‘intangible assets’ depending in part on the subjective views, experiences and preferences of the people asked (Cooper *et al.* 2003; Gann and Whyte 2003). It is easy to calculate and minimise physical heat loss from a building, but the target of minimising a loss of potential learning through good design is considerably more intangible. Different schools, children, cultures and context at different times will create a variety of conditions for potential learning. Therefore, intangible assets within the built environment are viewed as benefits to clients and other stakeholders that are very difficult to quantify (Abdul-Samad and Macmillan 2004). Though it is difficult to achieve explicit links, studies have produced some evidence linking the physical school environment with teaching and learning (Price WaterhouseCooper 2003; Higgins *et al.* 2005). Within the school environment, elements of intangible benefits associated with well-designed built environment include effective delivery of learning outcomes, improved educational attainment and calm schooling environment.

These very different views of design have an impact on formal descriptions of design quality in programmes such as BSF and on informal discourses of the participants of such programmes.

METHOD

The research reported here is based on the context analysis of published reports and of exploratory semi-structured interviews with experienced professionals representing key actors in the provision of schools.

The secondary data included 40 government and non-government policy reports on design quality, including studies on design quality in buildings; design quality in schools; and, a small sample of international reports. For each report key definitions and perspectives on design were identified. Particular focus was given to the actions suggested to be taken in the BSF programme to facilitate the achievement of design quality in educational facilities in the context of wider approaches.

The interviews included 14 key stakeholders to the BSF process. Each interview was semi-structured lasting one to two and a half hours. The interviewees belonged to the following organisations: Partnership for Schools (PfS), the government agency charged with the delivery of BSF programme; 4ps, the local government's project delivery specialist; Department for Children, Schools and Families (DCSF); Construction Industry Council (CIC) involved in the development of the DQIs; Commission for Architecture and the Built Environment (CABE); Building Research Establishment (BRE); architects and; a contractor involved in the BSF process; and, an architect not involved in the BSF process. The interviewees were asked about organisation career histories, their experiences in schools design and perception of the BSF programme regarding the handling of design quality. The specific purpose of the interview was to learn as much as possible about the concerns, perceptions, reactions, observations and thoughts in connections with the BSF programme. All interviews were tape-recorded and transcribed *in verbatim* so that the raw data could be systematically analysed.

The findings presented in this paper are from a preliminary analysis of this data-set as part of an ongoing qualitative research project. At present a number of open codes and a relatively descriptive analysis of the case have been developed. This is presented below.

SETTING: BSF PROGRAMME

In 2003/2004 the Building Schools for the Future (BSF) programme was launched as a coordinated national strategy driven by the, then, Department of Education and Skills (DfES). In 2005/06 the government’s investment in school buildings reached £5.5 billion. This included £2.1 billion for the Building Schools for the Future programme which become a key part of the current strategic and targeted capital programme (The Education and Skills Committee 2007).

The BSF target is to rebuild or refurbish every secondary school in England by 2020 with an extended government capital investment of £45 billion. The aim is to provide schools that: include a diverse curriculum for students aged 14 to 19; acknowledge new ways of teaching and learning taking into consideration the impact of ICT; are open to the community; include students with special educational needs into mainstream schools; use the building as a tool for teaching and learning (e.g. sustainability), and; accomplish the pertinent ventilation requirements. Furthermore, the design of new school buildings within the BSF programme aims to account for current and future developments in education and technology as well as the local and global environment. The programme's target is to achieve educational buildings that inspire new ways of learning and to provide 'excellent' facilities that benefit the whole community. Ultimately, all these various changes will have an impact on the form of the building.

Despite its size the BSF programme comes on the back of significant investment in schools. Indeed, the last decade has already seen one of the largest school building programmes in UK history mainly through the Private Finance Initiative (PFI) procurement route. Between 2000 and 2005 PFI has been the main source of funding from the Department for Education and Skills (DfES) for new or replacement schools. The introduction of PFI projects into schools in the UK generated a great deal of debate and received mixed responses. The Audit Commission report *'PFI in schools'* (2003) which assessed quality and cost in early PFI projects (up to 2002) showed that PFI schemes did not deliver high quality buildings. The study not only found that few schools came out well in terms of the buildings cost of ownership but that the PFI sample scored, statically speaking, significantly worse than the traditionally funded sample. The BSF attempts to respond to that criticism, with a programme of improvements. The main difference between the PFI initiative for schools and the BSF is that the latter is not merely a building or procurement programme. However, a recent study carried out by CABE (2006) shows that, though still in the early stages, many of the BSF schools on the drawing board are facing the same problems as previous programmes.

EMERGING FINDINGS

A key goal for the BSF programme is to ensure that schools are designed or redesigned to allow for educational transformation. Design quality is presented as very important to the achievement of good schools. This section describes preliminary findings based on the analysis of reports and policy documents and semi-structured interviews. It also illustrates some challenges associated with the understanding of the term design quality in the BSF context. As the work is still in process, it will not be possible to provide with strong evidence on the outcomes. However, several preliminary findings emerge.

Description of design quality in reports

The last decade has seen the publication of a host of reports addressing the need for good design in buildings, (RIBA 2001; CABE 2002; CABE 2004). The Government has highlighted the importance for good design in buildings through different initiatives and reports such as 'Better Public Buildings Initiative' (Department for Culture 2000). This report highlights that good design provides a host of benefits. Within the school context, the ones that have been best designed encourage children to learn. A number of government organisations, such as the Office for Government Commerce; the Commission for Architecture and the Built Environment (CABE); and the Department for Children, Schools and Families (DCSF), have increased their attention to the achievement of design quality in educational buildings. The findings and recommendations from some of the key reports from these 3 organisations are highlighted and discussed in this section.

Office of Government Commerce (OGC)

The OGC is an office of HM Treasury, responsible for improving 'value for money' by driving up standards and capability in procurement. In 2007, the OGC published 'Achieving Excellence 9' as part of a series of eleven guides providing guidelines on how to achieve excellence in construction. This specific guide deals with the achievement of good design. It explains the characteristics of a well designed building and indicates how design quality can be raised through the procurement process. It also specifies the importance of a design champion if design quality is to be achieved. Furthermore, the importance of having an integrated project team is highlighted.

Commission for Architecture and the Built Environment (CABE)

CABE is the government's advisor on architecture, urban design and public space. It is one of the most dedicated organisations in the provision of advice to stakeholders in an attempt to ensure the achievement of high quality design in educational buildings. Amongst the many reports published by CABE the most relevant to defining design quality are:

- 'Being involved in school design: a guide for school communities, local authorities, funders and construction teams' (CABE, 2004): probably one of the most comprehensive reports regarding the provision of guidelines for stakeholders involved in the design of a school. The aim of this guide is to demonstrate the importance of carefully planned collaboration between funders, local authorities, school communities and design teams in order to achieve the best facility possible. In particular, the guide aims to be relevant to the Building Schools for the Future (BSF) programme. It includes ten case studies of schools across England that provides examples of effective involvement across a range of procurement routes. The report highlights the importance of clarity in the process of briefing and design development.

- 'Assessing Secondary School Design Quality' (CABE, 2006): a guide for school communities, local authorities and design and construction teams to enable good design in schools. The report assesses the design of a representative sample of 52 secondary schools completed between 2000 and 2005 using a variation on the design quality indicator (DQI) for schools. A key finding is that users argued that a good school is one that has a 'sense of place'; a building that is inspiring and welcoming but that at the same time has to be functional in a way that encourages good behaviour and is easily managed. Flexibility was highlighted as another important aspect of the building. In particular, the ability to use different spaces for different purposes. Finally, it was found that the school should be 'green' and 'sustainable', taking into consideration alternative forms of energy and should be built using robust materials from sustainable resources.

- 'Creating Excellent Secondary Schools. A Guide for Clients' (CABE, 2007): presents 10 points that need to be achieved for a well-designed school. They can be grouped into the three categories: its functionality, the way the building is designed to be useful as a school; its built quality; its impact, on the users, the local community and the environment. The report states that a successful synthesis of these key points can lead to the achievement of good design. The case studies in the report address each of the main issues referred to above.

Department for Education and Skills (DfES - now DCSF)

DfES has shown a growing interest in the achievement of good design of school buildings through the publication of ‘*Building Bulletins*’ that provide guidance to designers planning building projects. Some of these bulletins have specifically targeted the BSF programme - cf. ‘Building Bulletin 98’ (DfES, 2004b). This bulletin provides a briefing framework for secondary school projects through the BSF programme. The latest report published by DfES, the ‘Better Buildings, Better Design, Better Education’ (DfES, 2007) shows the capital investment in education in the last ten years based on a survey of all the local authorities in England. The foreword of this report states that the investment in school buildings is an once-in-a-lifetime chance to create buildings that inspire learning and are a source of pride for local communities. Several case studies of good design in schools are included indicating the way in which the schools were designed to support new broader approaches to teaching and learning; such as school sport and healthy eating, personalised learning and provision for pupils with special needs.

Understandings of design quality

A number of stakeholders involved in the BSF programme, such as for example contractors, designers, policy makers and consultants have had a significant impact on the parameters for and appraisal of design quality. These stakeholders’ perceptions of what important attributes of good design are differ. Some of these attributes are quite subjective and are subject to the perception of the person being interviewed. Reaching a common definition of what design quality actually means to the different people has proven itself to be a challenge.

What follows is a presentation of the views of a cross section of stakeholders from the interview sample that concern the understanding of the term ‘design quality.’ This helps to illustrate the difficulties and challenges people phase during the daily process of designing a school. From the analysis of the interviews 3 different aspects of design quality are highlighted. Firstly, the role the school building has to play on the educational transformation. Secondly, the importance of a school building that has something unique about it, a ‘sense of place’. Thirdly, the acceptance that the design of a school building has a complex nature.

Role of the building on educational transformation

The role that the school building has to play in educational transformation is one of the main concerns amongst the interviewees. In particular, how to achieve a design of the educational facility that it is fit for purpose. However, the opinions of what exactly fitness for purpose is varied across the group. For example, the consultant engineer for the programme explains that design quality is about “making sure [that the school building] fulfils its function which is the learning aspect”. For him a school building that is fit for purpose is pivotal to the achievement of a good school. He also highlights that clients have shown concerns about spending the allocated money merely on a ‘landmark’ building they would rather spend it on good educational facilities. The concept of fitness for purpose was also prevalent amongst the architects. Yet, they portrayed the building as one component of the school environment. A senior architect argued that the school buildings have a limited role to play in whether or not a school achieves educational attainment. Whilst designers are continuously asked to deliver transformation within the BSF programme, he was of the opinion that he and his peers in their roles of professional designers are limited in the level of transformation they can provide. The perception the users have of their new school building will also have an impact on their ability to learn.

The architects and the contractor highlighted their concerns about how the school would benefit from the design of 'fancy' buildings. Again, the idea that the architectural design of a building is only one aspect of the school was highlighted. A senior architect argued that many designers produce superficially attractive and glitzy buildings, lacking in the ability to relate the physical spaces needed to deliver the educational transformation required.

What is clear from the analysis is it that the building has a role to play in the route to achieving educational attainment. However, what is not clear is the individual responsibilities the different participants have in this journey.

Building a 'sense of place'

The achievement of a 'sense of place' within the school environment is acknowledged as an important aspect of design quality. This is linked with the views of Markus (1993) where he describes buildings as 'social objects', there buildings cannot be seen as a separate entity, they are to be considered within the wider context. Different schools, children, cultures and context at different times will create a variety of conditions for potential learning. The creation of the 'sense of place' within the school is, therefore, not only a building matter; though designers have the potential to create spaces that can aspire to become special ones. One architect argued that design quality is about creating special spaces within the school building. In her view the most important aspect of designing a school building '… is about creating the heart of the school, which is the social aspect which is never written into the brief'. Another designer further indicated that one important feature of a good school 'is the architectural space, particularly communal spaces'.

The designers in the interview sample highlighted flexibility in the school building as an important feature. The design of school buildings spaces that are flexible enough to accommodate all the changes, including the changes in users and in curriculum was portrayed as a key challenge. Understanding the ongoing changes and the uncertainties in the educational sector and addressing this from the outset in designing the building is by no means a trivial task. Nonetheless, if flexibility is achieved it enables the introduction of a variety of spaces into the school design 'to respond to the fact that schools are no longer just classrooms and corridors'. This matter was seen as very important to the achievement of design quality.

Complex nature of the school building

The views amongst the interviewees indicate the acceptance of the complex nature of designing a school building. Therefore, the views on what a good school should look like vary. As an example, a senior architect stated that a good school is:

> 'One where the design of the building supports the learning and integrates the ICT technologies, it is healthy, naturally ventilated, well lighted, acoustically responsive and accessible'.

One of the developers of the Design Quality Indicators, a tool created to assess the design quality of a building, addressed the complexity involved in the design of schools when the future teaching and learning processes have to be acknowledged. He argued that:

> 'One of the big challenges is that there has been a fairly determined pedagogy in school design for the last 20 to 30 years. What seems to be happening now is that because the pedagogy is breaking down, becoming more fluid, it is very difficult to visualise what that form might look like'

From the point of view of the contractor there is a balance that needs to be achieved in order to have a good school. He argues that the school is a complex system that needs to address the importance of the teacher. Within the BSF programme, he thinks, the money allocated to each school is being spent in the building and the ICT. There is no money allocated to train the teachers. He argues that 'the teacher makes the difference, and I think this is really lost in the BSF'.

Summary

It is clear that the academic literatures and debates on design quality are reflected in the formal descriptions of design quality found in the reports analysed. Interestingly these organisations have extended Vitruvius' tripartite concept to build a criteria for well-designed buildings (cf. CABE 2003, 2006; OGC, 2007). In general terms these reports describe design quality as a combination of: excellence, value, meeting clients' needs and meeting design requirements. Such ideas also resonate with the views of those involved in the actual realisation of the BSF projects. There seems to be an agreement on that 'school' buildings need to have quality in their design and therefore should not only be cost driven. Though, some of the attributes of design quality are quite subjective and different aspects of the quality are important to different users.

CONCLUSION

This paper explores the understandings of the term 'design quality' in the educational context, in particular within the BSF programme. From the analysis of the reports and the interviews conducted this preliminary work shows that design quality is very important to the people involved in the BSF process. However, from the many reports analysed it is not clear how to address the transformational education encouraged by the BSF. Several reports have prescribed the attributes that a building should demonstrate to be a well designed school. The tripartite approach to design has been seen as architecturally valid to assess the 'building' quality. This view is counteracted by the concern of stakeholders' involved in the process. They face significant difficulties and challenges when designing schools and the understanding of the term 'design quality' in the BSF context. In general, they view design quality of a 'school' as more than just a building. It is experienced as intimately related to modes of learning. The BSF programme is about educational transformation. Buildings have a pivotal role to play in this journey. Therefore, judgements of the quality of its design need to be made in this wider context.

The research presented here forms a basis for continuing research in design quality in schools that draws on the rich case provided by the Building Schools for the Future programme. The following are suggested areas for future research. One direction for research involves more detailed empirical research on the design practices and processes that are involved in attempts to achieve design quality in the BSF programme. Another direction for future research includes the comparison of this process with past examples within the same sector and across other sectors nationally and internationally. Finally, an important area for further study is the inputs of various stakeholders in the supply-chain to the design quality of the school.

ACKNOWLEDGEMENTS

I would like to acknowledge the inputs and advice of Derek Clements-Croome and Jennifer Whyte in working with me on the 'Achieving Design Quality in Schools' research project and gratefully acknowledge support from the EPSRC, which funded this project through the Innovative Construction Research Centre held at the University of Reading (http://www.icrc-reading.ac.uk).

REFERENCES

Abdul-Samad, Z. and Macmillan, S. G. (2004). Improving Design Quality in the Built Environment through Knowledge of Intangibles. International Engineering Management Conference proceedings, Singapore 12-14 Oct, Vol. 3, pp. 898- 902.

Audit Commission (2003) PFI in Schools. Audit Commission, London.

CABE (2002). The Value of Good Design. Commission for Architecture and the Built Environment, London.

CABE (2003) Creating Excellent Buildings: A Guide for Clients. Commission for Architecture and the Built Environment, London.

CABE (2004) Being involved in school design: a guide for school communities, local authorities, funders and construction teams. Commission for Architecture and the Built Environment, London.

CABE (2005). Picturing School Design. London, Department for Education and Skills.

CABE (2006) Assessing Secondary School Design Quality. Research Report. Commission for Architecture and the Built Environment, London.

CABE (2007) Creating Excellent Secondary Schools. A Guide for Clients. Commission for Architecture and the Built Environment, London.

Cooper, R., Bruce, M., Wootton, A., Hands, D. and Daly, L. (2003). Managing Design in the Extended Enterprise. Building Research and Information 31(5): 367-378.

DCMS (2000). Better Public Buildings: A Proud Legacy for the Future. Department for Culture, Media and Sport,. London.

DfES (2004). Schools for the Future: transforming schools an inspirational guide. Department for Education and Skills. London.

DfES (2004b). Building Bulletin 98. Department for Education and Skills. London.

DfES (2007) Better Buildings, Better Design, Better Education. Department for Education and Skills. London.

Gann, D. M. and Whyte, J. K. (2003). Design quality, its measurement and management in the built environment. Building Research and Information 31(5): 314-317.

Gann, D. M., Salter, A. S. and Whyte, J. K. (2003). Design Quality Indicator as a tool for thinking. Building Research Information 31(5): 318-333.

Higgins, S., Hall, E., Wall, K., Woolner, P. and McCaughey, C. (2005). The Impact of School Environments: A Literature Review. The University of Newcastle for the Design Council.

HM Government (2006). Better Public Buildings, CABE.

Keniger, M. (2004). "Achieving Design Quality: from Intent to Implementation." Building Research and Information 32(3): 251-254.

Macmillan, S. (2004). Design as a Value Generator. In Designing Better Building. Edited by S. Macmillan. London, Spon Press.

Markus, T.A. (1993). Buildings and Power: Freedom and Control in the Origin of Modern Building. Routledge, London.

OGC (2007) Achieving Excellence 9: Design Quality. Achieving Excellence in Construction Procurement Guide, Office of Government Commerce.

PriceWaterhouseCooper (2003). Building Better Performance: An Empirical Assessment of the Learning and Other Impacts on Schools Capital Investment Research Report No. 407. London, Department For Education and Skills.

RIBA (2001) Valuing good Design. London.

The Education and Skills Committee (2007). Sustainable Schools: Are we building schools for the future? Seventh Report of Session 2006–07, Vol. 1, House of Commons, The Stationary Office, London.

Thomson, D. S., Austin, S., Devine-Wright, H. and Mills, G. (2003). Managing value and quality in design. Building Research and Information 31(5): 334-345.

Vitruvius, P. (1999). Ten books on architecture. Cambridge, Cambridge University Press, translation by Ingrid D. Rowland.

Wotton, H (1624) The Elements of Architecture. A free translation of de Architectura by Marcus Vitruvius Pollio.

A COMPARISON OF EUROPEAN INFRASTRUCTURE MARKETS

Stephen Gruneberg

University of Westminster, London, UK

s.gruneberg@westminster.ac.uk

Abstract

Built infrastructure includes roads, railways and water supply and treatment. This construction work is mainly carried out on behalf of public sector clients or by private sector clients dependent on public subsidy or control.

In order to compare infrastructure markets in different countries and because a uniform definition of infrastructure is not available, a new econometric model is proposed to estimate the size of national infrastructure markets. The model adopts a benchmark approach using information on built infrastructure in UK construction industry statistics. The purpose is to estimate the size of infrastructure markets and the distribution of different types of infrastructure using the UK as a benchmark. The applicability of the results for each country depends on the actual differences found in national data compared to the benchmark figures.

The model is applied to show differences in size and growth rates of infrastructure markets in 30 countries and a breakdown of expected submarkets by type of infrastructure.

KEYWORDS: Built infrastructure, econometric modelling, infrastructure markets, European construction industries, gross fixed capital formation

Introduction

Infrastructure is often overlooked as it forms only a relatively small proportion of total construction output. In 2006 the provisional figures for contractors output show infrastructure was only 10.15 per cent of construction output, according to official construction data (DBERR, 2007). Yet infrastructure projects are amongst the largest investments and have an economic significance far beyond their construction costs. For example, investment in infrastructure may be viewed as the foundation upon which economic growth and development take place. As such it can be viewed as a lead indicator. It is therefore important to measure infrastructure investment to anticipate wider economic changes likely to occur in different economies.

As with any international study, international comparisons of infrastructure investment also present a number of difficulties. The composition of infrastructure varies from country to country and the costs of providing different types of infrastructure vary greatly within countries. International comparisons based on purchasing power parities or exchange rates are prone to inaccuracies as directly comparable indices of infrastructure costs and volumes are not available. There are therefore both qualitative and quantitative problems associated with international comparisons, which invariably form difficulties in international studies. This paper does not seek to overcome these issues but presents the findings of a benchmark approach to international comparisons of infrastructure which may begin an alternative approach to the assessment of infrastructure in different countries.

The European Commission publish information through Eurostat, (European Commission, 2008), and this data is an example of readily available internationally consistent and comparable national income accounts data. Nevertheless, the size and growth rates of infrastructure in the different countries of Europe vary greatly. These variations may be due to the size of each economy, the levels of national income per head and government policies. Differences in the stages of development, levels of maintenance of the physical infrastructure, and national priorities and requirements also contribute to the variability of investment levels to be found across Europe.

Although government and the public sector is seen as responsible for providing most infrastructure or at the very least ensuring the services of infrastructure are delivered, increasingly the private sector has become involved. This trend has developed over the past two decades in Europe as a result of political changes and priorities and because the private sector was seen as capable of managing much of the infrastructure and financing it without the need for government to borrow directly for capital projects. The Private Finance Initiative and the collapse of the Soviet Union both contributed to these changes. Nevertheless, because of the economic and strategic importance of infrastructure government remains engaged with it and in the UK several industry regulators have been set up to oversee the provision of infrastructure services and ensure they serve the public good.

The conventional approach, adopted by bodies such as the OECD, (2006), for estimating the size of annual global infrastructure investment is based on gross domestic product (GDP), the value of existing infrastructure and population growth. This top down approach uses macroeconomic aggregates to estimate an extremely small but important component of the economy. As an alternative, gross fixed capital formation (GFCF) represents only that part of the economy dedicated to providing new fixed capital, such as plant and machinery, buildings and infrastructure. As these activities are related to each other, the model proposed here is based on GFCF rather than GDP.

A new econometric model of infrastructure based on GFCF is therefore proposed to facilitate international comparisons. As definitions of infrastructure vary from country to country, a benchmark model based on the UK construction industry provides a common yardstick for estimating infrastructure in different countries.

The next section deals with the methods used and a description of the benchmark model. The model is applied to different European countries in the subsequent section and the final section draws conclusions from the findings.

Method

Construction and infrastructure data and definitions vary between European countries. Nevertheless, this study of 30 national infrastructure markets includes 26 countries, which are members of the European Union (EU), and Iceland, Norway, Switzerland and Turkey, which remain outside. The definition of infrastructure used here is based on the list of infrastructure types given in Construction Statistics Annual (DBERR, 2007). The list comprises water, sewerage, electricity, gas, communications, air transport, railways, harbours (including waterways) and roads. This list includes ports and harbours, which do not feature as prominently in many European countries. Nevertheless, UK construction data is used to estimate the relative components of infrastructure and these estimates are then applied to GFCF data for each European country.

GFCF rather than gross domestic product (GDP) is used as GFCF is comprised of construction and other fixed capital investment. Indeed construction comprises 46 per cent GFCF, (Author, in preparation, 2008a) although GFCF only takes construction new build (NB) and new plant and equipment into account. The model used here uses both new build infrastructure and repair and maintenance of infrastructure to define the size of the total infrastructure market. As repair and maintenance (R&M) was on average almost half of annual construction output between 1995 and 2006, total construction output is equivalent to approximately 87 per cent of GFCF.

The benchmark model can be used to analyse total infrastructure markets and submarkets. In the UK using the average percentage of total infrastructure represented by each type of infrastructure in the UK, the different types of infrastructure can be estimated for each country in Europe. Author, (in preparation, 2008b,) found the average share of different types of infrastructure between 1995 and 2006. The result is given in Table 1.

Table 1 Average percentage share of UK infrastructure 1995 to 2006 by type of structure

Type of structure	**Percentage**
Water	15.20
Sewerage	10.78
Electricity	6.41
Gas	3.30
Communications	8.25
Air	5.05
Railways	15.75
Harbours	5.07
Roads	30.17

Total infrastructure	100.00

Source: DBERR, (2006) Construction Statistics Annual, Table 2.8c

Using the percentages in Table 1, estimates of infrastructure submarkets can be found for all countries included in the Eurostat (ibid.) data. However, this use of the UK infrastructure benchmark model is limited. The same UK percentages are applied to each country and cannot therefore be used for cross border comparisons. Nevertheless, using the benchmark data as an international yardstick is a tool for comparing actual performance in each country, where the data is available. Moreover, the model can be interpreted to mean that in any country, given the value of its GFCF, its total infrastructure output can be compared to the benchmark model in terms of size in proportion to the UK ratio of infrastructure construction to GFCF.

Each country's annual infrastructure growth rate in the model also moves in line with the growth rate of its GFCF. Any deviations found in actual construction output would reveal out-performance or underperformance compared to the benchmark model. The benchmark model therefore provides a simple method for estimating and comparing countries' infrastructure markets. It represents a first iteration in the development of an econometric model of infrastructure.

This benchmark data is used in conjunction with annual data published by the European Commission (ibid.) on gross fixed capital formation in each country to estimate the performance, size and growth rates of each country's infrastructure market. The model can be used to identify and classify infrastructure markets in four types of market: small and rapidly growing markets, large and rapidly growing markets, small and slowly growing markets, and large and slowly growing markets.

In the national income accounts, GFCF is analysed by 6 asset types. The construction element in GFCF includes housing and "other constructions". "Other constructions" includes commercial development and public facilities, such as hospitals and universities. Infrastructure is therefore only one of several components included in "other constructions". An adjustment is therefore needed. From the Construction Statistics Annual (DBERR, ibid.) 'other non-housing excluding infrastructure new build output' is therefore deducted from "other constructions". The residual is used as an estimate of new build infrastructure in the model and links the two sources of data, namely the Office of National Statistics National Income Accounts data and the Department of Business, Enterprise and Regulatory Reform Construction Statistics Annual data.

The model of infrastructure based on GFCF uses the ratio of UK new build infrastructure construction to GFCF. This ratio forms the coefficient a in Equation 1. To estimate total infrastructure construction activity, Author (in preparation, b,) combines new build infrastructure and infrastructure repair and maintenance. The average ratio of repair and maintenance to new build for all construction output is used as the coefficient *b* in Equation 1:

$$I = a(GFCF + bGFCF) \qquad \text{(Equation 1)}$$

where I = total new build and repair and maintenance infrastructure

$a = \Sigma\{I_{NB}/GFCF\}/n$, that is the average annual ratio of $I_{NB}/GFCF$

and $b = \Sigma\{R\&M/NB\}/n$, that is the average annual ratio of R&M/NB.

The model produces the size of infrastructure for any given year based on the GFCF of that year. The long run rate of growth of infrastructure investment from 1995 to 2006 in each European country is given as the geometric mean of the annual percentage changes in infrastructure.

The European infrastructure market

Table 2 summarises the findings of the model. Countries are listed in order of size in 2006 at 2005 prices and the average annual growth rate of total infrastructure investment is given for the period from 1995 to 2006. The slowest growing infrastructure markets tend to be those in the relatively mature and wealthy economies of Europe. With the exception of Iceland the fastest growing markets tend to be those in Eastern Europe. With the exception of Poland, Eastern European economies tend to be relatively small. For most countries, even moderately sized infrastructure projects tend to have a major impact on the total size of their infrastructure markets.

Table 2 Infrastructure markets in 2006 at 2005 prices (€m) and average annual growth 1995 – 2006

Country	Size in 2006	Average growth rate
EU (27 countries)	95,100	3.37
Germany	16,907	0.77
France	14,408	3.41
United Kingdom	13,668	4.90
Italy	12,209	2.34
Spain	11,612	6.23
Netherlands	4,217	3.14
Turkey	2,641	5.20
Belgium	2,607	3.24
Switzerland	2,596	1.41
Sweden	2,182	4.07
Poland	2,115	6.66
Austria	2,113	1.66

Greece	1,971	7.90
Norway	1,963	5.55
Denmark	1,959	5.10
Ireland	1,782	9.48
Portugal	1,295	2.23
Finland	1,264	5.50
Czech Republic	1,078	2.54
Romania[1]	870	10.27
Hungary	808	6.41
Slovakia	448	4.97
Slovenia	319	7.24
Bulgaria	256	10.32
Luxembourg	252	5.05
Lithuania	226	11.75
Latvia	192	18.17
Iceland	180	12.65
Estonia	171	11.89
Cyprus	111	3.82

[1] Data based on 1999 - 2006 only

Source: Eurostat, (2008) Table NAMA P16 K, European Commission

These broad patterns of growth in the last decade are likely to continue for the foreseeable future due partly to EU policies and directives aimed at developing the new accession states of Eastern Europe.

From Table 2 the average annual growth rates of infrastructure markets between 1995 and 2006 ranged from 0.77 per cent in Germany to 18.17 in Latvia. The 27 countries of the EU as a whole grew at the rate of 3.37 per cent per annum. This wide variation in growth rates demonstrates a wide difference of infrastructure conditions in the different countries of Europe. Moreover, countries with similar growth rates also experienced very different patterns of growth.

The data in Table 2 is illustrated in Figure 1, which appears to support the argument that smaller infrastructure markets are associated with more rapid annual rates of growth.

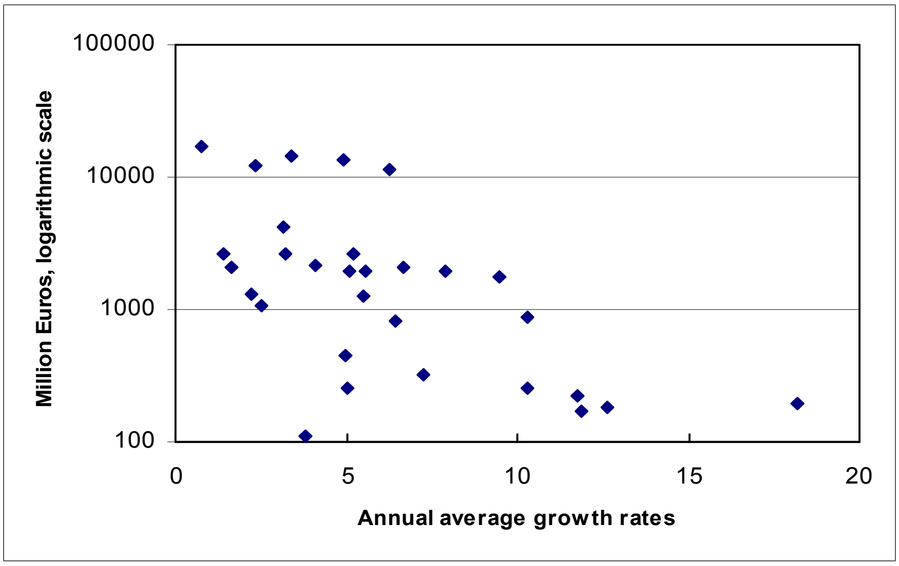


Figure 1 Size and growth rates of European infrastructure markets in €m at 2005 prices

From the same data the quadrants in Figure 2 show the four types of market referred to above. More specifically, large markets are defined as in excess of €2,000m, small markets as less than €2,000m, slow growth as less than 4.99 per cent per annum and rapid growth as greater than 5 per cent per annum. It is immediately apparent that the majority of countries form themselves into two polarities: those that may be classed as large but slow growth markets and those that are small but rapid growth markets.

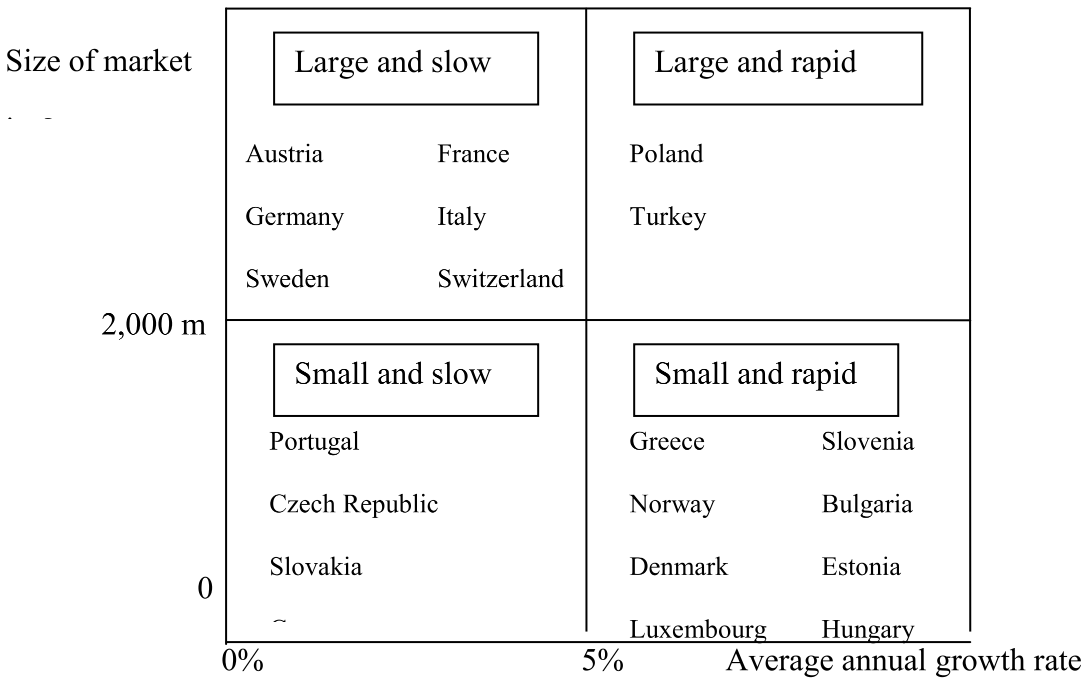


Figure 2 Quadrant analysis of European infrastructure markets

Only three countries appear to have performed well as large and fast growth infrastructure markets, namely Poland, Turkey and Spain. Those countries in the top left quadrant, representing large but slow growth markets, tend to be either large mature European economies, with relatively high incomes per capita, where infrastructure has been largely developed. By contrast, the lower right quadrant is largely populated by those states that have either recently joined the European Union, the new accession countries, or are relatively small economies with a high income per head.

An analysis of size and average growth rates is not necessarily indicative of the performance of infrastructure markets as the performance of two countries with similar growth rates can be very different, regardless of size. For example, the performance of the slowest growing infrastructure markets is illustrated using indices in Figure 3, which compares infrastructure growth patterns since 1995. This may be due to the contrasting nature of the different economies in this group. For example, the German infrastructure market grew by just under 10 per cent between 1995 and 2006, while the Czech Republic grew by over 30 per cent in the same period. Portugal expanded by 50 per cent by 2001 but by 2006 the Portuguese market had contracted to be just 30 per cent larger than in 1995.

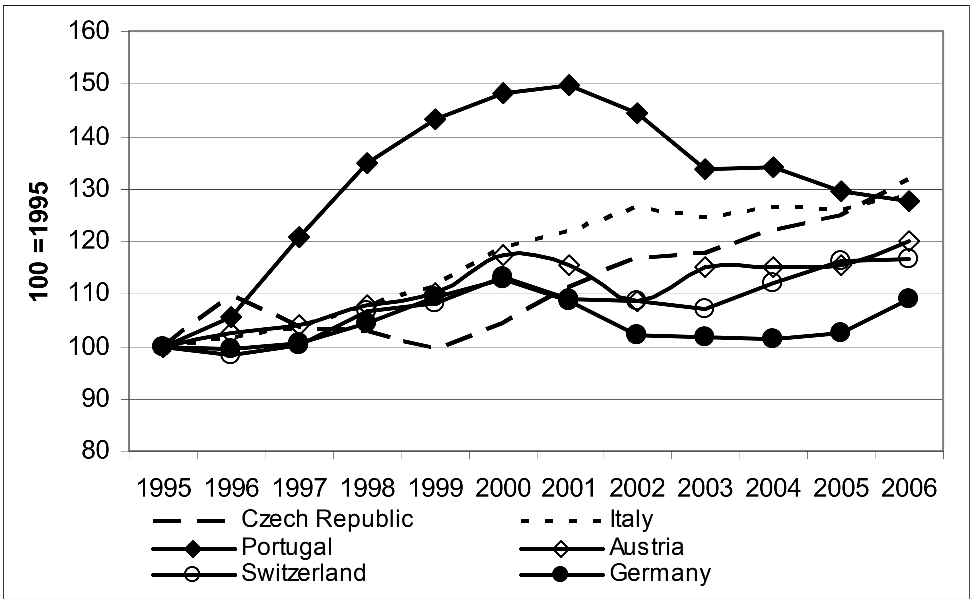


Figure 3 Infrastructure volume indices of lowest growth countries

The experience of the most rapidly expanding infrastructure markets is more uniform in appears. Figure 4 shows a more consistent pattern since 2002, reflecting the need for infrastructure investment to repair and prepare for the economic growth in Eastern Europe and therefore part of European Union policy, while the rapid growth of the Icelandic infrastructure market is a reflection of local circumstances.

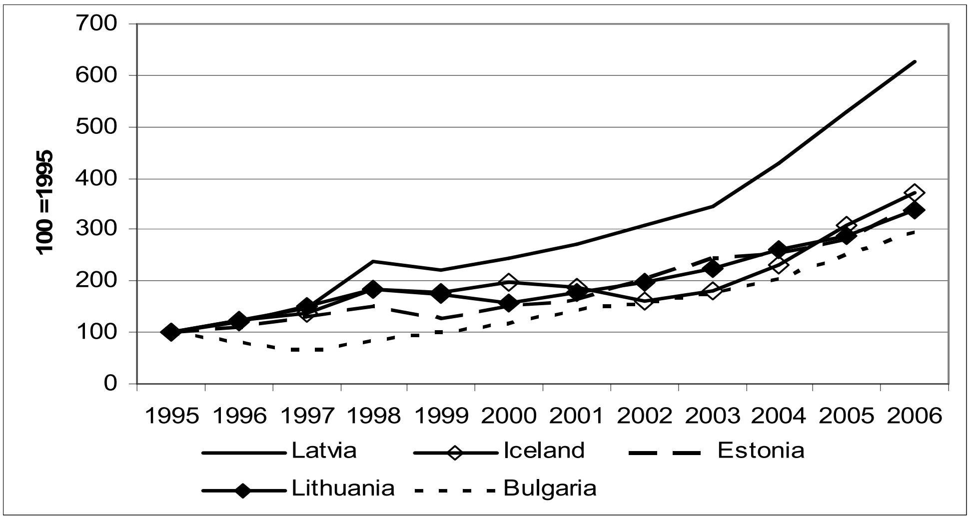


Figure 4 Infrastructure volume indices of highest growth countries 1995 - 2006

Finally, using the benchmark model, Table 3 presents an analysis of the submarkets in the major infrastructure markets in the largest European economies, as defined in Figure 2. The data in Table 3 may be used to assess the relative importance of different submarkets in different countries but at best the data is indicative rather than definitive. As such it forms a starting point for further international research of individual markets.

Table 3 Infrastructure by type of structure in 2006 at 2005 prices (€m)

	Water	Sewerage	Electricity	Gas	Communi- cations	Air	Railways	Harbours	Roads
Germany	2,570	1,823	1,085	558	1,395	854	2,663	857	5,101
France	2,190	1,554	924	475	1,189	728	2,269	731	4,347
United Kingdom	2,078	1,474	877	451	1,128	690	2,153	693	4,124
Italy	1,856	1,317	783	403	1,007	617	1,923	619	3,684
Spain	1,765	1,252	745	383	958	587	1,829	589	3,504
Netherlands	641	455	270	139	348	213	664	214	1,272
Turkey	402	285	169	87	218	133	416	134	797
Belgium	396	281	167	86	215	132	411	132	787
Switzerland	395	280	167	86	214	131	409	132	783
Sweden	332	235	140	72	180	110	344	111	658
Poland	322	228	136	70	175	107	333	107	638

Austria	321	228	136	70	174	107	333	107	638

Concluding remarks

This paper has demonstrated that the UK benchmark model proposed here can be used to estimate European infrastructure markets and submarkets. Where no actual data is available, the need to model a market from available information is a second best option. Like weather forecasting there is bound to be a large margin of error. The figures in the tables presented here are only indicative and further research is needed to test and improve the benchmark approach.

The simplicity of the benchmark model only provides an approximation. While this has the benefit of simplicity, more variables can be added to the model to mirror the factors that influence infrastructure demand, such as changes in the population. Modelling infrastructure markets will always be problematic. Unlike other parts of the construction industry such as commercial development or housing, the infrastructure market is particularly vulnerable to sudden changes in demand due to changes in government policy and direct government intervention. At the same time, the size of the largest infrastructure projects can lead to distortions of trends as large discrete projects are begun and completed.

From the findings of the UK benchmark model, rapid long run average growth per annum is associated with smaller markets. This is not necessarily a guarantee of continued long run rapid expansion. Indeed the average long run rate of growth of all EU countries is only 3.37 per cent per annum. Of the fastest growing markets, and with the exception of Luxembourg in Western Europe, the countries of Eastern Europe tend to be smaller than the old member states of the EU such as France, Germany and the UK. The main reason for rapid infrastructure growth in the countries of Eastern Europe is due to their economic expansion as a result of economic policies emanating from Brussels.

Much work still needs to be undertaken to develop the benchmark approach. For example, having presented the findings of this model further research is required to test the estimates against actual annual output. Further research will reveal long run trends and forecasts. Ultimately, the value of the model will be in accurately forecasting infrastructure demand for different types of infrastructure in different countries. This would have benefit for policy makers in planning resource requirements and skills training and for international contractors seeking new markets.

References

Congressional Budget Office, (2007) *Trends in Public Spending on Transportation and Water Infrastructure, 1956 to 2004,* Washington DC, The Congress of the United States

DBERR (2007) *Construction Statistics Annual*, Norwich, The Stationery Office

European Commission, (2008) *Eurostat, Table NAMA P16 K*, Brussels, European Commission http://epp.eurostat.ec.europa.eu

Author, (in preparation, 2008a,) Estimating the UK infrastructure market from Gross Fixed Capital Formation, RICS, *Proceedings of COBRA*, Dublin

Author., (in preparation, 2008b,) A benchmark model of the UK built infrastructure market using gross fixed capital formation, *Proceedings of ARCOM*, Cardiff

OECD, (2006) *Infrastructure to 2030*, Paris, OECD

The ability of fresh Higher Education students to reflect

By Ezekiel Chinyio and Angela Nash

Abstract
Learning is a life-long endeavour and Higher Education Institutions exist to foster learning. One aspect of learning is the ability to reflect where a learner can establish what was done in the right or wrong way, document it and use it as a feed-forward input in future conduct. This paper explores the reflective ability of 24 fresh students who had completed the first 5 months of their university experience. These students were taught different skills in one of their subjects (modules) over a period of 3 months. One of the skills they learnt is the art of reflection concerning both in-class and out of class learning activities. In their first semester in the University, the students were assisted with the art of reflection with the expectation that they will carry on reflecting on their own and in life after this head start. At the end of their first semester, they were tested with an exercise that involved them making a reflection. This paper uses content analysis to discuss the reflections of the students concerning a learning activity of their choice. From the submissions analysed, 50% of the students were able to identify and reflect on an activity and amongst these, they could map out strategies for future conduct.

Keywords: Learning, reflection, students, Higher Education Institution, Assessment, Knowledge.

INTRODUCTION TO REFLECTION AND LEARNING

Attempts to describe 'reflection' have a history that stretches back to ancient Greece (Maranhao, 1991). The term is used in a number of different ways and may mean different things to different people (Pee et al., 2002).

Boyd and Fales (1983) defined reflection as "the process of internally examining and exploring an issue of concern, triggered by an experience, which creates and clarifies meaning in terms of self, and which results in a changed conceptual perspective".

In consolidating many definitions, Mellor (1998) concurs with Knowles (1993) in reiterating that: ' ... reflection is an intra-personal process ... through which personal and professional knowing can occur ... Reflection is seen as a process and method of informing practice with reason ... 'It is a type of thinking that is associated with deep thought and aimed at a better understanding (Cottrell, 2008). It is a means to learning and indeed, deep reflection is recognized as a higher-order learning activity (Honey and Mumford, 1986; Biggs, 2003). However, there is a suggestion that there is an incomplete understanding of the psychology involved in reflections (Day, 1993; Bolt and Powell, 1993).

Schön (1987) distinguishes between three types of reflection. Two of these, reflection in action and reflection on action are reactive while the third type, reflection for action, is pro-active. Reflections can be conscious or unconscious (Bolt and Powell, 1993; Mamede and Schmidt, 2004) and structured or unstructured (Cottrell, 2008). Structured reflection can be question-based, open, synthetic, developmental or evaluative (Cottrell, 2008). Evaluative reflection is retrospective in nature and useful for planning and is the subject matter of this paper. It involves asking and answering questions such as (Cottrell, 2008): What happened generally? What did you do? How might you prepare differently for a similar occasion?

Different avenues can be used to facilitate a reflection and these include the use of diaries, journals and reflective logbooks, portfolios, interviews and story telling (Francis, 1995; Colton & Sparks-Langer, 1993; Pultorak, 1993).

The benefits of reflection include (Cottrell, 2008; Mamede and Schmidt, 2004):

- gaining a more in-depth and honest picture of ourselves;
- becoming more aware of our hidden motivations, our thinking styles, and of how we appear to other people;
- developing a better understanding of what affects our own performance and progress;
- developing our insight, judgement and ability to teach others;
- gaining more control over our own thoughts, emotions, responses and behaviour so that we are in a better position to achieve what we want to achieve.

Higher Education Institutions and reflection

Educational programmes that are run by the Institute for Learning & Teaching (ILT) in Higher Education seek to develop 'reflective practitioners' (Pee, *et al*., 2002). In the UK, the use of a reflective 'progress file' is recommended throughout higher

Education (Quality Assurance Agency for Higher Education [QAA], 2000). Some institutions implement this in the form of Personal Development Planning (PDP) which is a "means by which students can monitor, build and reflect upon their personal development" (Dearing, 1998). The PDP is: "a structured and supported process undertaken by an individual to reflect upon their own learning, performance and/or achievement and to plan for their personal, educational and career development" (QAA, 2001).

Within PDP, students are expected to reflect and use lessons learnt to plan for the future. The idea is that the art of reflection and forward planning will become a life-long endeavour (Biggs and Tang, 2007). Each Higher Education Institution (HEI) operates its PDP in a best-fit way.

In the context of PDP, this paper is based on a research that studied how students could reflect after being in a HEI for one semester. The next section describes the research method. After that the results of the study are given; followed by a discussion. The paper is then wrapped-up with a conclusion.

RESEARCH SCOPE AND METHOD

Research is worthwhile to appraise the utility and effectiveness of students' reflections (Pee *et al*., 2002). In this regard, our action research studied how HEI students could reflect. This evaluation was subsumed within an assignment which was submitted as a portfolio that included several elements:

- A self-analysis
- A pictorial representation of oneself
- A reflection on one's strengths and weaknesses
- Reflection on key events
- Action planning

The portfolio tasks were issued to the students in Week 1 with the instruction to return completed portfolios within 3 months (13 weeks). This time span was guided by the length of the semester in which they had to take the module concerned. The module and compilation of the portfolio lasted from September 2007 to January 2008. Most tasks in the portfolio involved a self-reflection on the part of each student.

The students were introduced to PDP and reflections in the first week and encouraged to apply the concepts. The students were encouraged to update their reflection diaries and learning logs on a fortnightly basis. To assist the students, templates were provided for them which they could fill.

Although the students responded to all aspects of the portfolio, only their self-'reflection on key events' is covered in this article. Other aspects of the portfolio are outside the scope of this article. Table 1 provides the basis of the analysis discussed in this paper, i.e. a model of reflection discussed by Biggs (1988).

Sampling and analysis

The exercise involved students who were starting a construction related course at the University of Wolverhampton. 134 students completed the exercise and their submissions inform this article.

Table 1: Basis of reflection (Adapted from Gibbs, 1988)

Heading	Question to answer	Pointers when writing
Description:	What happened? What, when, where did it happen?	DESCRIBE the event briefly, to give the reader some background detail. Be factual. Do not break confidences.
Feelings:	What was I thinking and feeling?	DESCRIBE your views during / after the event
Analysis:	What sense can I make of this situation?	DESCRIBE some reasons for your opinion. Offer rationale.
Conclusion:	What else could I have done? What have I learnt from this?	SUMMARISE any other options that might have been taken.
Action Plan:	If this arose again what would I do?	STATE the main focus of your learning. What "golden rule(s)" have you learned?

After submission, each portfolio was marked and graded on a scale of A to F where 'A' represents excellence and 'F' a dismal output. Due to time constraint only 24 submissions are discussed in this paper. From each category of A to F, 4 submissions were selected by convenience to inform the analysis. The analytical approach adopted was 'qualitative content analysis' which involves a scrutiny towards establishing meanings and intentions (Fellows and Liu, 2003).

FINDINGS

All the 24 students submitted a portfolio but not all of them responded to each task. An investigation of the portfolio task shows that 12 students (50%) in the selected sample did respond to that task while the other 50% did not. The breakdown of the responses within the sample is shown on Figure 1.

42% of the portfolios wherein the learning log was not completed pertain to students who scored 'D' and/or below. Complimentarily 42% of those who scored 'C' and/or above did complete their learning logs. Amongst the 12 students that described a learning activity; their responses to questions posed is catalogued on Table 2. These 12 students reported on activities independently but some of these were similar, i.e.: 3 students reported on making a formal presentation; 2 students reported on an assessment activity; and 1 each reported on a boxing competition, writing a good CV, site surveying, accessing electronic resources, reviewing a module, going for work experience and using graphics in WORD.

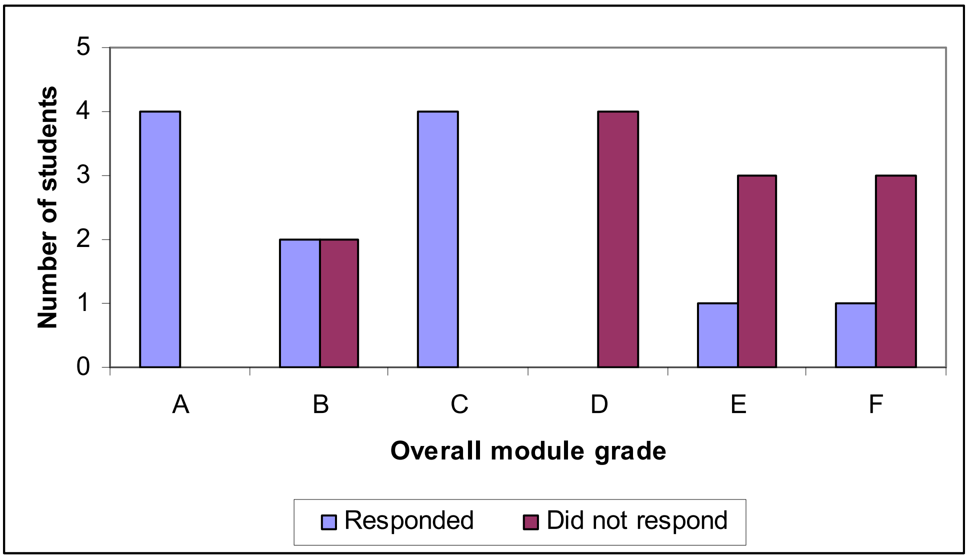


Figure 1: Completion of the learning log by the students sampled

Table 2: Responding to questions in the learning log

Question in the learning log	Number who responded	% (out of 12)
What were the most valuable learning points?	12	100%
What skills/knowledge have I gained from this activity?	11	92%
How and when will I apply this learning?	8	67%
Any further follow up action required?	6	50%

Learning points
As a guide, the students were asked to reflect on 'their most valuable learning points' A diverse range of issues was highlighted e.g. how to prepare and make a presentation, causes of fatalities on construction sites, self awareness and assessment, being dedicated, etc.

The backgrounds and experiences of the students are different. Each of them must have chosen an activity that impacted on him/her significantly.

Skills/knowledge gained
Most of the students responded here (Table 2) but their answers appear to fall into 2 main categories:

– *Professional and or technical competencies* e.g. writing a good CV, making a presentation, estimating, surveying, researching and use of IT.
– *Behavioural and social aspects* e.g. communicating in a better way, ability to express one's feelings and opinions to others, being self-confident and camping.

Applying their learning
8 people responded to this aspect and out of these:

– 3 indicated that the lessons learnt would be valuable to them throughout their lifetime.

- 2 said they would use these lessons in career practice.
- 2 indicated the lessons will be useful ‘when need be’ e.g. at interviews.
- 1 respondent said he will apply the knowledge learnt while at University.

On follow-up action
- 3 respondents said they will continue to learn and improve e.g. on one’s CV
- 1 committed himself to further reading while one each said they would implement the skills learnt at University and at work.

DISCUSSION AND CONCLUSION

The 24 submissions utilised in the present analysis are obviously not a precise representation of the population. More than 50% of the population did discuss a learning activity. The insight from the foregoing is that some students were able to reflect on their relatively short time in the University and identify certain lessons they had learnt.

When asked to identify skills and knowledge gained in their specified learning activity, more responses (79%) were made by those who scored ‘A to C’ in comparison to those who scored ‘D to F’ (21%). Likewise, those who scored ‘A to C’ returned 80% of the comments on how they would apply their learning. The trend is suggesting that those who engaged with the portfolio tasks fully and their associated reflections, did obtain higher grades. From a tutor’s perspective, an opportunity to learn about the students more has opened up, i.e. why some of them did not do certain tasks. It could be that: some of these tasks were difficulty for them; they had no time; they needed more motivation like one-on-one assistance; they learn more in other ways than through reflection; etc.

Reflections can be done unconsciously and manifest in our actions implicitly. So someone may reflect without being able to articulate this. The submissions of the students represent what they could express. It may be that another approach, say interviews or storey telling, may yield a different set of outcomes.

It is premature to draw a definitive conclusion at this stage. Rather, the entire data set will be analysed to gain a better understanding. However, the submission of portfolios by students marks a milestone achievement within the context of PDP, which is to set students on the path of lifelong reflection and planning. An objective of PDP is that students will take control and drive their reflections and planning. This will be very relevant to them in future practice; where currently construction practitioners rarely seize the opportunity offered by reflection and analysis (Taylor, 2004). We hope our students will always turn back in reflection rather than turn back in surrender. Some of them have identified lessons that will be valuable to them in life. Our hope is that this discovery will be made by all and not just a few.

Finally, most of the students in our sample are enrolled on a 3-year course. Their ability to reflect must be nurtured as they progress. It is pertinent for them to be expert reflectors by the time they leave university. Thus, their reflection abilities will be re-assessed in the second and third year of their study, which is part of our continuing research agenda.

References

Biggs, J. B. and Tang, C. (2003). *Teaching for quality learning at university* (3rd edn). Maidenhead: Society for Research into Higher Education & Open University Press.

Bolt, E. and Powell, J. (1993) *Becoming reflective*. London: South Bank university.

Boyd, E.M. and Fales, A.W. (1983) Reflecting learning: Key to learning from experience. *Journal of Humanistic Psychology*, **23**(2), 99 – 117.

Colton, A.B. and Sparks-Langer, G.M. (1993) A Conceptual Framework to Guide the Development of Teacher Reflection and Decision Making. *Journal of Teacher Education*, **44**, 45 - 54.

Cottrell, S. (2008) *The study skills handbook* (3rd ed). Basingstoke: Palgrave Macmillan

Day, C. (1993) 'Reflection: a necessary but not sufficient condition for professional development', *British Education Research Journal,* **19**(1), 83-93.

Dearing, R. (1998) *Higher Education in the Learning Society.* London, UK: HMSO.

Fellows, R. and Liu, A. (2003) *Research Methods for Construction* (2nd ed). Oxford: Blackwell Science.

Francis, D. (1995) The reflective journal: a window to preservice teachers' practical knowledge. *Teaching and Teacher Education,* **11**, 229 – 41.

Gibbs, G. (1988) *Learning by Doing. A guide to teaching and learning methods.* Oxford: Oxford Polytechnic Unit.

Honey, P. and Mumford, A. (1986) *The manual of learning styles*. Maidenhead:

Knowles, J. G. (1993) 'Life-history accounts as mirrors: a practical avenue for the conceptualisation of reflection in teacher education'. **In** Calderhead, J. and Gates, P. (eds) *Conceptualising Reflection in Teacher Development.* London: The Falmer Press.

Maranhao, T. (1991) 'Reflection, dialogue and the subject'. **In** Steier, F. (ed) *Research and Reflexivity.* London: Sage Publications.

Mamede, S. and Schmidt, H.G. (2004) The structure of reflective practice in medicine. *Medical Education*, **38**(12), 1302 – 1308.

Mellor, N. (1998) On Reflection: One psychologist's explorations around an episode of reflecting. *Educational Psychology in Practice*, **14**(3), 167 - 175.

Pee, B.; Woodman, T.; Fry, H. and Davenport, E.S. (2002) Appraising and assessing reflection in students' writing on a structured worksheet. *Medical Education*, **36**(6), 575 – 585.

Pultorak, E.G. (1993) Facilitating reflective thought in novice teachers. *Journal of Teacher Education*, **44**, 288 - 295.

QAA (2000) *Developing a progress file for Higher Education*. Summary report of the consultation exercise. Gloucester: QAA.

QAA (2001) *Guidelines for HE progress files.* Gloucester, UK: Quality Assurance Agency for Higher Education.

Schön, D.A. (1987) *Educating the Reflective Practitioner*. San Francisco: Jossey-Bass.

MANAGING THE CAMPURBIS PROJECT

José Teixeira
Civil Engineering School, University of Minho, Portugal
jct@civil.uminho.pt

Catarina Tuna
Civil Engineering School, University of Minho, Portugal
catarina@civil.uminho.pt

Campurbis is an urban project taking place in the city of Guimarães in the north of Portugal. The aim of the project is to develop a platform for economic development based on the sustainable interaction between innovation, technology and arts. The project physical location is an ancient industrial district right in the heart of the city that faced a strong decline after the last quarter of the twentieth century, leaving behind a set of empty buildings and valuable heritage of the tanning and textile industries. The Campurbis project has been launched by the partnership of the City Council and the University of Minho and aims at merging the value of both institutions for fully achieving the project goals. However, managing urban rehabilitation projects is a complex endeavour because of the multiple viewpoints to attend and the restrictions imposed by the nature of the site. Design options often are a complex balance between historical and functional requirements and project outcomes are continually evaluated by a diversity of stakeholders. This paper briefly describes the project and analyses the difficulties faced the project management team in performing its duties. Unlike other projects where the design brief clarifies the scope and the restrictions, this project is an interesting case study where the flexibility of design must encompass the demands of a variety of stakeholders, functions and site circumstances.

KEYWORDS: project management; urban rehabilitation projects.

HISTORY

Through most of the twentieth century, the Historic Centre of Guimarães (HCG) entered into a process of economic, social and building decay both causing and being a consequence of its continual lost of attractiveness. This led to the degradation of life conditions of the residents and to the departure of many of those, therefore making things worst. The problem was as dull as the HCG contains a great umber of important cultural assets of great historical relevance as it was the first capital of the Portuguese kingdom in the 13th century and played an important role thereafter, in the cultural context of the North of the country.

Aware of this realty, the Municipality (Câmara Municipal de Guimarães – CMG) decided to establish in 1985 a technical commission specially devoted to the refurbishment of the area (Gabinete Técnico Local – GTL). From then on, the GTL has been conducting the rehabilitation of old buildings and the improvement of the public space, by using traditional construction materials and preserving traditional construction techniques, therefore enhancing local businesses and maintaining residents. Consequently, the negative trend has been largely countered, significantly augmenting the attractiveness of the HCG (Figure 1). This has been extensively evidenced by the increase of real estate value, the development of new economic activities, the installation of new functions, the betterment of life conditions of residents, etc. Parallel to the widespread recognition of the valuable work of GTL, the HCG was classified as Cultural Human Heritage by UNESCO in 2001 and has deserved several other remarks of international merit thereafter.

Figure 1: Guimarães, Cultural Human Heritage (UNESCO, 2001).

Up to the last quarter of the twentieth century, the city of Guimarães and the surrounding area was a nub for industrial development, mostly focusing on the textile cluster after the 1950's. This fostered the attractiveness of the region, fixing residents and fostering urban expansion therefore generating or expanding urban communities of variable sizes, catalysed by nearby industrial units. But then the economic activity began to decrease because of the crises in the textile sector which led to unemployment and to the degradation of life conditions of people.

The Couros District is a small area of about 10 hectares, close to the HCG, crossed by a small river with the same name. The origin of the tanning activity in the area is lost in the memory of time (Couro means leather in the Portuguese language). Actually, the place was used for the treatment of leathers and other animal furs since very ancient times. However, for sanitary reasons, the Couros District evolved to the textile activity in the mid twentieth century and later followed the downshift of the textile cluster in the area. The remains of this route are evident in the landscape, notably the tanning stone tanks and the old industrial buildings laying the river downstream. In 1971 the area was classified as an industrial nucleus of public interest by the Portuguese Government (Direcção Geral do Património Cultural - DGPC) (Figure 2).

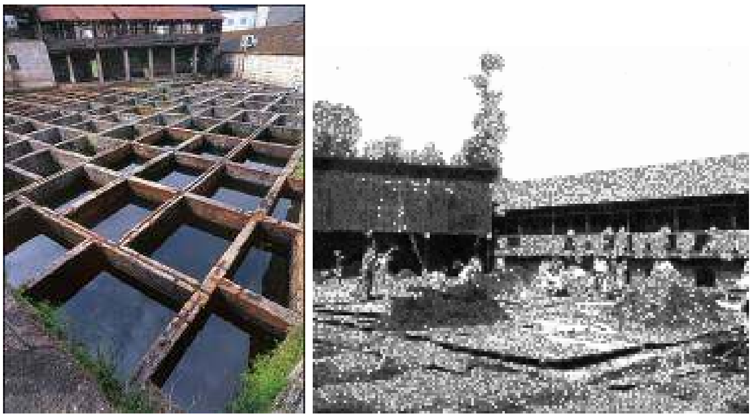


Figure 2: The remains of the tanning tanks and the traditional tanning process in the Couros District.

In 1975 a School of Engineering of the University of Minho was established in Guimarães (Escola de Engenharia da Universidade do Minho EE-UM) and has been growing since. The impact of the EE-UM in the city and the region has mostly been viewed as the most significant higher education institution (presently with over 6000 students), a vehicle for the diffusion of knowledge (with relevant impact in the local industry), a catalyst for residents (students, researchers and teachers), an important employer, client and actor in the real state market and so on.

But the relation between the EE-UM and the city can be enlarged with beneficial effects both to the University and to the Municipality. Actually, there is an international trend for converting old industrial cities into modern service economies supported by high technology research and development (R&D) and by creative activities. In all these areas, the role of the Universities may be crucial by:

- Conducting and supporting R&D;
- Securing innovative businesses;
- Attracting creative people for living, researching and working in the region;
- Delivering cultural performances of various types;
- Bringing in a great number of students and visitors;
- Inserting purchase power in local businesses

The Couros District emerged as an opportunity for increasing collaboration between the Municipality and the University. For the CMG, intervening in the Couros District is an opportunity for benefiting from the experience gained in the CHG while developing a new urban refurbishment approach whereby:

- Attracting to the area new interrelated functions and activities, capable of inducing innovation, technological development and cultural offer;
- Generating opportunities for levering competitiveness and differentiation of the area while increasing its value in enlarged contexts;

- Fostering the growth of cultural consumption (art, performance, leisure, worship) and is relationship with connecting activities.

In the other hand, the development strategy of the UM is grounded in its growing and upholding experience and presents the following main vectors

- To develop new approaches for lecturing and learning
- To collaborate with the industry for promoting innovation and the process of learning by interacting, learning by doing and so on;
- To foster new models of linking training, culture and economic activity

THE CAMPURBIS PROJECT

Blending the strategies of CMG and UM led to the foundations of the CAMPURBIS project specially designed for the Couros District. The project essentially aims at embodying a common strategy of both institutions for innovative urban intervention which is expected to increase the national and international relevance of the city of Guimarães and its University. The project main objective is:

To develop a platform for economic development based on the sustainable interaction between innovation, technology and arts anchored in an intensive training effort of human resources.

The project physical location is an ancient industrial district in the heart of the city of Guimarães that faced a strong decline after the last quarter of the twentieth century, leaving behind a set of empty buildings and valuable heritage of the tanning and textile industries. The CAMPURBIS project has first been launched by the partnership of the City Council and the University of Minho but has been attracting more partners. In view of the project main objective and taking into consideration both the project location and the characteristics of the partnership the following four strategic lines have been set up:

1. Urban rehabilitation and revitalization
2. Creativity and entrepreneurship
3. Cultural attraction
4. Economic development

Accordingly, the CAMPURBIS project has been split into four independent yet inter-related sub-projects, each devoted to the accomplishment of each strategic line:

1. The um@couros sub-project is the university dimension of CAMPURBIS and is based on the concept of virtual campus and aims at:

   a) Increasing the attractiveness of Guimarães for university students and researchers;

   b) Developing new paradigms of learning and fostering new models of inter-relating learning, culture and economic activity;

   c) Installing equipments to help the integrated development of innovation and technology

2. The aim of the R&R Couros sub-project is to transform the District into a rehabilitated and revitalized area where the objectives of CAMPURBIS and its sub-projects may be accomplished. The R&R Couros sub-project encompasses the following components:

   a) Qualification of the public space (infrastructures, leisure areas, mobility, green spaces, paths, etc.);

   b) Environmental recovery of River Couros (de-pollution, regeneration, ecological corridors, energy generation, etc.);

   c) Refurbishment of existing buildings (maintenance, re-construction, demolition, new construction)

3. The CULTUR Couros sub-project is devoted to endow the Couros District with a set of equipments that may help increase the cultural and tourist attractiveness. The Couros District sub-project includes the following components:

   a) Increase the value of existing buildings, by transforming them into lively spaces, able to attract new functions and visitors;

   b) Installation of areas for exposition, museum and cultural diffusion;

   c) Integration with existing cultural projects in the area

4. The INTER Couros sub-project aims at transforming the Couros District into an area of institutional interaction which is essential for creating the entrepreneurship culture, the main engine of economic development of the area, this being the main objective of the CAMPIBIS project. The INTER Couros project covers the following initiatives:

   a) The installation of an information and communication centre whereby promoting the recovery and diffusion of economic information;

   b) The promotion of strategic instruments for economic development;

   c) The installation of public services and association centres

MANAGING THE CAMPURBIS PROJECT

The CAMPURBIS project is now at its first development stages. Looking at the component sub-projects, it may be stated that R&R Couros and um@couros are possibly more advanced than the other two. The course of action of CULTUR Couros is partially dependent on the results of the recent application put forward by the City for European of Culture in 2012. INTER Couros is mainly dependent on the attractiveness of the other three and on the mobilization effort of other partners.

The R&R sub-project is expected to run under a two phase approach (design + implementation) whereby the client (CMG) makes or contracts the design and further contracts implementation. This is because the Municipality of Guimarães owns the land and part of the buildings or is in the process of acquiring them for the CAMPURBIS project. Presently, most of the effort in the R&R sub-project is directed to design, namely:

- Infrastructures (water supply, drainage, electricity, communications, wireless broadband, etc.) and public space;
- De-pollution of the river;
- Refurbishment of the buildings with specified programme:
    - Living Science Centre (Centro de Ciência Viva);
    - Centre for Advanced Graduate Training;
    - Design Institute – Design UM

However, other partners beyond CMG have an important role in the design of some of the above projects, particularly UM that is providing technical support to the river de-pollution (mathematical modelling and design consultancy), the wireless infrastructure, the refurbishment of existing buildings (both defining programmes and assisting action in ancient structures) and that is establishing the contents for the Living Science Centre.

The um@couros sub-project is presently dealing with the learning approach and the programme of studies for the actions to base in the Centre for Advanced Graduate Training (CAGT). The Centre will be organized into the following training and research areas depicted in figure 3.

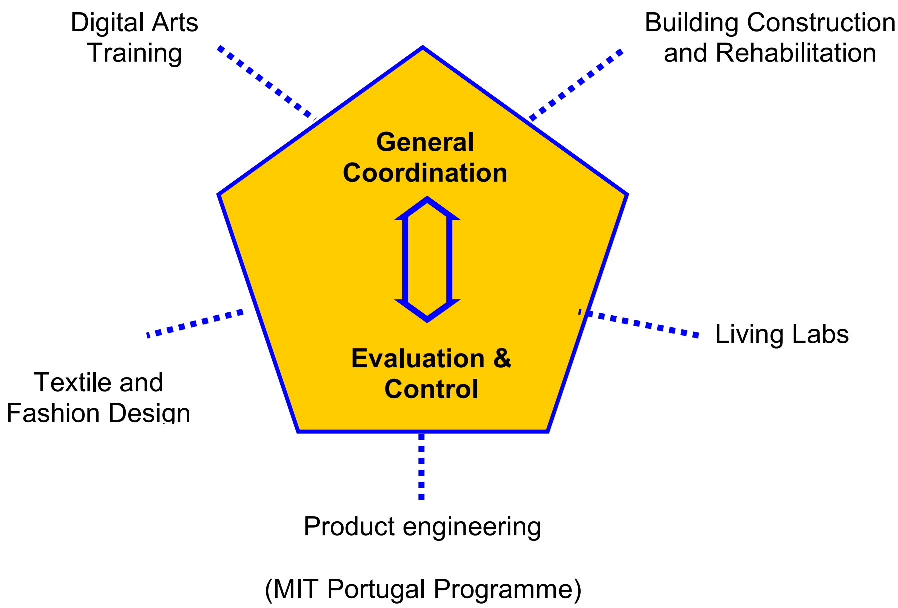


Figure 3: Organization of the Centre for Advanced Graduate Training (CAGT)

The difficulties in management the project so far directly follow from its objective and nature.

Firstly, making a rehabilitation project achieve economic relevance within a Historic City Centre is not an easy task. Several rehabilitaion projects of this nature are currently being carried all over the country but their economic success has not being challenged adequately. In most cases, indirect advantages of the project are predicted (for example, the increase in real estate demand leading to more purchase power of residents, the increase in tourism yielding more business opportunities, etc.) but their economic impact is difficult to establish. The truth is that social factors have frequently taken the lead, given the poor living conditions of people in old city centres and the focus on housing of most of those projects. But the Couros District is largely inhabited for the reasons explained above, and the focus of CAMPURBIS is quite different, therefore raising the issue of its economic achievement. Instead of depending on the preference of current inhabitants or the wish of return of those who left, CAMPURBIS must develop its own attractiveness factors to capture new functions and new people.

Predicting attractiveness is not an easy task either. Until recently, his has not been raised as an issue in most projects of this type. It was granted by the existing monuments which would continuously benefit from visitors' contributions for their own recovery and maintenance. But now city centres compete with each other because most are refurbished or in the process of refurbishment. Couros for example has a relevant industrial past and so do many other locations of the same type. It is the combination of a set of relevant factors that will build up its attractiveness. Managing CAMPURBIS project includes balancing those factors in order to achieve the objectives established – too much conservation would prevent new functions to install; too much intervention would destroy the cultural heritage; too much academic activity would turn it in an University Campus alone; and so forth. And this has to be dynamic according to the demand opportunities found.

CMG and GTL have gained relevant design experience in the Historic Centre but the approach followed has mostly been conservationist. Traditional construction materials and processes have been used in refurbishment and keeping residents and local businesses has been the main focus of the operation. The approach to Couros ought to be different in the sense that new functions and new public are aimed for the old district. Buildings therefore must perform to those functions adequately (structure, safety, comfort, economy, etc.) whereas this is not always the case of those of the HCG. The difficulty arises from installing those functions in the ancient industrial buildings whilst preserving them adequately. Some area has to be left out and in some cases new structures will have to be erected inside the old industrial halls. Additionally, this has the effect of raising the project costs significantly.

Another problem is managing the project scope because it mostly depends on its own success. For example, the installation of spin-offs and small businesses will greatly depend on the project success but enough room must be allocated for them from the start. Accordingly an open design approach has been followed whereby the spaces can be easily switched to other functions at a given time in the future. But this has to fit the constraints imposed by the metrics of existing buildings. Therefore, some of them will just be used as an external skin for the functions set up internally.

Finally, the traditional approaches to planning and scheduling are hardly applicable because activities are far from deterministic in what concerns to scope, resources and duration. Alternative methods taking into consideration the variability of design and allowing for design change have to be adopted instead.

CONCLUSIONS

Concluding, it may be stated that managing urban rehabilitation projects is a complex endeavour because of the multiple viewpoints to attend and the restrictions imposed by the nature of the site. Financing the project is seldom assured at the inception stage and mostly relies on funds raised from people and companies attracted by the project. However, this greatly depends on the way they measure the project success and on their perceived contribution to the project. Design must be flexible enough to accommodate changes but sufficiently accurate to allow for the specified contracting approach. Careful attention must be paid to scope management from the first stages of the project development. Non-traditional approaches to planning must be used due to the non-deterministic nature of project activities.

REFERENCES

Bandeira, M. (2007) O Projecto CampUrbis em Guimarães ou a Univer(c)idade: uma eutopia em devir. The Creative and Cultural Sectors Seminar – the Lisbon Agenda, 31st Oct - 1st Nov. Available at: http://www.eu2007.pt/NR/rdonlyres/B7472C09-6311-460D-BD9F-1BC1F5597E51/0/MiguelBandeira.pdf

CMG, UMINHO (2007) (2007) Projecto campurbis – Campus universitário na malha urbana histórica, available at http://www.cm-guimaraes.pt/files/1/documentos/483399.pdf

CMG, UMINHO (2007) Projecto campurbis - Campus universitário na cidade histórica. Seimário International "Espaços urbanos criativos para a competitividade", Faro, 18-19 Oct 2007, available at http://www.inteli.pt/download/INTCITIES/ProjectoCampurbis_Campus universitárionacidadehistórica.pdf

INTELI (2007) Intelligent Cities - Cidades Inovadoras e Competitivas para o Desenvolvimento Sustentável, Programa Interreg IIIC Zona Sul Projecto n.º 3S0075I, available at: http://www.intelligentcities.net

Selada C. (2005) Cidades e Regiões de Inovação: O Papel dos Parques de C&T, O Projecto Intelligent Cities, FCT-UNL, 14 Dezembro 2005, available at: www.intelligentcities.net/uploads/gc/10082_10082_ApresentaçãoINTELCITIES_2005Dez.pdf

Stalberg, C. E. (1994) The Intelligent City and Emergency Management in the 21st Century, The International Emergency Management and Engineering Conference, Florida, April 18-21, available at http://www.stalberg.net/cespub2.htm.

Teixeira, J. C. (2007) Cidade e Universidade, Intelligent Cities Workshop 30th October, Centro Cultural Vila Flor, Guimarães.

THE EFFECTS OF THE INDONESIAN CONSTRUCTION INDUSTRY ON THE ECONOMY: A SERIES OF INPUT-OUTPUT TABLE ANALYSIS

M. Agung Wibowo[1], FX Sugiyanto[2], Firmansyah[3] and O. Amoudi[4]

ABSTRACT

The construction industry contributes significantly in term of scale and its share to the process of development in developed and developing countries. Roads, railways, schools, offices, shops, factories provide the necessary public infrastructure and private physical structures for many productive activities such as services, commerce, utilities and other industries. The industry is not only important for its finished product, but also employs a large number of people (directly and indirectly) and therefore has an effect on the economy of a country/region during the actual construction process.

However, there has been lack of comprehensive study on the role of the construction industry in Indonesia, particularly its linkages with other industries. This paper presents an analysis of the relationship between the construction industry and other industrial sectors forming the national economic account in Indonesia. The series of Input-Output tables (1990, 1995, 2000 and 2003) were applied to carry out on this study.

The work is based on surveys, which were carried out in Indonesia to investigate how the construction industry links to the economy. The data from Indonesian Statistical Bureau were used (the input-output tables) to investigate the linkages between the construction industry and other industrial sectors. The linkages of the construction industry into other sectors were analysed.

Key words: *the construction industry, developing countries, economy, a series of Input-Output tables*

1. INTRODUCTION

The Construction industry played key role in the economic transformation for both developed and developing countries. The industry itself has also significant contribution to the economic output of a country. Many studies have been done on this field. Roads,

[1] *Lecturer at Civil Engineering Department, Construction Management Group, Diponegoro University, Indonesia*
[2] *Lecturer at Economic Department, Diponegoro University, Indonesia*
[3] *Lecturer at Economic Department, Diponegoro University, Indonesia*
[4] *Research student, Construction Management Group, School of Civil Engineering, Nottingham University, UK*

bridge, railway, irrigation works, schools, hospitals, dwellings, offices, factories and other construction products have become important elements of society and crucial for people's living standards. Data that come from different levels of development of countries indicate a positive correlation between per capita value added by construction and per capita gross domestic product (GDP). The importantance of this industry is due largely to the direct and indirect impact it has on the national economy. It stimulates the growth of other sectors through a complex system of linkages (Brian and Ofori (1988), Crosswhite, 2001, Lean, 2001).

However, the processes or the mechanisms of how the construction sector contributes to the economic development are still difficult to be evaluated. It is still argued that there is a reasonably well-defined relationship between construction output and the level of development. This has led to confusion and misconception in analyses of construction sector in the national economy (Drewer, 1980, Groak, 1994).

It is very common to the people to use GDP as an indicator to measure the industry contribution. However, the construction industry may not be an industry that can be measured fully based on the GDP figures. The reasons for this issue are, as follows:

- The GDP figures are based on the value added basis. The value added components represent the income of various factors of production, such as: wages, profits, interests and rents. However, the construction process needs a very large proportion of intermediate inputs from other sectors (e.g. manufacture, mining, services and trade) compare to the value added. The value added of construction sector is relatively small in comparison.

- The GDP may not be as a suitable tool to conduct an economic impact analysis where the characteristics of the industry is using a large inputs which come from other industrial sectors, such as construction industry. For example, if there is an increase in final demand for construction products, there will be an increase in the output of that construction sector, as a producer react to meet the increasing demand. This is the direct impact. As the construction sector increases its output, there will be also an increase in demand on construction sector's suppliers and so down the supply chain. This is the indirect impact. As a result of the direct and indirect impacts the level of income throughout the economy will increase, a proportion of this increased income will be re-spent on final goods and services. This is called as an induced effect. The ability to quantify these multiplier effects is important as it allows economic impact analysis to be carried out. The economic impact analysis using inter-industry models provides a method to evaluate the economic effects of a proposed project or policy.

The objective of this study is to provide an elucidation of series of input-output tables in order to evaluate the role of the construction industry into the economy.

2. THE CONTRIBUTION OF THE CONSTRUCTION INDUSTRY TO THE ECONOMY

The formation of the fixed capital investment is a vital concern for the state of the nation as it represents investment in the future of the economy of the country. Fixed investment usually consists of houses and infrastructures in both public and private sectors, as well as the business investment in plant and machinery of all industries.

The concept of the gross capital stock is useful in measuring the productive capacity of the economy. The underlying idea is that a machine or building continues to yield the same contribution to output each year regardless of its age, until it reaches the limit of its useful life, when this contribution falls to zero and it is scrapped (Ive and Gruneberg, 2000).

Investment in theconstruction sector can be defined as construction-related to the Gross Fixed Capital Formation (GFCF). GFCF is an expenditure on fixed assets (buildings, vehicles, machineries, etc) either for replacing or adding to the stock of fixed assets. These fixed assets are repeatedly or continuously used in the production process (Ganesan, 2000).

The construction sector constitutes about 40%-60% of the GFCF in most developing countries. The proportion of investment that goes to entirely new construction is likely to be higher than that which goes to repair and maintenance (Ganesan, 2000). In developed countries, the construction industry accounts for approximately one third of the total investment in physical assets in the economy. This is about the same as the investment in plant and machinery (Ashworth, 2002).

The construction investment can be an important public policy tool that is often used by central and local government to accelerate development and create employment. This decision is not the result of consumers' expenditure on goods and services, but as an investment decision, which has an effect on money injection into the economy (Ive and Gruneberg, 2000).

The multiplier effect demonstrates the impact of a change in investment on the levels of income and employment in an economy. The main concept of the multiplier is based on the recognition that the various sectors that make up the economy are interdependent.

The construction industry has significant interactions with other economic sectors as a backward and forward linkage (Bon, 2000;Ganesan, 2000). The backward linkages show the relationship of inter-industry purchases to total input, while the forward linkages show the relationships of inter-industry sales to total output.

Figure 1 shows that construction needs inputs which come from other industries and production factors (land, labour and capital). On the other hand, the products of construction are used by the society to run their social, commercial and business activities.

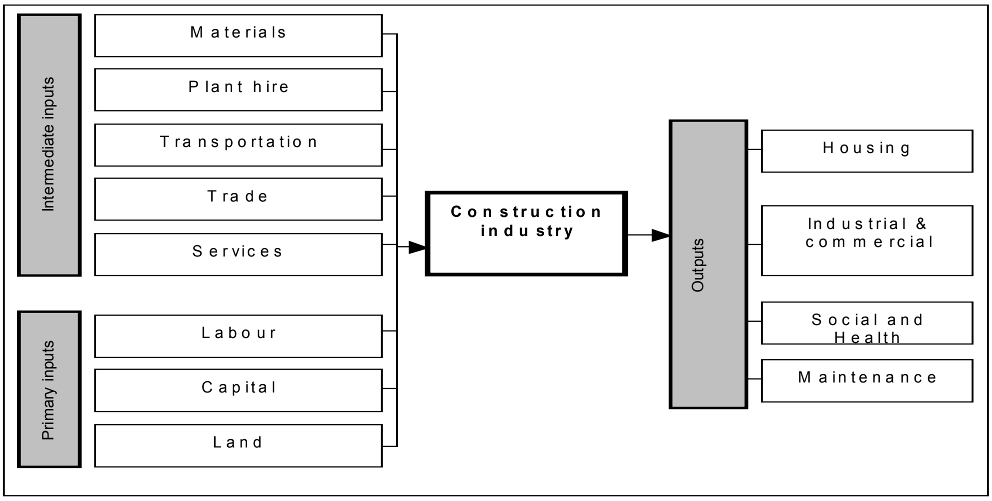


Figure 1: Construction as an input-output process (Lowe, 2003)

3. AN INPUT-OUTPUT ANALYSIS

The concept of input-output analysis originated from the work by Professor Wasily Leontief in 1957. He invented this concept as a tool to examine the interaction between industries in an economy as part of a national economic account system. This technique has proven to be a very useful modelling system that can be used for assessing linkages between sectors in the economy concern (Lean, 2001).

The structure of an input output table consists of transactions for industrial inputs and outputs, which are represented by the rows and columns of a matrix. The elements of rows show the distribution of outputs from a particular industry across sectors in the economy, while the elements of the column represent the inputs of a particular industry. In other word, the row wise of the input-output table represents receipts of economic sectors, while the column wise of the input-output table explains expenditures of economic sectors.

An extensive explanation of the input-output structure is provide by Miernyck, 1965, Miller, 1985, Lowe, 1993, Scottish Statistics Office, 2002 and Bon, 2000, which can be summarised as follows:

It can be seen from Figure 2 that the structure of the Input-Output table consists of:

- 4 production sectors (to simplify the explanation) as intermediate inputs and outputs;
- Final demand (Y) that includes:
    - Consumption (C);
    - Investment (I);
    - Government (G);
    - Exports (E);

- Value added (V) that includes:
    - Employee compensation (L) (e.g. labour services)
    - Other value added aspects (N) (e.g. government services (paid for in taxes), capital, profit;

The structure of the Input-output table consists of four quadrants (Figure 2), as follows:

- Quadrant I:

Quadrant I shows transactions for intermediate inputs to produce outputs. The intermediate inputs are those, which are required for the production of consumers' and capital goods rather than for their final user. As it is assumed that one sector produces only one good, Quadrant I is therefore represented by square matrix, which the number of rows and column are equal. Total number of rows and columns (i.e. the dimension of the matrix) used depends on the data collection. Each element in the matrix represents an expenditure of a sector which corresponds to an income for the receiving sector. The diagonal element of matrix shows transactions within the industry industrial it self.

- Quadrant II:

Quadrant II contains the final demands for goods and services. Total amount of this quadrant corresponds to the gross national expenditure in a national income accounting. Each column represents a category of spending in a national economy, for example consumers' expenditure, investment in fixed assets and stock building (gross fixed capital formation), government spending and exports. If the exports are presented by net of imports, the sum of quadrant II for each industry is equal to the gross domestic product.

- Quadrant III:

Quadrant III of the input-output table deals with the value added of each industry that is represented by a column. The rows represent the primary inputs and value added that consist of labour wages, profits, payment to the self-employed, rents and government services, which are equal to gross national income.

- Quadrant IV:

Quadrant IV represents the value added aspects that go directly to the final demand.

		Intermediate inputs				Final Demand (Y)				Gross output
		1	2	3	4	Consumption	Investment	Government	Export	
		QUADRANT I				QUADRANT II				
Intermediate outputs	1	X11	X12	X13	X14	Y1C	Y1I	Y1G	Y1E	X1
	2	X21	X22	X23	X24	Y2C	Y2I	Y2G	Y2E	X2
	3	X31	X32	X33	X34	Y3C	Y3I	Y3G	Y3E	X3
	4	X41	X42	X43	X44	Y4C	Y4I	Y4G	Y4E	X4
		QUADRANT III				QUADRANT IV				
value added	L	VL1	VL2	VL3	VL4	V1C	V1I	V1G	V1E	L
	N	VN1	VN2	VN3	VN4	V2C	V2I	V2G	V2E	N
Gross input		X1	X2	X3	X4	C	I	G	E	X

Figure 2: The input-output table (Miller, 1985

5. DISCUSSION

The data used for this discussion was collected from the Indonesian Statistical Bureau. The construction industry in Indonesia has been included in the National Development Plans by the People's Deliberative Assembly, and constitutes as one of important sector of economic activity in terms of its contribution to national production. The distribution of the construction industry is about 6-8% of the total GDP between 1995 and 2005 (Figure 3).

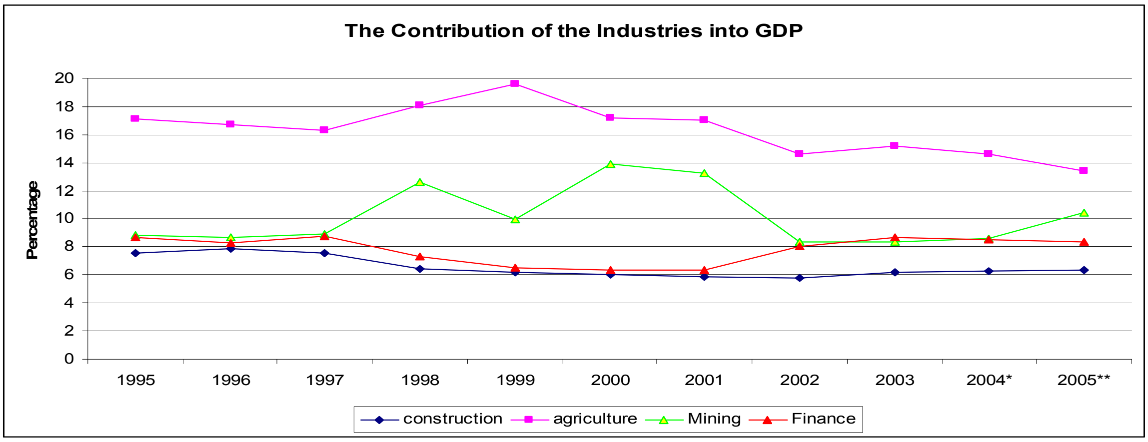


Figure 3: The Contribution of the Industry into GDP

The contribution of the construction industry into the economy can be examined through the application of the Input-Output Tables. Series of Input-Output tables (1990-2003) was collected from the Indonesian Statistical Bureau.

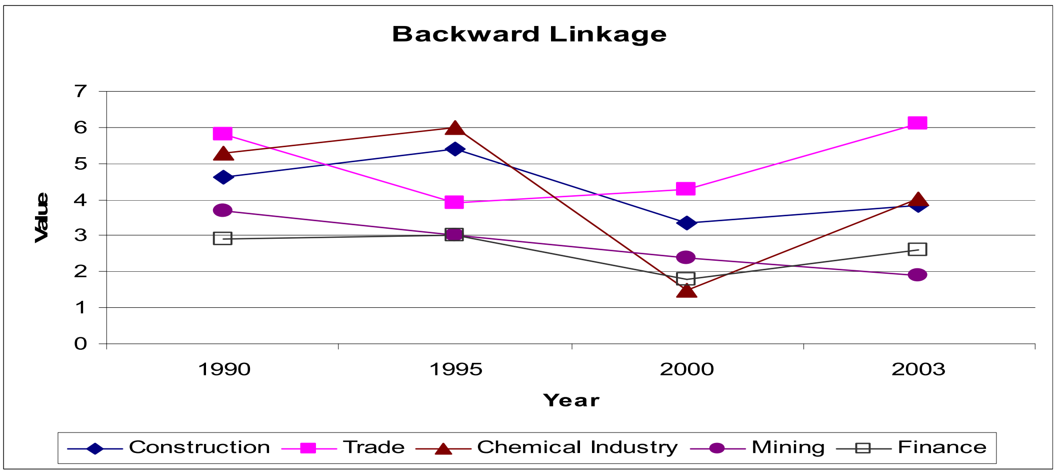


Figure 4: Direct Backward Linkages

Figure 4 shows backward linkage indicators. The backward linkages in this paper relate to direct input interdependence between the construction sector and other sectors. To put it differently, they refer to purchases by the construction sector of intermediate goods in inter-industry transactions. These inputs purchase, priced at producer prices, are the fixed coefficients indicating required amounts per unit of construction output. It can be seen that the construction industry is considered to be one of the industries which has highest direct backward linkage indicator. The higher the backward linkages a sector has, the more important that sector is in promoting the economic growth of the economy.

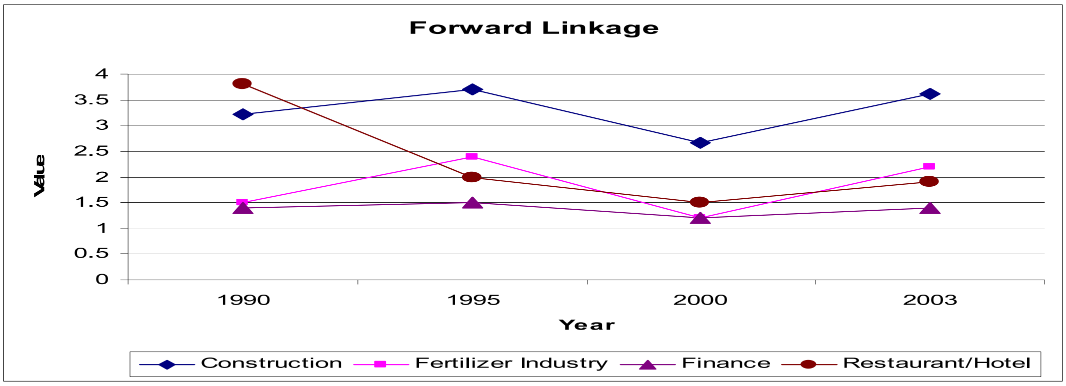


Figure 5: Forward Linkages

Figure 5 shows forward linkage indicators. Similar to backward linkages, forward linkages relate to deliveries of construction outputs to other sectors, as intermediate goods, plus final demand components. The forward linkage coefficients represent how much the construction sector delivers to other producers and final demand users per unit of output.

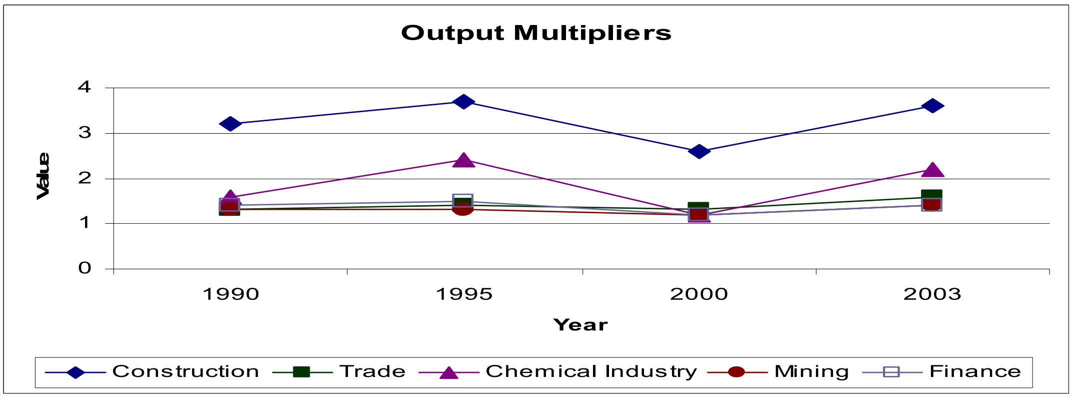


Figure 6: Output Multipliers

The output multipliers represent the effect of one monetary unit change in final demand of the construction industry on total output of all others industries. It should be noted that the construction industry ranks very high in terms of output multipliers compare to other sectors (trade, chemical, mining and finance industry)

6. CONCLUSION

The input-output analysis provides a comprehensive description of great value in understanding the economic role of the construction industry. The construction industry provides a very important contribution to the national/local economy through its job generating ability for unskilled, semi-skilled and skilled labour. The construction process needs inputs from other industries and production factors (labour, land and capital). This could generate considerable employment through multiplier effects.

This study has examined the actual mechanism of the role of the construction industry in the economy particularly in term of the backward and forward linkages between the construction industry and other industrial sector. The series of the input-output tables were used to investigate the effect of the final demand change of the construction industry to other sectors whether as direct or multiplier effects at macroeconomic level.

7. REFERENCES

Akintoye, A and Skitmore, M (1994), ***Models of UK Private Sector Quarterly Construction Demand***, Construction Management Economics, **12**, 3-13

Ball, M and Wood, A (1995), "How many Jobs does Construction Expenditure Generate, *Construction Management and Economics*, Vol 13, 307-318

Bon, R and Crosthwaite, D (2000), The future of International Construction, Thomas Telford, London

Brian. and Ofori, G. (1988). "Construction and Economic Development: a Case study." *Third World Planning Review*. Vol. 10, No. 1, 41-50.

Carty, (1996), Construction, Journal of Construction Engineering and Management, September, 1995, 319-328

Cooke (1996), Economics and Construction, Mac Millan, UK

Drewer, (1980), Construction and Development: A new Perspective, Habitat International, Vol.5, No.3/4 pp 395-428

Field, B. and Ofori, G. (1988). "Construction and Economic Development: a Case study." *Third World Planning Review*. Vol. 10, No. 1, 41-50.

Ganesan, S. (2000). Employment, Technology and Construction Development. Ashgate, UK

Groak, (1994), Is construction an industry ?, Construction Management and Economics, Vol.12, pp 287-293

Gruneberg (1997), Construction Economics: An introduction, Mac Millan, London, UK

Hillebrandt (1984), Analysis of the British Construction Industry, MacMillan Publisher, Ltd, UK

Hillebrandt, P.M. (2000), Economic Theory and the Construction Industry, 3rd, Macmillan Press Ltd, UK

Henriod, (1984), The Construction Industry issues and strategies in Developing Countries, World Bank Publication, Washington

Ive, G and Gruneberg, L (2000). The Economics of The Modern Construction Sector, Macmillan Press Ltd, UK

Kaming (1997), The Construction Industry in Indonesia, Kinerja Vol.2, 9-21, Yogyakarta, Indonesia

Killingsworth (1990), A preliminary investigation into formulating a demand forecasting model of industrial construction, Cost Engineering Vol.32, 11-15

Lean, C. S. (2001). "Empirical Tests to Discern Linkages between Construction and Other Economic Sectors in Singapore." *Construction Management and Economics*. Vol. 19, 355-363

Lowe, J.L. (2003). Construction Economics, www.callnetuk.come/home/johnlowe 70/

Miernyk, W.H. (1965). The Elements of Input-Output Analysis, Random House, New Yorks.

Miller, R. E. (1985). Input-Output Analysis, Prentice Hall, New Jersey, US

Moavenzadeh (1978), The Role of the Construction Industry in the Development Process, Public Policy XXII,2: 219-241

Oxford (2000), Advanced Longman Dictionary, UK

Statistics Indonesia, http://www.bps.go.id

Thomas.H.R, (2002), 2000 Peurifoy Lecture: Construction Practices in Developing Countries, Journal of Construction Engineering and Management, Vol.128

Turin.D.A (1973). ***The Construction Industry: Its Economic Significance and Its Role in Developmen****t*, 2nd, University College Environmental Research Group, UK.

Walker, A. (1996)."Project Management in Construction, 3rd" , Blackwell Science, UK

Wells, J (1986), ***The Construction Industry in Developing Countries: Alternative Strategies for Development***, Croom Helm Ltd, UK

Wibowo, M.A. and Mawdesley,M.J. (2002). Systems Modelling to Evaluate the Effects of Labour Intensive Construction, Proceeding International Conference on Advancement in Design, Construction, Construction Management and Maintenance of Building Structures.

MONITORING DEGREE OF COMPLEXITY IN MULTICULTURAL CONSTRUCTION

Kalle Kähkönen
VTT Technical Research Centre of Finland
kalle.kahkonen@vtt.fi

Risk management, its methodologies and tools are an important starting point for portraying potential problems and their impacts. This paper shall first provide discussion on the limits of traditional project risk management in modern multicultural construction business. It is considered that the results and process of traditional normative risk management are sometimes too static for modern business conditions where situations can change in a continuous manner. The core content of traditional risk management paradigm is well-understood and widely-studied. However, our thinking model seems to be stuck with the formal structuring beyond this existing paradigm. This paper shall present project complexity monitoring as a potential solution for exceeding the scope of current risk management solutions. Degree of complexity is seen as a major uncertainty source from which potential problems in construction projects arise. The paper is based on on-going research and development effort about global projects and relating managerial solutions.

KEYWORDS: risk management, project management, multiculturalism

INTRODUCTION

Complex project is a concept that has rather recently gained increasing attention and interest in the project management community. It is a key term in the IPMA (International Project Management Association) Competence Baseline used for explaining the required competence difference between different types of project managers where, particularly, project managers entitled as certified senior project manager provide a reference point for explaining the criteria and competence elements that meet the needs to complex projects (IPMA, 2006) . Accordingly, the most important criteria for characterising complex projects are i) many interrelated sub-systems / sub-projects and elements, ii) several organisations, iii) several different disciplines, iv) different and possibly overlapping phases, and v) need for wide variety of project management methods and techniques. Usually these criteria are met in large-size projects but they can be at least partially present in smaller projects as well.

The example above about the use and definition of the term complex project can be considered as an intuitive opinion by experienced practitioners demonstrating the importance of the concept for practitioners. Concerning construction operations a lot of research tradition exists in the field of task level productivity which has been the origin for studies addressing task complexity (Gidado, 1996). More recently researchers have turned heir attention towards project level complexity (Girmscheid & Brockmann, 2007). Shenhar et al. (2002) introduce complexity as a factor that is due to the size of the project/system scope. Additionally, researchers have explored the structure and dimensions of complex projects and complexity in projects. "The concept of complexity is being used as an umbrella term associated with difficulty and inter-connectedness" (Geraldi, 2007). Thus the term has implicit links to characteristics such as uncertainty, dynamism, uniqueness, lack of clarity, and variety of perspectives and cultures. The term complex project have recognised importance for companies and their project managers, whereas for the research community this term, its coverage and implications to the project management body of knowledge can be seen as potential research topics.

Complexity in projects has been understood as a general source for various managerial challenges. With its outreach to uncertainty and lack of clarity it may also provide a starting point for understanding root causes of project risks which can then link the identified complexity to the project risk management.

Purpose of this paper is to present a piece of research where the monitoring of degree of project complexity is studied as a potential new risk identification solution for multicultural construction projects.

RESEARCH METHOD AND CONTEXT

The piece of work presented in this paper is an example of constructive proof-of-concept study. It is based on early finding presented shortly in the introduction. The actual 'construction' is a solution for estimating and monitoring the degree of complexity in construction projects. This has gone through a field test within a project management training course. This session was participated by experienced project managers.

This research is part of larger Global Project Strategies (GPS) research project for the period 1.4.2007 – 31.3.2009. GPS aims to develop new ways to manage effectively and innovatively global projects that are implemented in complex institutional and business environments with several participating organizations. The main research areas are project networks, risk management, culture and diversity. GPS is a joint research effort by VTT, Helsinki University of Technology, Helsinki School of Economics, participating companies and it is carried out in co-operation with Stanford University Collaboratory for Research in Global Projects (CRGP) program.

CONVENTIONAL RISK MANAGEMENT

Core of conventional risk management

There are several project management state of the art standards and other presentations in textbooks that provide a definition of project risk management content. The risk management content is generally defined as several stages or processes. Some of these merely describe the core risk management process whereas others can be somewhat more descriptive in terms of explaining special characteristics of risk management with additional phases or stages.

Figure 1 introduces to the project process the core content of risk management (Kähkönen, 2006). The basis of this model is in the recognition that some repetitive tasks seem to form the core effort required in various situations for completing the present needs for obtaining an improved understanding of the risks and/or opportunities contained within the project. Other processes around the core of risk management are called accessory processes, which characterise in a more detailed manner the on-going required effort.

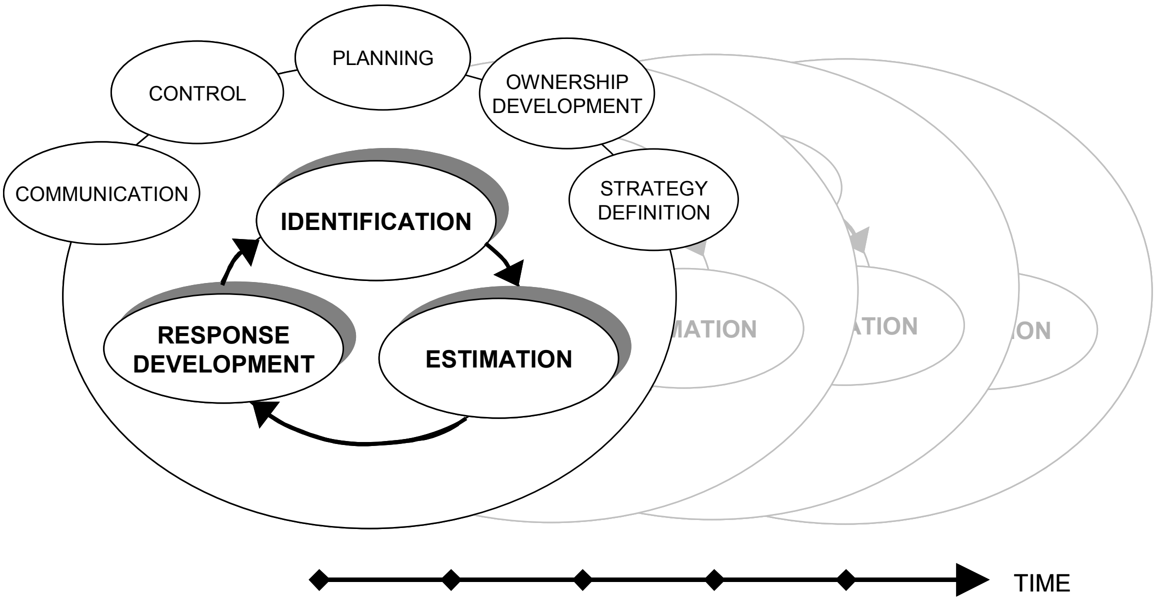


Figure 1: Risk and opportunity management core processes and accessory processes

Risk (and opportunity) identification is the most crucial process of risk and opportunity management. During this process one can completely loose the game of having improved risk awareness for the project or one can gain a substantially new understanding that in turn could easily result in improved performance. All succeeding tasks are based on the outcome from risk identification; of particular note are the achievements concerning human and group risk awareness that are usually gained during this phase. When human risk awareness improves it usually influences one's thinking and work immediately. If key people are involved together in risk identification sessions on the projects, this phenomenon can result in straightforward project plan and management improvements. In simple terms, risks, identified and accepted as being important, stick with people and have influence over them.

Typical tools for risk identification are i) checklists, ii) prompt list and risk matrix (*risk levels*: project, company, business environment; *risk dimensions*: product, time, money, people), iii) cause and effect diagrams. Although various checklists with general or detailed titles are perhaps the most widely used risk identification tools it is the root causes of risks which can be seen as main target of this exercise. Cause and effect diagramming that can be equipped with questions *Why?/For what reason?* is naturally pointing to this direction.

Where conventional risk management paradigm fails?

Varieties of efforts having traditional risk management paradigm as a starting point have been documented widely in scientific periodicals and text books, for example (Cooper et al, 2005; PMI, 2004; IPMA, 2006; Chapman & Ward, 2002; ISO, 2003; Smith, 1999; Nicholas, 2004). It would be unfair to judge all these sources and work behind them as promoters traditional risk management paradigm since many of them surely goes beyond this. However, dominantly in most sources the starting point and basic principle for explaining the content of risk management is the core of risk management according to the traditional paradigm. The following shortcomings can be linked to the traditional risk management paradigm

1. Too much emphasis on mechanical risk identification, analysis and response cycle i.e. it has normative nature
2. Risk management understood as a separate additional process
3. Use of universal definitions and model instead of situation specific approaches
4. Risk management procedures are often too static compared with dynamics of the actual situations
5. The ”traditional” paradigm tends to lead to ”rear window” solutions instead of meeting the uncertain future based on foresight and proactive measures
6. Single "focal" company thinking model does not meet the characteristics of modern networked business
7. Opportunities i.e. upside risks not included in a well-balanced manner or they are fully ignored

Several issues listed above fall beyond the scope of this paper and chances for improvements arising from the complexity concept. However, it looks obvious that alternative approaches are needed and the list above can be used as encouragements for disconnections if necessary.

Chance for improvement

Risk identification procedures with checklists result typically in wide variety of risk titles, actual or potential problems, causes, impacts etc. Further analyses of this material are proposing that it is possible to name general root causes or risk clusters behind various more detailed risk titles (Figure 2). This study is showing how numerous project risk issues can actually arise from less numerous root causes. Therefore it looks possible that by evaluating severity of carefully selected root causes one can directly address first the root causes and after that study more detailed risk titles. In a way this is proposing quite different risk identification approach by proposing the use of generic root cause titles as a first step and then more detailed risk title discussions after that.

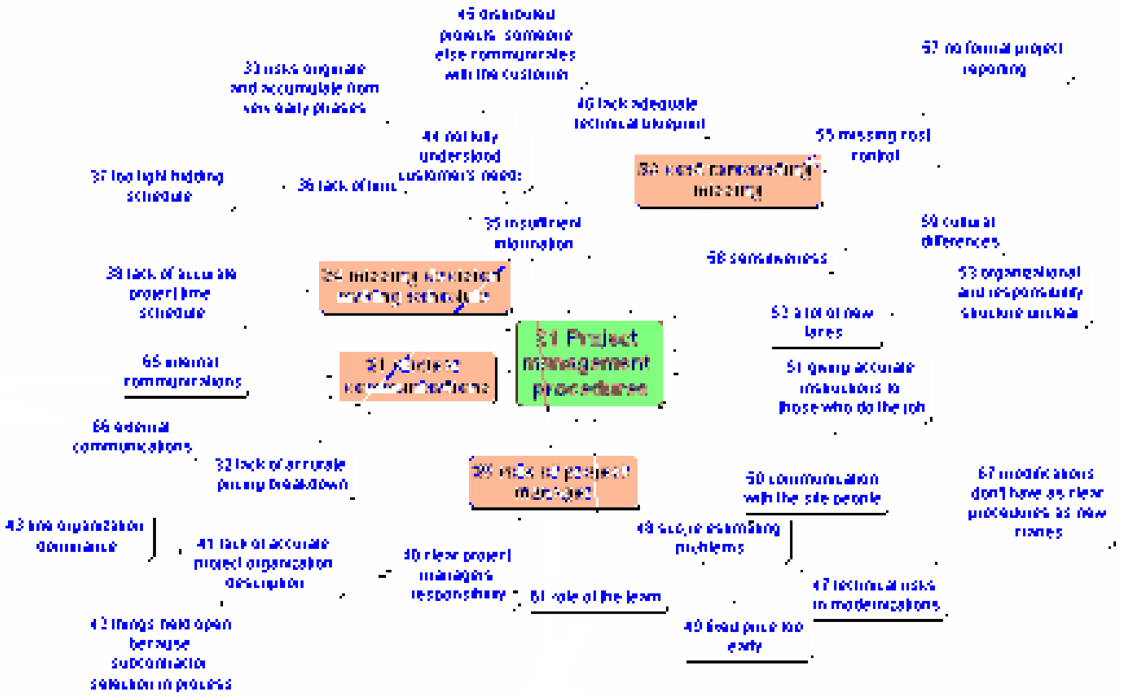


Figure 2: Identification of generic risk causes behind more detailed risk titles (Dietrich et al, 2004).

STRUCTURING AND ESTIMATING DEGREE OF PROJECT COMPLEXITY

Elements of complexity

Earlier studies are proposing that it is possible to break down the overall project complexity into explanatory elements. Examples of these previous structuring of such elements are Geraldi (2007): i) Level of Immaturity, ii) Dynamics, iii) Number of sources/elements, iv) Interdependence, v) Reference, vi) Transparency, vii) Empathy; and Girmscheid & Brockmann (2007): i) Overall complexity, ii) Task complexity, iii) Social complexity, iv) Cultural complexity.

The structuring of complexity elements presented in Table 1 is based on workshop with project managers of international large-size projects. Titles originating from previous studies were presented as starting point. The proposed structuring is aiming to present a balanced set of key elements that based on earlier studies are able to clarify the overall degree of project complexity. The weight connected to each complexity element is proposing its relative value compared with others.

Table 1: Elements of project complexity and their (possible) relative weights for estimating the overall complexity.

Complexity element	***Weight***
1. Task ▪ Uniqueness	30

▪ Contract type ▪ Claiming culture ▪ Change orders	
2. Social ▪ Chemistry ▪ Leadership	30
3. Organizational ▪ Formal and informal interdependencies ▪ Skills and competencies	20
4. Cultural ▪ Country issues ▪ Institutional issues and diversity: internally, external stakeholders	20
5. Cognitive ▪ Learning impact	10

Subjective estimates

Subjective estimates refers here to the fact that project risk estimates must be prepared by knowledgeable individuals. Deriving subjective estimates means that estimates are prepared by encoding individuals' experiences and beliefs. The use of judgement of knowledgeable experts does not mean that those estimates would necessarily be unreliable, but the subjective estimate approach of expressing risk in this context rather refers to the fact that best possible source of information - i.e. knowledgeable people - is used. Although the best possible information source is used while using subjective estimates for encoding experts' beliefs, both the goodness of estimates and biases in estimates become important issues to consider (Kähkönen & al, 2006).

The goodness of estimates and biases there can be naturally seen as objects for improvements but another different aspect is to focus on understanding and communicating the overall quality of estimates. It happens easily that background variables, their formulas and dependencies over objects in the model become invisible and the overall credibility of the model can decrease dramatically. Therefore it is important to make the use of tool as transparent and communicative as possible (Figure 3).

	Weights					***Final normerated figu***
	3	0.5	1.5	0.42	16.67	20.83
	3	0.3	0.9	0.25	16.67	12.50
	3	0.2	0.6	0.17	16.67	8.33
	3	0.1	0.3	0.08	16.67	4.17
	3	0.1	0.3	0.08	16.67	4.17
		1.2				***50.00***

Estimate						
	1.9.07	1.10.07	1.11.07	1.12.07	1.1.08	1.2.08
1. Task	2	5				
2. Social	5	3				
3. Organizational	2	3				
4. Cultural	2	3				
5. Cognitive	2	5				

Calc. figures						
	1.9.07	1.10.07	1.11.07	1.12.07	1.1.08	1.2.08
1. Task	14	35	0	0	0	0
2. Social	21	13	0	0	0	0
3. Organizational	6	8	0	0	0	0
4. Cultural	3	4	0	0	0	0
5. Cognitive	3	7	0	0	0	0
	45.83	***66.67***	***0.00***	***0.00***	***0.00***	***0.00***

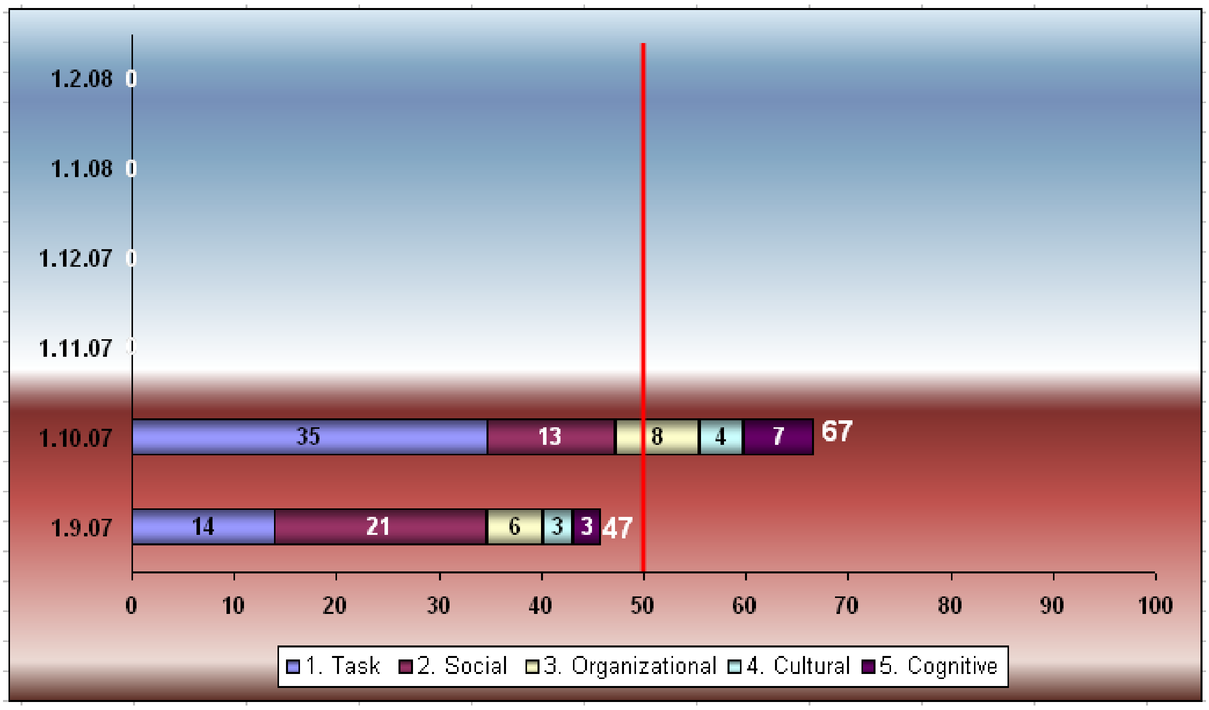


Figure 3: Tool for monitoring degree of complexity in projects. Example of monthly subjective estimates (applying scale 1-5), calculations and final output.

Monitoring of degree of project complexity refers to estimates that are prepared regularly according fixed-length repeating cycles. This is also often called time-pacing in literature. The rhythmic time-pacing principle is different compared with the conventional risk analysis and management practice where the main attention is on so-called critical milestones or events, e.g. bid preparation, contract negotiations and start on site.

PROOF-OF-CONCEPT TEST

The complexity monitoring as an approach for estimating the overall risk potentiality and its tool have been

1. Presented in two events for companies (Project Days 2007, Espoo, Finland) and 'Advances in the Management of Uncertainty' during Nokia internal training days at Aulanko, Finland Sep 6, 2007

2. Tested using a case project as a part of project management training course in June 2008. The course was participated by 20 experienced project managers.

The following summarises the main findings obtained from the presentations and test. *Positive observations and feedback:* i) the tool works well as a discussion starter and helps us to focus on important aspects, ii) the titles forming complexity are the ones we often discuss in our project meetings. This tool can provide framework for this part of our work. iii) Scores of various elements and total score make this exercise valuable by building concretical reference points. iv) Looks suitable for large-size investment projects. *Negative observations and feedback:* i) "Degree of complexity" is difficult concept, which I would present to my clients and partners only in carefully selected cases. ii) Requires knowledgably facilitator who can connect the results to practical risk management.

DISCUSSION

Degree of complexity can be a useful concept for characterizing any kind of construction project. Company managers and project managers have intuitively started to use it as a part of their work. This intuitive use together with the recently increasing existence of this term in literature are indicating that also the research society need to put attention on the concept complexity and explore its implications to the project management body of knowledge. More specifically it has been proposed in this paper that project complexity and relating tools can provide clear contribution or even change the content of risk analysis and management by putting attention on regular monitoring of root causes of risks and to use this data as a main source for further risk analysis.

Regular monitoring of factors resulting in increasing project complexity can be a way to get grip of dynamics of construction projects and communicate this information onward. For example, when sudden change orders appear the complexity of project can increase promptly and priorities of risk titles change and new titles can appear. Without regular monitoring this event and its causes to risk management can be ignored.

CONCLUSIONS

Compared with conventional project risk analysis the concept 'degree of project complexity', its structuring and its regular monitoring present a alternative route to capture root causes of project risks as a first step. During the next step the results of this analysis can be utilised as input data for forming more detailed risk titles.

The presented approach and tool based on it look particularly suitable for construction projects which clearly are 'complex' at first sight. Typical characteristics of such projects are existence of factors/actors causing uncomfortable uncertainty, for example new partners, client or business environment, multiculturalism, dynamics due to change orders, additional requirements and non-completed contracting.

The gained results from presenting and testing the approach and the complexity monitoring tool with company representatives are encouraging.

REFERENCES

Chapman, C. and Ward, S. (2002) Managing Project Risk and Uncertainty. Chichester: John Wiley & Sons Ltd.

Cooper, D., Grey, S., Raymond, G. and Walker, P. (2005) Managing Risk in Larger Projects and Complex Procurements, Chichester: John Wiley & Sons.

Dietrich, P., Lehtonen, P. and Lindblom, L. (2004) Firm-specific developmental schemes in the management of multiple projects, Project Business (PB) Research Group, Helsinki University of Technology (HUT), BIT Research Centre.

Dombkins, D.H. (2007) Complex Project Managers, Defence Partnership Conference, London, June 4-6.

Geraldi, J. (2007) Patterns of Complexity: The Thermometer of Complexity, Project Perspectives, 24(1), 4-9.

Gidado, K. (1996) Project Complexity: The Focal Point of Construction Production Planning. Construction Management and Economics, 14, 213–225.

Girmscheid, G. and Brockmann, C. (2007) The Inherent Complexity of Large Scale Engineering Projects, Project Perspectives, 24(1), 22-26.

IPMA. (2006) ICB - IPMA Competence Baseline, Version 3.0, International Project Management Association, Nijkerk, The Netherlands.

ISO (2003) ISO 10006 Quality management systems - Guidelines for quality management in projects. Geneva: International Organisation for Standardisation.

Kähkönen, K. (2006) Management of uncertainty, in Commercial Management of Projects book by Blackwell Science Publishing Ltd, February 2006, 211-233

Kähkönen, K., Artto, K., Karjalainen, J., MArtinsuo, M. and Poskela, J. (2006). Management of Uncertainty, (Draft book), Helsinki University of Technology.

Nicholas, J.M. (2004) Project Management for Business and Engineering. Burlington: Elsevier Butterworth-Heinemann.

PMI (2004) A guide to the project management body of knowledge. Newtown Square: Project Management Institute.

Pryke, S. and Smyth, H. (2006) The Management of Complex Projects. Oxford: Blackwell Publishing Ltd.

Shenhar, A. J., Dvir, D., Lechler, T. and Poli, M. (2002) One Size Does Not Fit All – True For Projects, True For Frameworks. In: Slevin D. P., Pinto J. K. and Cleland D. I. (Eds.) Proceedings of PMI Research Conference 2002, Project Management Institute, USA, 99-106.

Smith, N.J. (1999), Managing Risk in Construction Projects. Oxford: Blackwell Science Ltd.

Williams, T. (2002) Modelling complex projects. Chichester.-Wiley.

AEC INDUSTRY CULTURE CHANGE: *'A UNIQUE PHILOSOPHY'*

A. Weippert
Queensland University of Technology, Brisbane, Australia
a.weippert@qut.com

S.L. Kajewski
Queensland University of Technology, Brisbane, Australia
s.kajewski@qut.edu.au

The highly competitive Architectural, Engineering, and Contractor (AEC) industry has become an integral part of today's global economy and the management of its unique '*culture'* seems to be dominating the strategy of many of today's business decisions. Every organisation, group and project team within the AEC industry has its own unique culture, sub-culture, character, nature, and identity, each with their own history of success and failures that simultaneously reinforce and challenge their distinctive way of '*doing things*'. Unfortunately, people (culture) has always been '*instinctively programmed*' to resist any form of change. In an attempt to better understand the AEC industry's inherent resistance towards change this paper discusses the current status of an ongoing PhD research investigation in developing an AEC industry-specific best-practice change framework. Leveraging off the outcomes of a two year Australian industry and government supported Cooperative Research Centre for Construction Innovation (CRCCI) research project ('*Project Team Integration: Communication, Coordination and Decision Support'*), as well as referring to recent international case studies and related literature investigations, research activities include further identifying, processing, analysing and categorising various best-practice change methods, models, frameworks and processes utilised within the AEC and other industry sectors, and incorporating them into developing an AEC industry-specific '*Innovation-driven Change Framework'* that will help transform the AEC industry and its inherent resistance towards change.

KEY WORDS: Innovation-Driven, Culture; Change; Framework; Delphi

INTRODUCTION

Despite the growing '*theoretical'* awareness of the cultural '*dynamics'*, little attention is given to developing innovative and practical processes, frameworks and models that can easily be employed when attempting to implement and manage a sustainable innovation-driven change initiative within the geographically dispersed and project-based AEC industry. By developing and fully embracing an enhanced '*culture change philosophy*' (as an integral part of developing the proposed '*Innovation-driven Change Framework')* that takes into account the AEC industry's '*unique'*, '*complex'* and '*multi-levelled*' culture throughout the implementation process of an innovation-driven change initiative - will in turn provide a more realistic and sustainable approach on how to manage it.

To meet the PhD research objectives, an exhaustive literature investigation provides the foundation for the development of a sustainable AEC industry specific best-practice '*Innovation-driven Change Framework*' that comprises of six key, interconnected and interdependent dynamics (Figure 1) that the author of this paper believes are to be considered when any form of change or new way of '*doing things'* is proposed within an organisation or project team environment.

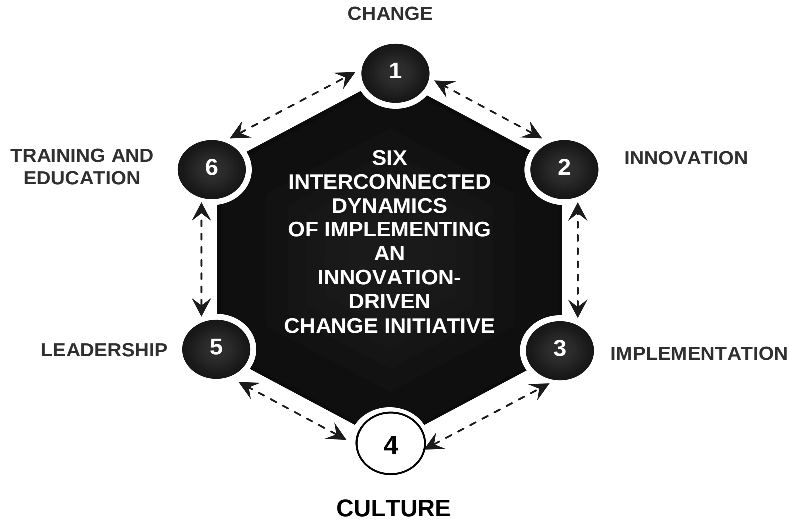


Figure 1: Innovation-Driven Change Framework

The development of the author's *AEC Industry-Specific Innovation-Driven Change Framework* (Figure 1) is based on the premise that should one of the six interdependent dynamics be influenced, 'dealt with' or changed, it will affect one or more of the other five dynamics. For example, senior management and change leaders can arguably not implement a new business strategy or innovative business process (i.e.: an innovation-driven change initiative) without simultaneously…:

i. Confirming the organisation's ability to ***change*** and willingness to ***adapt*** to a new or innovative way of doing things
   - Identifying and applying the most suitable change model available
   - Clarifying the 'need' vs. 'want' of 'doing things' differently
   - Comparing the drivers and barriers of implementation
   - Analysing the various influencing cost, timing and difficulty factors

ii. Confirming the organisation's, group's or project team's ability and willingness to adapt to a new or ***innovative*** way of 'doing things'

iii. Considering and applying the most suitable ***implementation strategy*** in order to maximise benefits and meet central business objectives of an organisation, group or project team

iv. Correctly identifying and fully understanding how best to manage the various dynamics of their inherent ***culture and sub-cultures***, including (a) individual beliefs, values, attitudes, assumptions, etc. towards the proposed change; (b) developing unique ***motivation*** strategies, ***rewards*** and ***incentive*** packages for managers, employees and project team members alike; and (c) promote a ***trusting*** and ***sharing*** environment that is willing to ***commit*** and fully embrace the proposed change

v. Clearly identifying effective ***leaders*** and committed ***champions*** who are capable of achieving the implementation goals and objectives and who facilitate appropriate working environments that encourage ***innovative thinking***; an ***'atmosphere of creativity'*** where staff enjoy the freedom to solve complicated problems in non-traditional ways; the desire to institutionalise innovation as standard business practice; and the support for collaborative efforts

vi. Recognising the essential need to facilitate both internal and external ***training*** incentives that encourage ***lifelong learning***, ongoing development, and active creation and sharing of knowledge to help ensure the successful implementation of innovation-driven change initiatives within existing and future work environments. The development of a ***learning culture*** that is attuned to absorbing and applying the required ***knowledge*** and ***skills***, will help ensure employees and project team members (end-users) are effective in their application of the proposed innovation-driven change initiative

Therefore, should any of the six interdependent AEC industry-specific innovation-driven change dynamics be ignored, disobediently followed, irregularly lead / managed / monitored, or simply overlooked, then the implementation process of a proposed innovation-driven change initiative or 'new way of doing things' is unlikely to succeed.

Finally, to help further validate the fourth dynamic (culture) as being an integral part of the proposed sustainable AEC industry specific best-practice '*Innovation-driven Change Framework*' (Figure 1) - the exhaustive international PhD literature investigation provides an in-depth look at the following areas, which due to restrictions imposed, could not be included in this paper:

- Various culture and sub-culture classifications (e.g.: 'strong vs. weak' cultures) of various industry sectors (not only AEC)
- Relationship between beliefs, attitudes, values and behaviour
- Organisational culture models, factors and characteristics
- Construction industry cultures and personalities
- Innovation-driven / technology-led cultures
- Learning cultures
- The need for developing unique motivational strategies, rewards and incentive packages for managers, employees and project team members alike
- The need for promoting a trusting and sharing environment that is willing to commit and fully embrace the proposed change

RESEARCH APPROACH

In an attempt to demonstrate leadership and to enhance the efficiency, productivity and competitiveness of today's AEC industry, this paper discusses the current status of an ongoing and in-depth PhD research investigation in developing a sustainable AEC industry specific best-practice '*Innovation-driven Change Framework*' that can (a) strategically be employed within AEC industry project-based organisations, business plans and project team environments to help determine their current levels of '*readiness*' and '*adaptability*' towards the sustainable implementation, leadership and management of an innovation-driven change initiative; (b) provide AEC industry leaders with a set of best practice guidelines that can assist in identifying, assessing and potentially overcoming the '*deeply embedded*' cultural and sub-cultural '*threats*' and '*opportunities*' that challenge the successful uptake of a sustainable innovation-driven change initiative – i.e.: by looking at organisation and team member values, attitudes, perceptions and beliefs, etc. towards the implementation of an innovation-driven change initiative; and (c) assist change leaders in identifying and quantifying the need, expectations, preparedness, willingness, and sustainability of accurately '*matching*' the implementation of an innovation-driven change initiative with that of the uniquely interwoven and profoundly entrenched levels of cultures and sub-cultures within the AEC industry.

Due to the restrictions imposed on the length of this paper, the author will only focus on summarising a small portion of the author's PhD literature investigation findings, by providing a brief outline of the following:

- Reasons why the study of the fourth dynamic (culture – Figure 1) is important to the AEC industry – i.e.: thereby gaining a better understanding and awareness of the 'generic' human factors and characteristics (values, perceptions, attitudes, etc) that need to be considered when attempting to bring about change within an organisation or project team environment
- A working / operational definition for the term 'culture' is proposed by the author - underpinning the fourth interconnected dynamic of the proposed sustainable AEC industry specific best-practice '*Innovation-driven Change Framework*' (Figure 1)

- Reasons for resisting change are highlighted
- The need for accepting change is emphasised
- Finally, examples on how to bring about change within culture are introduced

WHY CULTURE?

"…our culture makes us who we are… a company defined by its people, their talent, and the opportunity to do some pretty amazing things" (McDermott R. and O'Dell C. 2001) p77

Decisions made without awareness of the '*operative culture forces*', may result in unanticipated and undesirable consequences. The better understanding of culture therefore needs to be taken seriously to help anticipate consequences and make choices about their desirability (Schein E. H. 1999). Research identifies six reasons why the study of an organisation's culture is important (Table 1):

Table 1: Importance of Studying Culture

IMPORTANCE OF STUDYING CULTURE
i. Culture focuses on communication at all levels of the corporate hierarchy, where individuals identify who they are in relation to one another and the organisation, and where shared understandings form identifiable subgroups / sub-cultures.
ii. By focusing on culture, one inevitably focuses on the daily routine and '*sense-making*' that is the process of building identities and shared reality among organisation members.
iii. A cultural approach focuses on largely ignored issues such as assumptions and brings underlying values and motives to the surface.
iv. The understanding of culture offers a better insight to the managers and leaders of organisations – not in order for them to better shape the culture, but to better understand and participate in the '*sense-making*' activities of organisation members.
v. Undertaking a cultural approach will help identify novel approaches and understandings of future organisations.
vi. Culture is pervasive, not simply a variable that affects the organisation, but indistinguishable from the organisation

(Pepper G. L. 1995)

"…when we know what culture is, we know what needs to be changed for culture to change….only once we appreciate its nature can we understand how it might be changed…when we know its role, we can comprehend its importance" (Williams A., Dobson P. et al. 1993) p11.

The better understanding of culture "… *thus helps generate insight into the organising activity that would be overlooked or presented differently in other approaches"* (Pepper G. L. 1995) p29

WHAT IS CULTURE?

The word '*culture'* stems from the word '*cultivate'* (the cultivation of soil) (Webster 1956) – i.e.: the way in which people act on nature. In the case of humans, culture is often the primary way in which one group (organisation, team, etc) differentiates itself from another (Williams A., Dobson P. et al. 1993; Duarte D. L. and Snyder N. T. 2001). Based on various literatures identified during this PhD investigation, the term '*culture'* has a wide range of definitions, including:

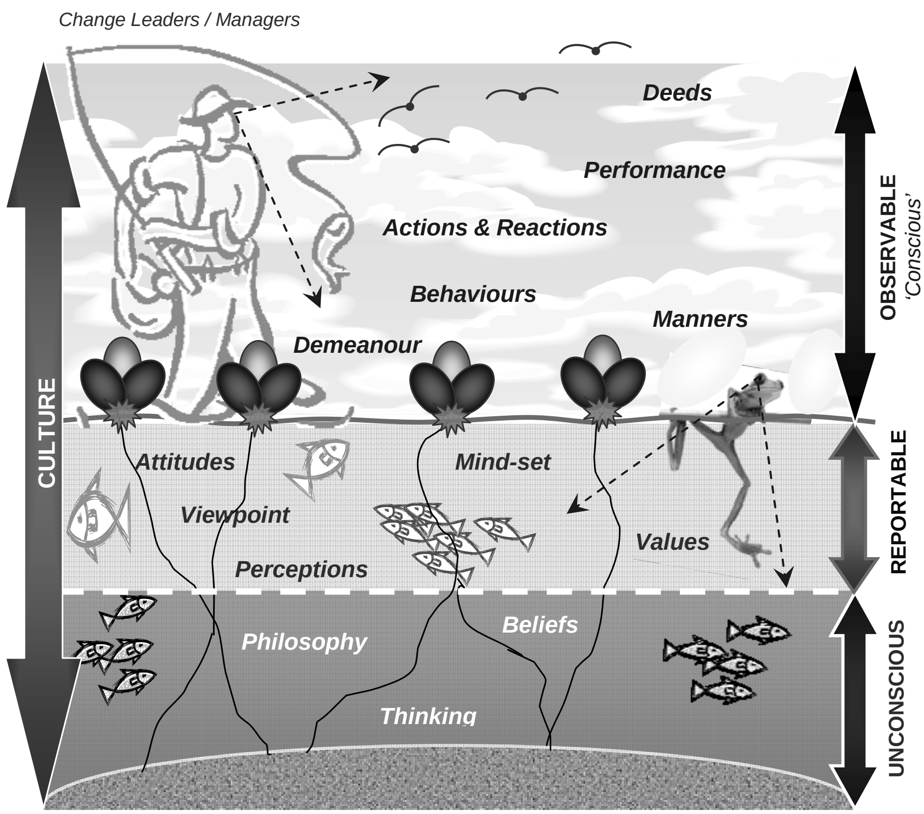
"…being a set of mores, values, attitudes, beliefs, and meanings that are shared by the members of a group or organisation…influenced by traditions, myths, history and heritage...the sum of how we do

things around here" (Hensey M. 2001) p49 (Williams A., Dobson P. et al. 1993; Duarte D. L. and Snyder N. T. 2001)

"…pervades the decision-making and problem-solving process of the organisation, influencing the goals, means and manner of action…a source of motivation and de-motivation of satisfaction and dissatisfaction [thereby] *underlining much of the human activity in an organisation"* (Williams A., Dobson P. et al. 1993) p15

"…a pattern of shared basic assumptions that has been learnt whilst solving problems, that has worked well enough to be considered valid and, therefore, to be taught to new members as the correct way to perceive, think, and feel in relation to those problems…[culture therefore] *begins to form wherever a group has enough common experience which in turn becomes the property of that group"* (Schein E. H. 1999) p13 and (Schein E. H. 1997) p12

The characteristic patterns of a group's behaviour and the elements of its culture can also be portrayed using a diagram of a *Lilly pond* (Figure 2). Briefly, the *Lilly Pond of Culture* illustrates that the behaviour, attitudes, and values of members is dependent upon the sets of both conscious and unconscious beliefs that individual members possess, and that these beliefs are seen as a '*key element*' of organisational culture (Williams A., Dobson P. et al. 1993). Another way of interpreting the *Lilly Pond of Culture* is as '*hidden scripts*' created by repeated interactions between members of a group, which are used (consciously and unconsciously) to guide their behaviours. These, over time, become '*invisible'* and '*second nature*', serving as '*shortcuts'* for guiding daily actions, creating perceptions or assumptions, and forming an fundamental part of any decision-making process (Duarte D. L. and Snyder N. T. 2001).



Adapted from (Williams A., Dobson P. et al. 1993)

Figure 2: The '*Lilly Pond*' of Culture

WORKING / OPERATIONAL DEFINITION FOR THE TERM 'CULTURE'

Based on the afore mentioned findings of the in-depth literature investigation of this PhD study, the author proposes the following working / operational definition for the term 'culture' - underpinning the fourth interconnected dynamic of the proposed sustainable AEC industry specific best-practice '*Innovation-driven Change Framework*' (Figure 1):

Culture is a collection of common experiences, standards, assumptions, perceptions, morals, beliefs, and 'ways of thinking' that both 'represent' and 'influence' the way 'things are done' by members within an organisation, group, or team environment

INDIVIDUAL RESISTANCE TOWARDS CHANGE

"…since an organisation's success or failure is essentially due to the things that its employees do or fail to do… planned change also is concerned with changing the behaviour of individuals and groups within the organisation" (Robins 1998) p629

From an individual's perspective, resistance towards innovation-driven change initiatives resides in basic human characteristics (perceptions, personalities, needs, fears, etc). Five reasons as to why individuals resist change are illustrated in Table 2:

"…change substitute ambiguity and uncertainty for the known…" (Robins 1998) p633

Table 2: Five Individual Sources of Resistance towards Change

SOURCE OF RESISTANCE	CHARACTERISTICS
i. Habit	**We as humans are essentially habitual in nature (creatures of habit), where life's complexities and daily decisions are challenging enough. To cope with today's stressful work environment, employees rely on many '*habits*' and '*programmed responses*' that have developed and become entrenched within them over time. But when confronted with change, the tendency to respond in ones habitual ways itself becomes a source of resistance. By simply '*changing places*' can disrupt an individual's habits when, for example, a department decides to move to a new office building or when a team moves onto the next project – causing involuntary changes to certain established habits, such as: building new working relationships; identifying new personal/professional boundaries; etc.**
ii. Security	**Certain people have an elevated need for security and are likely to resist change because it threatens their sense of *safety* - fearing that the implementation of an innovation-driven solution may threaten their current employment status, need of expertise, or skill-sets.**
iii. Economic Factors	**Similar to the '*security*' factor, these economic-based fears surface due to employees being concerned that they won't be able to '*…perform the new tasks or routines to their previous standards, especially when pay is closely tied to productivity*.'**
iv. Fear of Unknown	**Employees and project team members dislike uncertainty within their work environment. Therefore, if the reasons and benefits of implementing an innovation-driven change initiative is not clearly articulated (clouded or disguised), they may develop a negative attitude or behave dysfunctional toward the newly proposed initiative**
v. Selective Information Processing	**Individuals tend to shape their world through their perceptions of their environment. Once created, this *perceived world* tends to resists any form of change**

	(where employees / project team members '*selectively process information*' in order to keep these perceptions intact) - achieved by '*…only hearing what they want to hear… ignoring any information, arguments, statistics or potential benefits that may influence the world they've created around them*'

Adapted from (Robins 1998) p633

NEED FOR CULTURE CHANGE

"…if people fail to see the need for change (whether threat or opportunity driving it), they will not change" (Black J. S. and Gregersen H. B. 2002) p20

Fortunately, the last two decades show an increase in organisations and project teams seriously considering the *human factor* (culture) as an essential component of a business decision-making process in determining the need to employ an innovation-driven change initiative – i.e.: where the culture and sub-cultures of today's project-based organisations and teams are perceived to play an essential role in the implementation process of a sustainable innovation-driven change initiative. Many organisations decide to change their existing culture based on the need to implement a strategy-driven change initiative, usually due to a certain business '*crises*' or '*opportunity*' being identified, which in turn '*insists*' on the need to change the existing culture itself. Interestingly, many organisations and project teams who successfully change their culture and sub-cultures initially do not have '*culture change*' as their initial or main objective. Instead their main objective is to successfully implement a new business strategy or introduce a new company policy. This process subsequently and very much coincidently, also changes employee beliefs and attitudes towards that change or '*new way of doing things*' and thus the culture of the organisation as a whole (Williams A., Dobson P. et al. 1993)

"…if you do not see a truck racing towards you, you are unlikely to jump out of the way… likewise… if you do not realise that you are standing on a treasure of gold, you are unlikely to bend down and pick it up" (Black J. S. and Gregersen H. B. 2002) p20

With change being the '*only thing constant in our world today*', the above extract reinforces the importance for organisations, groups and project teams to realise and create a need for culture change, before the act of change can take place. Unfortunately, to convince people of the need for change is easier said than done, because (a) people tend not to see even the most obvious threats and opportunities, and (b) being '*blinded*' by their '*traditions*' (the '*way we have always done things around here*') (Black J. S. and Gregersen H. B. 2002). By continuing to ignore the various *human factors* during a decision-making process can essentially result in the implementation of '*well-designed*' change solutions, frameworks, processes, etc. to fail due to a number of reasons, including (a) senior managers and project leaders lack of understanding, experience, capabilities and support, or (b) employees telling themselves '*…this too would blow over*' (McDermott R. and O'Dell C. 2001) p77. In other words, when considering the need to implement a innovation-driven initiative or '*new way of doing things*' into long-established organisational arrangements and multiple project culture and sub-culture environments, senior management and project leaders can not simply assume that once implemented, it will automatically ensure an increased sense of employee / project team member acceptance, commitment, or enhanced levels of trust and motivation – i.e.: a positive change in culture towards that implementation (Graham M.B.W. 1996).

METHODS OF CHANGING CULTURE

The author's PhD literature investigations identified and assessed a number of alternate methods and approaches to implementing culture change initiatives within organisational and project team environments. The two most relevant in meeting the aims and objectives of this PhD study – i.e.: help transform the AEC industry and its inherent resistance towards change - are discussed here.

Six Key Culture Change Factors

Almost two decades have passed since industry leaders were originally exposed to the first culture change mechanism (presented for the purpose this paper), which comprises of six key areas that need to be considered when attempting to change the culture of an organisation or project team. More recent literature investigations still support this approach and therefore validate its relevancy to incorporate it in helping develop the fourth dynamic of the 'Innovation-driven Change Framework' (Williams A., Dobson P. et al. 1993) and (Robins 1998), (Maull R., Brown P. et al. 2001) and (Schneider W.E. 2000). To follow, a summation of the six key areas and their relevance to successfully changing the culture of an organisation:

- **Changing People:** By changing people (particularly those in key positions or those with '*uncompromising attitudes*'), one may change the pattern of beliefs and attitudes within the organisation (promote cultural change). Recruitment, selection and redundancy are frequently part of the change process, but because employee commitment and positive culture is recognised as being essential to the long-term *survival* of an organisation, it is suggested to do this only once – that is, make one '*large cut'* rather than a series of small ones.
- **Changing People's Beliefs and Attitudes:** Due to beliefs of individuals directly being influenced by or formed through observation, interaction, participation, and persuasive communication, one or more of the following methods for changing the beliefs, attitudes and values of employees are recommended:
    - **Through use of role models (Champions):** Simply through observation, people are likely to imitate the behaviours of senior / key individuals (acting as role models or champions) that they believe are likely to lead to success.
    - **Through participation:** Formalised group discussions (morning meetings, team briefings, etc.), are alternate methods for developing shared beliefs and attitudes.
    - **Through use of formal communication:** Attempts in changing employee beliefs and attitudes can be used more effectively to better '*communicate'* the organisation's culture to their employees and local community from which they recruit the majority of their employees – e.g.: by publishing articles entitled '*protecting customer investment*'; '*putting the customer first*'; or '*responding to change demands'*.
    - **Through counselling:** When, for example, there is a need for an organisation to make significant reductions in staff in order to cut costs and improve its profitability, it is difficult to promote a proactive and positive culture at the same time. Therefore, once the process of informing management is complete, and there is complete commitment to the change from the most senior level, it is suggested each level of management carries out one-to-one interviews with their employees.
    - **Through Management Education:** Educating management and change leaders and then '*cascading'* this newly acquired knowledge and management process down to the rest of the staff is a central strategy for many organisations to achieve a cultural change.
- **Changing Behaviour:** Changing culture is not only a matter of teaching people new techniques or replacing old procedures or processes with new ones. Yet, training new skills is likely to influence an inevitably change people's beliefs and attitudes (culture) towards, their capabilities in producing a new product or outcome, or accepting the *new way of doing things*.

- **Changing Places:** Sub-cultures within an organisation develop around differences in functions, roles, and levels of its members. Therefore, by '*reshuffling*' or '*rotating*' groups / individuals, with different knowledge, experiences and skill-sets, and move them into key positions within other sub-cultures can result in improved performances, attitudes, beliefs and values in not only the department or project team they are relocated to, but also the one they left behind.
- **Changing Structures, Systems and Technology:** Changing the structure of an organisation or project team will usually make an unpredictable impact on its culture – influencing existing work groups and communication networks. By revising and improving existing rewards, appraisals, incentives, monitoring, budgeting and control systems (said to be linked to specific individual and group behaviours) will inturn increase the chances of changing people's beliefs and attitudes towards performing in the required way.
- **Changing the Corporate Image:** By developing a corporate image (e.g.: a name, logo, advertising, publication of success, etc.), typically develops positive attitudes among both clients, employees and their commitment towards the organisation or project. This is described in some cases as '*optimistic expectations*', where a positive attitude and commitment towards (a) the organisation, is viewed as being different towards (b) one's job, product quality or specific behaviour.

Four Generic Approaches to Changing Culture

The second method of implementing culture change initiatives within organisational or project team environments is presented in Table 3. The four unique approaches to changing culture also form an integral part of the fourth dynamic of the 'Innovation-driven Change Framework' – i.e.: to help industry leaders correctly identify and better understand the underlying truth and origin of an organisation's culture and the challenges it presents when attempting to implement an innovation-driven change initiative.. Interestingly, although related to the process of changing culture, these four generic approaches are also described as not necessarily culture specific. This is mainly due to certain change leader perceptions being that (in practice) there is little difference between trying to (a) change peoples attitudes, values, assumptions, etc. (culture) and (b) change structures, tools, operation systems, processes, or any other aspect of an organisation (Bate P. 1996).

Table 3: Four Generic Approaches to Culture Change

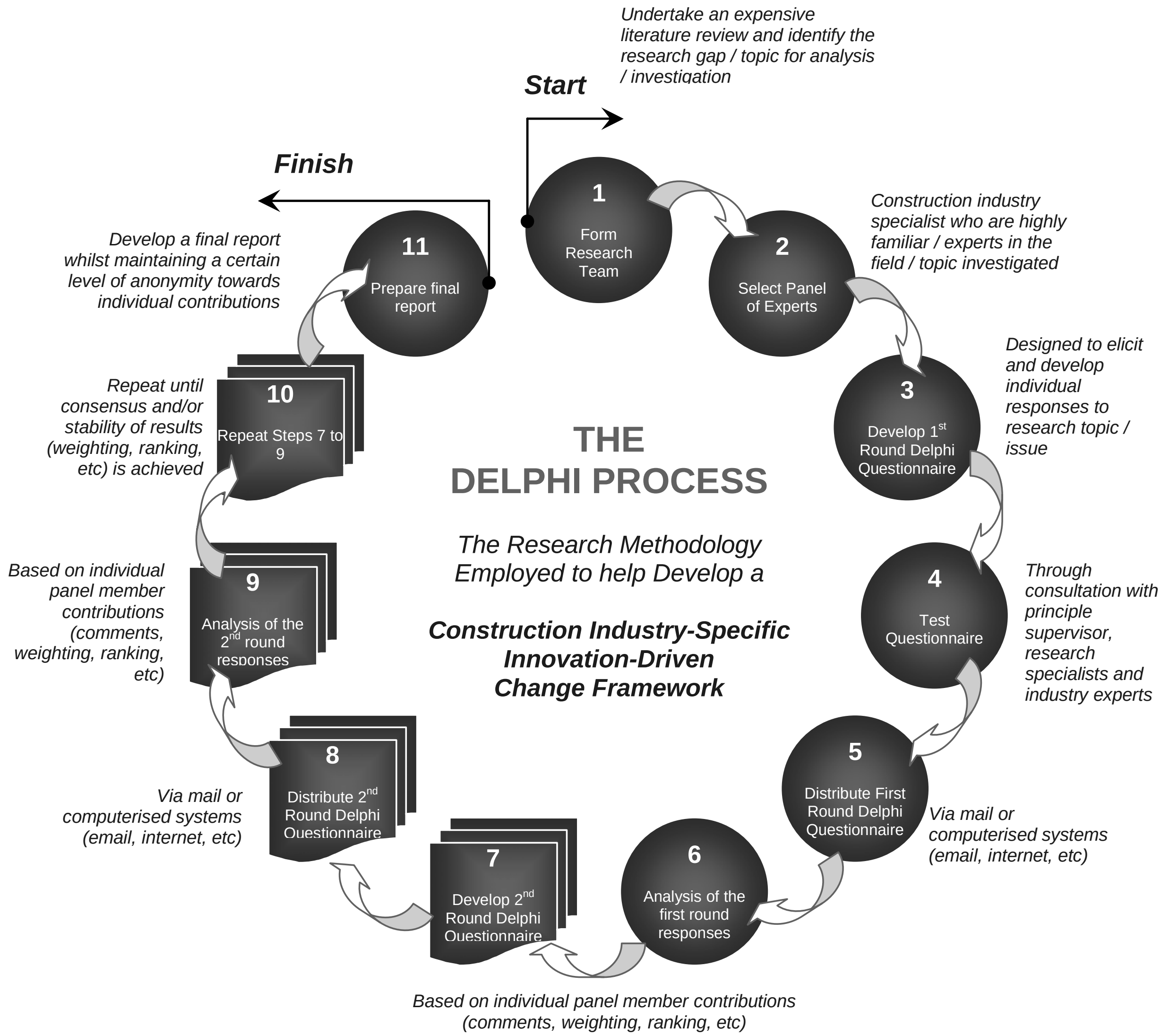
APPROACHES	CULTURE CHANGE CHARACTERISTICS
i. Aggressive	• **Also referred to as '*cultural vandalism*' or '*wilful attack*' on the traditional values of an organisation and its members, creates disruption and provides clear notice of intention to establishing a '*new culture order*'.** • **Fortunately these '*pre-civilised bullies*' belong to a small minority of the business world and tend to live in the past and sometimes motivated solely by the desire to irritate and create trauma.** • **Alternate terms used to describe this '*radical*' approach are: *Power coercive; Conflict centred; Non-collaborative; Win-lose; Imposed; Dictate approach; Unilateral***
ii. Conciliate	• **This approach believes cultural change can take place through '*non-dramatic, gradual and routine means*', and in many cases unnoticed by those involved.** • **Although seemingly plausible, it is more likely to be successful in bringing about '*first order development change*' rather than '*second order transformational change*'.** • **Alternate terms used to describe this '*conservative*' approach are: *Group problem solving; Win-win; Collaborative; Emergent; Integrative; Joint approach***
iii. Corrosive	• **Seen by many as an essentially political process can effect major change through the distribution of power and authority within the corporate hierarchy.** • **The organisation is viewed in terms of a '*formal authority and informal power*' – that is, an invisible network of power structures that are shared by all, with no dominant party, and found difficult for a solution to be imposed by any individual or group.**

	• **Ones this '*old boys network*' culture is established, changing it becomes increasing difficult due to the status quo.** • **Alternate terms used to describe this '*corrosive*' approach are: *Coalition; Unplanned; Evolutionary; Networking; Informal approach***
iv. Indoctrinate	• **Here organisations and their members can, through cultural training programs, focus on the concept of cultural change as a '*learning process*' (Schein E. H. 1999).** • **Yet, because training is (in its broadest sense) *planned and programmed*, it makes this approach in establishing a new culture less '*aggressive*', by '*imposing*' *a* '*suggested*' culture in a *peaceful* and less convincing manner – yet seen as not being incidental, self-directing or individually centred.** • **This process may be better suited to *technical* rather than *cultural* forms of learning – that is, where a training program is less sensitive to the special characteristics and qualities of cultural knowledge and learning requirements.** • **Alternate terms used to describe this '*learning*' approach are: *Normative and Re-educative***

Adapted from (Bate P. 1996)

FUTURE RESEARCH ACTIVITIES

By encompassing a sequential 'research in construction process' – i.e.: by considering both the nature of the data and investigative methods used, the research path within a construction industry environment (organisation, project, etc), is to be in unison with (a) the research plan / design, (b) data collection, and (c) data analysis (Fellows R. and Liu A. 2003)- this PhD study's next step aims to employ the eleven distinctive yet critical steps of the Delphi process (Figure 3) as the primary research methodology to help the author develop and validate the six key, interconnected and interdependent dynamics of the proposed AEC Industry-Specific Innovation-Driven Change Framework (Figure 1).



Adapted from (Illinois Institute of Technology (IIT) circa 1996), (Sharp A.G. circa 1997) and (Linstone H.A. and Murray T. 1975) p182 495

Figure 3: Innovation-Driven Change Framework

Outcomes of the above eleven step Delphi process will be documented in future papers.

CONCLUSION

Culture is one of the most difficult and complex dynamics to understand let alone change. This is mainly due to culture being defined and perceived in so many different and sometimes conflicting ways. Culture is also described as being both influencing and being influenced by various conscious (visible) and unconscious (hidden) factors that determine the unique way in which members of an organisation, group or project team address and interact with one another. Senior managers and change leaders therefore need to seriously consider the various features, characteristics and qualities of its culture and sub-cultures, and make it an integral part of their decision-making process of implementing an innovation-driven change initiative into an existing work environment. Should this '*lack of attention*' to the human aspects of today's highly competitive AEC industry and project-driven organisations continue, then the application of even the most optimum or fail-proof implementation strategy may in many cases be worthless. That is to say, if an organisation's most valuable resource (people) is not properly aligned with, and supportive of, the implementation strategy itself, the strategy will either stall or fail (Schneider W.E. 2000). Few could have predicted the substantial changes and almost '*seductive'* influence the introduction of certain technology-led and innovation-driven change initiatives would have on today's AEC industry overall culture (people) and business environment. Factors contributing to this level of '*confusion'* and '*naiveties'* is the immense difficulty in '*transforming'* individual personalities, as they are inevitably hindered by the AEC industry's (a) exceptionally fragile level of trust, (b) its reluctance to share knowledge and experiences, (c) its inherent and deeply entrenched resistance to doing things differently, and (d) its multiple levels of sub-cultures, each with their own unique perceptions, beliefs, value sets and attitude towards a proposed innovation-driven change initiative.

The six mutually dependent dynamics of the *Innovation-Driven Change Framework* (Figure 1) are discussed independently and comprehensively within the all-encompassing PhD literature investigation (presented in separate papers):

- CHANGE: An in-depth investigation into the act of change itself and the intricacies, methods, models, frameworks, drivers and barriers associated with it.
- INNOVATION: Various types, challenges, myths and realities of a proposed innovation-driven change initiative or '*new way of doing things*' is examined.
- IMPLEMENTATION: Various implementation strategies and processes for employing a sustainable innovation-driven change initiative are investigated.
- **CULTURE:** Although this paper only focuses on a summation of the literature investigation findings pertaining to the fourth dynamic of the *Innovation-Driven Change Framework* – that of the deeply embedded culture of project-based industry organisations - the in-depth PhD literature investigation provides (a) additional information on alternate culture types, personalities and characteristics, (b) explores a variety of motivational factors, rewards and incentives, and (c) examines the inevitable threats and opportunities that influence the success or failure of implementing a sustainable innovation-driven change initiative within today's highly competitive AEC industry arena.
- LEADERSHIP: Various challenges and opportunities associated with effectively leading or championing the implementation of a sustainable innovation-driven change initiative are highlighted.
- TRAINING AND EDUCATION: Elaborating on various factors driving the essential need to facilitate both internal and external training environments and incentives attuned to capturing lifelong learning (experience) and applying newly attained knowledge (lessons learnt) on how to successfully implement an innovation-driven change initiative within an organisation or project team environment.

Finally, based on the summation of literature findings documented in this paper, the author argues that every organisation and project team within the AEC industry has its own unique culture, character, nature, and identity. By employing an *AEC Industry-Specific Innovation-Driven Change Framework* that facilitates the means of better managing and leading a dedicated, highly skilled, motivated, flexible, co-ordinated, committed, and productive workforce, coupled with a leaner, flatter, and more responsive environment will ensure the fruition of an indispensable and sustainable culture change philosophy.

REFERENCES

Bate P. (1996) Strategies for Cultural Change, Oxford, Butterworth Heinemann

Black J. S. and Gregersen H. B. (2002) Leading Strategic Change: Breaking Through the Brain Barrier, New Jersey, Pearson Education Inc

Duarte D. L. and Snyder N. T. (2001) Mastering Virtual Teams: Strategies, Tools and Techniques that Succeed, San Francisco, Jossey-Bass Inc

Fellows R. and Liu A. (2003) Research Methods for Construction (Second Edition), Great Britain, Blackwell Science

Graham M.B.W. (1996) "Changes in Information Technology, Changes in Work", Technology in Society 18(3)

Hensey M. (2001) Collective Excellence: Building Effective Teams, Virginia, American Society of Civil Engineers (ASCE) Press

Illinois Institute of Technology (IIT) (circa 1996, February 2008) "The Delphi Method" Retrieved February, 2008, from http://www.iit.edu/~it/delphi.html and http://www.iit.edu/.

Linstone H.A. and Murray T. (1975) The Delphi Method: Techniques and Applications, Addison-Wesley Publishing Company

Maull R., Brown P., et al. (2001) "Organisational Culture and Quality Improvement", International Journal of Operations & Production Management 21(3)

McDermott R. and O'Dell C. (2001) "Overcoming Cultural Barriers to Sharing Knowledge", Journal of Knowledge Management 5(1)

Pepper G. L. (1995) Communications in Organisations: A Cultural Approach, McGraw-Hill Inc

Robins, S. P. (1998) Organisational Behaviour: Concepts, Controversies and Applications, New Jersey, Prentice Hall Inc

Schein E. H. (1997) Organisational Culture and Leadership, San Francisco, Jossey-Bass Inc

Schein E. H. (1999) The Corporate Culture Survival Guide, San Francisco, Jossey-Bass Inc

Schneider W.E. (2000) Why Good Management Ideas Fail: The Neglected Power of Organisational Culture Strategy & Leadership

Sharp A.G. (circa 1997, February 2008) "Delphi Technique: The Beginnings", Encyclopaedia of Business, 2nd ed, from http://www.referenceforbusiness.com/encyclopedia/Cos-Des/Delphi-Technique.html

Webster (1956) Webster's New World Dictionary, London, Macmillan & Co Ltd

Williams A., Dobson P., et al. (1993) “Changing Culture: New Organisational Approaches”, London, Institute of Personal Management (IPM)

INCENTIVIZATION AND INNOVATION IN CONSTRUCTION SUPPLY CHAINS

Obuks A. Ejohwomu and Will Hughes
School of Construction Management and Engineering, University of Reading, UK
O.A.Ejohwomu@reading.ac.uk; w.p.hughes@reading.ac.uk

The UK construction and building services sector is under pressure to engender the culture of innovation and incentivization as normal working practice in the delivery of 'flexible' and 'complex' infrastructures. The role of contracts in the incentivization of performance and particularly the diffusion of innovation in construction supply chains is not well understood. Therefore, this research contribution, which is qualitative, will investigate contract interfaces in construction supply chains to explore how construction clients, contractors, manufacturers and suppliers are motivated to improve the performance of products and services they procure or provide. The focus is on how information is shared in terms of scope, time and price and how it is diffused throughout the supply chain. Emerging evidence suggests that the culture of incentivization and information sharing are not standard practices and the contractual interfaces (particularly where it goes beyond the first tier of the supply chain) do not favour the diffusion of innovation. Innovation must be quantified for clients and manufacturers to better lead the process by which it is diffused throughout the supply chain.

KEYWORDS: incentivization, innovation, supply chain, healthcare infrastructure.

1. INTRODUCTION: A HEALTHCARE DELIVERY PERSPECTIVE

The significance of UK's National Health Service (NHS) cannot be over-emphasized. The NHS aims to provide healthcare for all at the point of need. Ever since it was established, successive governments, particularly in the last decade, have produced a plethora of policies in the midst of technological advancement for the sustainability of the NHS ethos[1]. While the procurement of healthcare facilities is intrinsically complex, it is made more difficult by the constant flux in government policy towards healthcare delivery. The policy context cannot be ignored when considering how healthcare facilities are bought. This long-standing challenge and the complexities associated with the delivery of healthcare infrastructure are the focus of this research. In order to work out whether the circumstances of the NHS create a unique procurement environment, the

[1] The underlining NHS ethos in the context of this research is providing healthcare at the point of need.

study will also draw on lessons captured from the delivery of facilities and infrastructure outside healthcare, as well. The aim is to consider the role of contracts in the incentivization of performance and particularly the diffusion of innovation in construction supply chain. Contract interfaces in construction supply chains will be explored to examine how construction clients, contractors, manufacturers and suppliers are motivated to improve the performance of products and services they procure and provide. The evidence to be collected will be on how information is shared in terms of scope, time and price and how it is diffused throughout the supply chain.

2. CONTEXT AND BACKGROUND

The most straightforward definition of innovation is that innovation is technical and organizational change (Gann, 2003); a more widely accepted definition – "…the actual use of a nontrivial change and improvement in a process, product, or systems that is novel to the institution developing the change" was offered by Slaughter (1998). However, the study of innovation predates the late 1960s (Gann, 2003), yet the key benefits of innovation as a driver for business competitiveness, quality and productivity improvements and, ultimately, economic growth, is largely only "thought of" and not "exploited" by most sectors in practice. The manufacturing sector is often portrayed as a good example of the latter, where creativity and innovation are increasingly driving the boundaries of performance (Guilford, 1959; Barron, 1969; and Stein, 1991); this compliments the argument that manufacturers invest more in research and development of 'creativity' than contractors and consultants (Gann, 1977). Where, creativity is the generation of creative ideas while innovation is the successful implementation of creative ideas (Eaton *et al.*, 2006).

To this end, the widespread perception that the construction industry performs badly compared to other industrial sectors (Winch, 2003), may hypothetically suffice the argument that the construction industry is less proactive and more reactive in adopting the culture of innovation. Fragmented supply chains and the existing divide between academia and industries have been identified, too, as inhibitors to innovation adoption in the construction sector (Dulaimi *et al.,* 2002). A claim, which other commentators argue could be remedied through the proactive influence of clients and manufacturers (Manley, 2008). In particular, Barlow (2000) reported that clients do have enormous capacity to encourage innovation diffusion amidst integrated working practices, which Manley and Marceau (2002) argue can be cultivated by clients' demand for "total package" solutions. Adopting the manufacturing industry's practice of a contractual interfaces with clear boundaries and transactions between them - these are usually simple buyer-seller relationships – favours creativity in the construction sector (Gann and Salter, 2000). Therefore, the overarching research question in this investigation, is, to what extent are incentives used to encourage innovation and diffusion in construction supply chain? In other words, there are limited studies, which currently address what incentives are used in construction contracts for effective delivery of work packages in the supply chain; the need to understand what non-contractual incentives are used for incentivizing effective delivery, and how are incentivization and innovation facilitated or inhibited in the construction supply chain? More importantly, the "reverse product model" on innovation diffusion proposed by Barras (1986 and 1989), is very 'macro' in its approach and not any construction specific in its application. This model is not sufficient for understanding the processes by which major new technologies are transmitted in the growth cycle (take-off of product innovations to radical growth process innovation and matured incremental process innovation) because it is not developed to capture the role of actors who participate (for example; clients, manufacturers, tradesmen and contracts) in the incentivization and diffusion of creativity.

2.1. CONSTRUCTION INCENTIVIZATION

The focus on the recurring question in construction contracting of "how to get people to improve their performance" is gradually shifting to that of "what kinds of incentives are in use in the construction sector" (Hughes *et al.*, 2006 and 2008). In other words, the authors (Hughes *et al.*, 2008) where in part investigating how construction participants describe what motivates them to innovate throughout the supply chain. Notably, Hughes *et al.*, (2008) have argued that the term incentives is better investigated by contextualizing its economic, relational, legal, and psychological perspectives, which may be associated with monetary and non-monetary incentives, contractual incentives and extra-contractual incentives. Although, this contribution has enlivened the discuss on incentivization in the construction sector; there is need to understand what construction industry participants think about when they are urged to perform quicker, cheaper and better. A gap – among the range of papers and articles about incentivization of performance there is almost no recognition of the extended supply chains (Hughes, *et al.*, 2008), which this investigation aims to address. The next section outlines the methodology by which the overarching aim of this research, which is, to understand the structure of construction supply chains and how they facilitate the delivery of infrastructures through incentivization will be achieved.

3. RESEARCH METHOD

The research method is qualitative, involving a scoping study, which comprises open, unstructured interviews. The interviewees (30 - 50) will be UK construction contractors, client, manufacturers and suppliers who operate in the healthcare, housing and education sectors. First, the data were interrogated for evidence of innovation and clarity of contract structure. Second, the views of data subjects were compared in the different sectors in relation to contract types, interfaces and supply chain management experiences. At each contract interface, the contract details were identified. These include method of calculating price, reward structures, penalties, how scope was defined, responsibility for design, responsibility for co-ordination, access to information from more distant tiers in the supply chain, and so on. Contrasting issues are chosen from initial interviews, and follow-up interviews are used for detailed data gathering. The data subjects are predominantly participants in the construction supply chain, rather than the client side of healthcare, housing and education, although some of these will be involved where they interact directly with the supply chain participants. The data is still being analysed through a combination of content analysis and graphical representation of contract and incentivization structures. By delineating these processes, we will be able to detect whether there are consistent and systematic features that encourage or impede innovation, leading to recommendations about contract drafting policy and supply chain structure for these cases.

3.1 ANTICIPATED CONTRIBUTION TO KNOWLEDGE AND PRACTICE

It is currently being envisaged that this research will help understand those features of supply chain and contract structures that contribute to engendering innovative solutions to the provision of flexible healthcare services and hospital infrastructure. In addition, a theoretical contribution would be achieved in terms of how the study will be mapping and characterizing supply chains, a process that is difficult and rarely carried out.

The research's envisaged contribution to practice at the regional level is to enable providers of infrastructure to learn from each other in terms of establishing reward systems that motivate and incentivize those who deliver infrastructure. At the national level the research may contribute to development of guidance and policy about how the procurement of infrastructure could or should be arranged to incentive innovation in the supply chain. At the international level, the UK national policy and guidance about incentivization of innovation in the supply chain may become a leading example, and insights into business theory will contribute to the wider debate on the role of contracts in business. In relation to the value of this research outcome, Policy-makers will be able to influence business practices because of an increased understanding of the intricacies of contract interfaces in construction supply chains. Emerging policies would question and challenge the culture of flexible contracts. This would enable decisions that can be effectively implemented, regarding a culture of innovation and incentivization in construction supply chains. Clients and their consultants will be able to choose the extent to which they wish to engender a culture of incentivization and innovation throughout the construction supply chain, with an understanding of the kinds of contract that encourage or discourage innovation. Clinicians and hospital workforce will have a better understanding of their key role and become more proactive in the delivery of flexible infrastructure. Main contractors will be able to understand better how to influence the business culture and the use of incentives, whether monetary or non-monetary, contractual or extra-contractual, throughout the supply chain. They will also be able to develop strategies for innovation through the supply chain, penetrating beyond the first tier. Specialist contractors and suppliers will be in a better position to engage in pre-contract activities in order to develop the diffusion of innovation throughout the supply chain.

5. EMERGING PATTERNS FROM PRELIMINARY ANALYSIS

The data gathering process, which is an open ended interview with an average duration of 75 minutes, is still ongoing amid the initial analysis and coding of interview transcripts (using Nvivo) in order to facilitate the seeking of patterns and theories where and if it exists. The characteristics of the data subjects thus far encompasses; CEOs, supply chain managers, procurement directors, commercial directors and development policy managers of manufacturing, supplying, main and specialist contracting and client organizations. While it may be difficult to achieve the exact balance in terms of aggregation of participating data subjects, patterns are beginning to emerge from the ongoing analysis. For example, it is the view of manufactures that the existing forms of contract interfaces, in particular, tendering are a barrier to innovation diffusion "*Participant (3) Sorry, you were unlucky, you were too expensive." Now we know when we put that product – and it is our finest recyclable product, it's designed purely so that when you take it off the roof, you'll have 95% return on it, and we put it in very competitively. Now the guy who we were up against now works for me, so I know where we were and we just – we weren't considered and yet that was a good example of going to the Authority said – the Architect said, "I really like the idea of this, I like the sound of this, get it tendered and if it's competitive, we'll use it." We had no chance. So I really don't know how you could ever prevent that happening because people have friends. It's nice if they're your friends, but I can see the wider picture that when it comes to tendering, you've got to prevent collusion, you've got to encourage competition, but you mustn't stifle innovation, whether it's on the contracting side or the production side".*

Main and specialist contractors seem to have a consensus view on the merits of innovation and incentivization but they rarely put it to practice because of contractual constrains *"Participant (1) ...I think we've got to look to improve what we do, and when you look at the air tightness, sort of, regimes, they have things that are going to save you money quickly, if you plug all the gaps up, you make sure that you're not losing air where you shouldn't be losing air. And so there's quick wins to be had, and I think they're probably more effective than the money, sort of, innovation, which is wind turbines, biomass boilers, this that and the other…*".

The public sector clients (UK housing associations mainly), which are a non-profit organization, are heavily regulated by the government whom they depend on for funding; and this puts them in a better position to drive innovation when compared with their private sector counterparts. In other words, they draw on the benefits of framework agreements and flexibility of not being profit driven, which they argue offers a more flexible contractual interface that is driven by working relationships and continuity of work "*…we try and be proactive, and I suppose, if we were talking about innovation, which – and there's a question in here – the things that we have done, a lot of the jobs that we've done for Hertfordshire have been series of residential houses, so it's repetitive, so it goes, bom, bom, bom, bom, bom. And they started off at about 21 weeks. I think we got them down to about 17...*"

5.1. DISCUSSION: THE PERCEIVED ROLE OF SUPPLY CHAINS (SC) IN THE INCENTIVIZATION AND DIFFUSION OF INNOVATION

The significance and/or role of SC in the incentivization and diffusion of innovation have generated mixed opinions and this can be attributed to the diversity of participants (data subjects). In particular, the majority of interviewees did not think it was directly beneficial, in practice, for businesses to have serious interactions with members of their supply chains beyond the first tier, even though they thought further interactions could in 'principle' yield some degree of long-term benefits. Further interrogation of data, however, indicates that the associating contractual interfaces associated with these set of interviewees, which are very traditional and non-negotiable in practice where a barrier to innovation as it did not allow room for "doing things differently". On the contrary, the very few participants who remained steadfast on the functional role of SC in the incentivization and diffusion of innovative ideas argued the SC is key to achieving increased productivity and heightened satisfaction in the construction industry. A logical explanation for such a firm opinion can be linked with the type of contractual interfaces, which where negotiable, relational and less transactional. It is worth noting also that these groups of participants (specialist contractors and manufacturers) were in practice prepared to accept the risks associated with the notion of having "to do things differently".

6. CONCLUSIONS

There is consensus among commentators that the UK construction and building services sector is lagging comparatively in creativity regardless of its peculiarity of being a provider of bespoke services. In other words, the fragmented structure of its supply chain and persisting divide between academia and industry remain a challenge. Though not readily conclusive in terms of statistical validity, emerging patterns into the role of contracts in the incentivization of performance and particularly the diffusion of innovation in construction supply chains suggests that clients, policies and market forces are the key drivers for creativity in the construction sector. In addition, transparent information management through relational contracting is central to innovation diffusion and incentivization with traces of practicality in the implementation of framework agreements and negotiable contracts because it somewhat guarantees continuity of work. However, the practicality of diffusing innovation throughout the supply chain is hugely limited because manufacturers and clients limit their engagements in the respective supply chains to the first tier and where it engages, the contractual interface is less favourable to creativity.

REFERENCES

Barlow, J. (2000) Innovation and Learning in Complex Offshore Construction Projects, *Research Policy*, 29, 973-989.

Barlow, J. and Koberle-Gaiser, M. (2007) Projects Form as a Vehicle for Delivering Innovative, Adaptable Healthcare Facilities: Examples from the UK's PFI Hospital Programme. *IRNOP VIII Conference, Projects in Innovation, Innovation in Projects.*

Barras, R (1989) Interactive Innovation in Financial and Business Services. The Vanguard of the Service Revolution, *Research Policy* 19, 215-237.

Barras, R (1986) Towards a Theory of Innovation in Services, *Research Policy*, 15, 161-173

Barron, F. (1969) *Creative Person and Creative Process*. Holt, Rinehart and Winston

Clough, P. and Nutbrown, C. (2002) *A student's Guide to Methodology*. London: Sage.

Dept. of Health (2001) *Press Release*, 2001/0553, 16 November 2001.

Dept. of Health (2007) *Press Release*, 2007/96783, 24 March 2007.

Dulaimi, M.F., Ling, F.Y.Y., Ofori, G. and De Silva, N. Enhancing Integration and Innovation in Construction. *Building Research and Information* 30 (4), 237-47

Eaton, D., Akbiyikli, R. and Dickinson, M. (2006) An Evaluation of the Stimulants and Impediments to Innovation With PFI/PPP Projects, *Construction Innovation*, 6, 63-77

Eisenhardt, K. M. (1989) Agency Theory: An Assessment and Review. *Academy of Management Review*. 14(1), 57-74

Gann, D (1997) *"Technology and Industry Performance in Construction – Draft SPRU Paper*", OECD Directorate for Science, Technology and Industry, University of Sussex, Brighton

Gann, D.M. and Salter, A. (2000). Innovation in Project-based, Service-enhanced firms: The Construction of Complex Products and Systems. *Research Policy* 29 (7-8), 955-72

Gann, D.M. (2003) Guest Editorial: Innovation in the Built Environment. *Construction Management and Economics*, 21, 553-555

Gibson, E. J. (1982) Working with Performance Approach in Building. CIB Report Publication 64. Rotterdam, Netherlands. CIB (International Council for Research and Innovation in Building and Construction).

Guilford, J.P. (1959). *Traits of Creativity*. In Anderson, H.H., Editor, Creativity and Its Cultivation. Harpar.

Hughes, W., Hillebrandt, P., Greenwood, D and Kwawu, W (2006) *Procurement in the Construction Industry: The Impact and Cost of Alternative Market and Supply Processes*, London: Taylor and Francis.

Hughes, W., Yohannes, I. and Hillig, J (2008). Incentives in Construction Contracts: Should We Pay For Performance? Conference: Knowledge and Information Management Through Life, held at the University of Reading.

Manley, K (2008) Implementation of Innovation by Manufacturers Subcontracting to Construction Projects. *Engineering, Construction, Architectural and Management*, 15 (3), 230-245

Manley, K and Marceau, J (2002) "" Integrated Manufacturing-services Business in the Australian Building and Construction Sector" *Australian Journal of Construction Economics and Building*, 2 (1), 1-12

Richmond-Coggan, D (2001) *Construction Contract Incentive Contracting Schemes: Lessons from Experience (C554)*, London: Construction Industry Research and Information Association.

Slaughter, S.E. (1998), Model of Construction Innovation. *Journal of Construction Innovation Engineering and Management*, 124, 226-31.

Stein, M.I. (1991). Creativity in People. *Leadership in Organizational Development Journal* 12, 4-10

OUTSOURCING IN CONSTRUCTION
A TRANSACTION COST THEORY INTERPRETATION

Nicola Costantino
Politecnico di Bari, Bari, Italy
costantino@poliba.it

Roberta Pellegrino
Politecnico di Bari, Bari, Italy
r.pellegrino@poliba.it

Roberto Pietroforte
Worcester Polytechnic Institute, Worcester, USA
roberto@WPI.EDU

The high variety of construction projects in the construction industry requires several technological and production capabilities by firms. The organization and production arrangements of these contracting organizations vary according to the particular type of construction in order to optimize the use of the production resources. This paper analyzes the characteristics of US contractors in terms of markets, technologies, capabilities and production arrangements according to the framework of transaction cost theory. The analysis shows that firms tend to internalize or outsource part of their production depending on the specificity of their assets. Census data are used to support the particular production criteria of firms as predicted with the considered theory.

KEYWORDS: Transaction cost theory, outsourcing, specialization, U.S. construction.

INTRODUCTION

The construction output is characterized by a high diversity of technological inputs of varying complexity. The variety of the technological and know-how requirements of construction projects determines specific demands that can be met by firms with matching capabilities. Such a factor leads different firms to develop expertise in particular types of construction and invest accordingly. These capabilities are reflected in the composition of the U.S. construction industry, whose enterprises are classified according to their specialization, namely, residential building, non-residential building, non-building and specialty trade construction firms. The characteristics of these firms, in terms of markets, technologies, capabilities and production arrangements, are not casual, but rather reflect the organization criteria of the supply chain that optimize the use of the production resources and that differ according to the type of construction. The variability of these criteria can be explained in terms of Transaction Costs Theory (TCT), particularly in regard to the asset specificity of production means and workers' capabilities. In fact, TCT provides a useful framework for analyzing how the construction firms organize their production, that is, why they decide to internalize or outsource the work production for a project. The purpose of this paper is to use TCT to predict the particular production arrangement (or extent of outsourcing) of a firm, depending on the specificity of their assets. Then, these theoretical considerations about the expected specialization and production characteristics of the firms that operate in the aforementioned construction markets are supported by U.S. census data. The rest of the article is organized as follow. Next section presents the characteristics of the U.S. construction market. Particularly, a series of theoretical considerations are developed to show the relationship between the number and specificity of technologies embodied in a construction project, and the specialization extent as well as type of investment by firms in a particular construction sector. These investments encompass the acquisition of human (e.g., know-how) or physical (specialized machinery) assets. Then, TCT is used to predict the production arrangements of firms in construction markets. The predicted production arrangements are compared with the census data of the US construction industry, either for general contraction firms or for specialty trade contractors. The data tend to agree with the predictions formulated with the theoretical framework of TCT. Lastly, conclusion and future research are presented.

CHARACTERISTICS OF THE U.S. CONSTRUCTION MARKET

The construction industry produces three broad categories of facilities: those that shelter people - residential buildings; those in which goods and services are produced, stored and exchanged - non-residential buildings; and those (infrastructure) that support all the activities of the users of the above mentioned building categories - non-building (civil and heavy engineering) facilities. Each of these products is characterized by a varying range of technology (trade) requirements that must be met by the firms in charge of its construction. Table 1 shows the main technologies and work activities, including their relative percentage costs, of 6 different types of projects in building and non-building construction. Cost data were drawn from cost estimating guides, such as R.S. Means, and industry sources. The considered projects result from a varying extent of intermediate inputs (labor, components, materials and machinery) with the prevalence of machine and labor intensiveness in non-building and building projects respectively.
Several considerations can be drawn from the analysis of the table data. Building construction (office, hospital and residential buildings) is characterized by more trades than those used in non- building construction (water related, tunnel and highway facilities), i.e., by a broader technological band width (Albino et al., 2000). Some of these technologies, or work activities (e.g., steel and exterior closure), are shared by two or more different projects such as office and hospital buildings, while others are specific to a given project. The machinery and know-how used in tunnel and highway construction, for example, are not interchangeable. Similarly residential constructions (single family homes) are dominated by wood framing and carpentry trades, which are seldom deployed in other types of building construction. The economic importance of technological inputs varies from project to project. Concrete work, for example, is more costly in a wastewater treatment plant than in an office-building project with a steel superstructure.

Table 1: Main technologies and relative cost range of different construction project types (Means, 2000)

Water and wastewater facility project	% Cost range	Tunnel project	% Cost range	Highway project	% Cost range
Major equipment	10-25	Excavation	34-58	Earthwork	6-9
Concrete work	10-20	Support	4-47	Roadway*	35-45
Mechanical installations	10-15	Lining	1-53	Drainage	6-9
Electrical*	10-15	Other construction	4-5	Utilities	12-15
Building finishes and misc. work	10-15			Landscaping	5-10
Earthwork and yard piping	5-15			Traffic items **	13-18
* Instrumentation and control included				* Base, paving and concrete work	
				** Signing, marking, guardrails	
High-rise office project		**Hospital project**		**Single family home project**	
Foundations	2-3	Foundations	1-2	Foundations	9-10
Substructure	3-4	Substructure	0,6-3	Framing	17-19
Superstructure (steel)	18-25	Superstructure (steel)	12-14	Exterior walls	12-21
Exterior closure	14-18	Exterior closure	10-12	Roofing	2-5
Roofing	0,5-2	Roofing	0,7-1,5	Interior construction	32-35
Interior construction (tenant work)	16-25	Interior construction	24-31	Specialties	3-7
Conveying	4-9	Conveying	2-5	Mecahnical	7-10
Mechanical	21-24	Mechanical	24-30	Electrical	3-5
Electrical	10-14	Electrical	11-15	Site work	< 1
Equipment	NA	Equipment	7-8		
Sitework	2-6	Sitework	4-6		

Another important consideration is the average size of projects, from a couple of hundred thousand US dollars, in the case of a single family home, to several hundred million US dollars in the case of a tunnel project or highway project. Project size and related technical complexity determine the geographical dimension of a given construction submarket. While a single-family home project may attract local firms (both general and specialty trade contractors), a large hospital project may attract firms (general and major specialty trade contractors) from all over the country. These considerations suggest that there is not a single construction market but "rather a set of sectors that are loosely related to one another by the nature of their products, technologies, labor arrangements and institutional settings" (Lange and Mills, 1979). The specific technological and know-how requirements of a given project, e.g., a single family home, determine a demand that is met by firms with matching capabilities.

Figure 1 differentiates the main types of projects within the construction industry into three clusters (A, B and C) according to two dimensions: the number of discrete technologies that are embodied in a given building type and the extent of their specificity. This last dimension reflects whether the same technology/ies can be deployed in more than one type of project. The three clusters identify the main markets in which construction firms operate and arrange their organization accordingly. Building construction (A) consists of a wide range of building types, each characterized by a large number of discrete technologies that need to be coordinated during construction. Most building types share the same technologies with varying specificity intensiveness. Commodity-like technologies, such as concrete and masonry work, can be applied to a wide range of building projects. Customized technologies, such as curtain walls and elevators, can be deployed on a more limited range of projects. Firms operating in non-residential building construction tend to specialize in projects with similar technological requirements in order to expand their markets. Thus these firms do not achieve a high level of specialization in any single type of building construction.

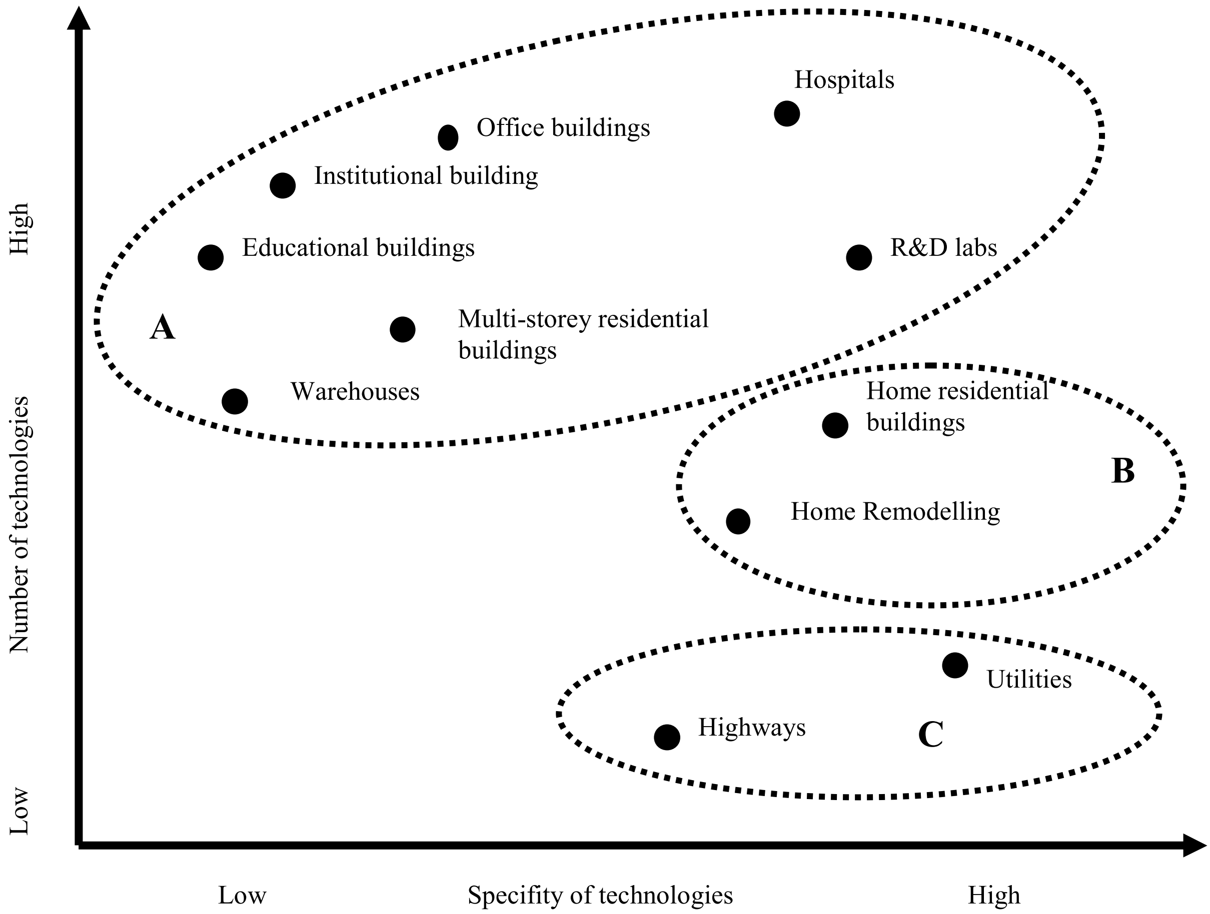


Figure 1: Classification of construction projects in terms of technological requirements and extent of their specificity

Residential construction (B) consists mostly of homes, small building units in which wood related technologies (i.e., framing and exterior walls) predominate and, as stated before, are not used in other building projects. Other technologies, such as mechanical and electrical, require basic services by specialty trades that are seldom needed in more complex building projects. Thus house building is characterized by a very high level of specialization, differently from multi-storey residential construction characterized by more challenging work activities and different technologies. Non-building construction (C) consists of facilities that embody a relatively lower number of technologies. Work activities often involve dedicated machinery, e.g., dozers for massive earth moving, high capacity cranes for bridges or pavers in roadways whose specificity is very high and that often cannot be redeployed in other types of construction. Thus firms operating in cluster C are expected to have a high level of specialization in a given type of construction.

The variety of technological inputs in construction raises the issue of how contracting firms organize their production, i.e., how much of this production should be self-performed or outsourced. Other important determinants of firms' organizational and production criteria are the relative economic value of the technology/ies within the overall cost of a given facility, its size and technological complexity as well as the geographic extent of its market. The following section addresses some of the determinants of the production arrangements that are expected to be adopted by firms according to the theoretical principles of institutional economics.

TRANSACTION COSTS IN THE CONSTRUCTION INDUSTRY

Similarly to manufacturing, in the construction industry a project is rarely accomplished by a single firm. Work production is often organized according to a variety of trades that deploy the technologies embodied in a given project. TCT provides a useful framework for analyzing the way in which construction firms organize their production, i.e., internalize or outsource the work production for a project. In this regard Coase (1937) argues that the structure of a firm is set up to minimize overall transaction costs (those incurred for searching and gathering information about buyers and sellers, writing and negotiating contractual agreements and administering their execution). Internalization of production activities is convenient only when these activities cannot be provided more cheaply on the market. Thus every firm faces the challenge of choosing the right governance structure for the implementation of these activities.

Building on the work of Coase, Williamson develops a theoretical framework for answering such a challenge (1975, 1979). According to the framework, the analysis of transaction costs explains why the exchange of goods and services is governed by a specific government structure, ranging from full internalization, or hierarchy, to full externalization, or market. In addition, Williamson recognizes the importance of hybrid organization forms which are characterized by a mix of markets and hierarchies. He shows how transaction costs are a function of asset specificity and puts forward transactional hazards as a major cause of transaction costs. As asset specificity increases, the most efficient government structure moves from simple market exchange to hybrid contracting and then to hierarchy (Williamson, 2008). Because of the high costs of organizing a transaction internally, hierarchy becomes "the organization form of last resort: try markets, try hybrids and have recourse to the firm only when all else fails" (Williamson, 2008). Several studies of construction firms have termed these hybrid forms as quasifirm (Eccles, 1981) or macrofirm (Dioguardi, 1983) and viewed them as a function of asset specificity (Gunnarson and Levitt, 1982). According to Williamson (1991), asset-specificity refers to "the degree to which an asset can be redeployed to alternative uses and by alternative users without sacrifice of productive value". In other words, investments made for a particular transaction have a higher value only for that transaction. It has little value for other types of transactions (McGuinness, 1994).

Williamson (1991) differentiates between six types of asset-specificity, four of which are applicable to the many physical (technologies) and human assets that are needed to complete a construction project. The four types include: 1) site or location specificity, 2) physical asset specificity, 3) human asset specificity, and 4) temporal specificity.

1. Location specificity refers the local availability of providers of a given technology, material or labor. Little availability creates a monopolistic situation with consequent "hold up" problems between provider and contractor, including higher cost.
2. Physical asset specificity refers to a specialized machinery that can be used for a single purpose. In construction typical examples are the boring and lining machine in tunneling in hard rock, the paving equipment in road building and the specialized cranes for the steel erection of a high rise building.
3. Human asset specificity refers to the specialized human skill arising in learning by doing. It encompasses the knowledge and experience of personnel that are specific to a firm's line of business and also to long-term cooperative links between general contractors and subcontractors.
4. Temporal specificity refers to a technology that is time specific. Its value is highly dependent on its timely deployment. Typical examples are the work activities that are on the critical path of a project time schedule.

Williamson's asset-specificity factors suggest that the varying combination of technologies and human assets plays a major role in the way construction firms organize their production and operate in the market. Table 2 provides a classification of the six-above addressed projects in terms of sources of asset specificity (in rough order of importance) and expected extent of self-performance or outsourcing. The table also includes the expected specialization rate of the firms generally involved in these projects, a dimension addressed in the previous part of this paper.

Table 2: Categorization of construction projects in terms of asset specificity and production criteria (Adapted from Ekström et al., 2003)

	A		B	C		
Type of construction projects	High-rise office building	Hospital building	Single-family home	Tunnel facility	Water and wastewater facility	Highway facility
Technological bandwidth	Broad	Broad	Broad / Average	Narrow	Average / Narrow	Average / Narrow
Asset specificity	Medium/High	High	Medium	High	High	High
Sources of significant asset-specificity	Human Temporal Locational	Human Temporal Physical Locational	Human Temporal	Physical Temporal Locational	Physical Temporal	Physical Temporal Locational
Subcontracting rate	High	Very high	Medium	Low	Low	Low
Coordination focus of main work and material flows	External	External	Ext./Internal	Internal	Internal	Internal
Specialization extent	Moderate	Moderate	Very High	Very High	Moder./High	High

In non-residential building construction projects are characterized by a very broad technological bandwidth. Firms operating in this sector must have personnel well versed in coordinating subcontractors and their numerous technological inputs to a specific building project (external coordination focus). In this regard, the availability of qualified in-house personnel is the principal source of specificity. Another source of asset specificity is the timely and local availability of subcontractors that, in the case of hospital projects, may provide highly customized and specialized services (physical asset specificity). The need for deploying coordination capabilities in technologically-related projects induces firms to achieve a moderate level of specialization in any given project. A high rate of subcontracting, in addition, entails a large in-house force for managing and coordinating subcontracting services (external coordination).

In residential building construction, projects are characterized by a variety of simple and standard technologies. Asset specificity is driven by the dominance of wood-related work activities that are seldom needed in other non-residential projects. Thus firms tend to work in residential projects exclusively. Because these technologies are critical for the timely completion of a project and represent a sizable percentage of a project cost, construction firms tend to internalize them. This production arrangement leads to a lower rate of subcontracting as compared to that of non-residential building contractors. The principal source of asset specificity is the availability of personnel that is well versed in coordinating the subcontractors' technological inputs (external coordination) and, at the same time, specialized in undertaking the direct production of wood-related work activities directly (internal coordination).

It should be noted that specialty trade contractors that operate as subcontractors in the above-described construction sectors are expected to have different capabilities even within the same type of trade. HVAC work, for example, is by far more complex in an office building than in a single family home. Thus these contractors will have a different extent of specialization (and of external coordination capabilities) depending on the technological requirements of the project in which they are usually involved.

In the non-building sector projects are characterized by a technological bandwidth that is narrower than that of building projects. Some deployed technologies, e.g., specialized machinery, give rise to physical, locational and temporal asset specificity because they are highly customized for a single construction task and may not be available in the location of a given project on a timely basis. Thus firms tend to internalize these technologies and acquire specific know-how with their use. A higher rate of self-performed work leads to a lower subcontracting rate and to a corporate focus on ensuring the efficient use of in-house resources (internal coordination focus). The need for amortizing investments in machinery induces firms to seek jobs with the same technological requirements, often on a widely distributed geographic area, with a consequent high level of specialization in a given project.

In the following sections U.S. census data are used to support the theoretical considerations about the expected specialization and production characteristics of the firms that operate in the three construction markets under consideration. The analysis focuses on only one of the main aspects of TCT, physical asset specificity as a predictor of production and operation criteria in conjunction with specialization. It should be noted this aspect alone cannot explain fully the way firms operate in the market. Other aspects related to inter-firm business transactions should be observed and measured. Asset specificity in combination with two pairs of factors (bounded rationality-uncertainty/complexity, and opportunism and small numbers) creates transactional hazards that ultimately determine a given governance structure of a transaction. These transactional dimensions cannot be observed with the statistical data used in this study, but rather with specifically designed empirical studies of transacting parties, such as the relationships between general contractors and subcontractors (Costantino et al., 2001).

CHARACTERISTICS OF GENERAL CONTRACTING FIRMS

The US construction industry has an atomistic nature with a very large number of relatively small firms. Approximately 80% of these firms, in fact, have fewer than 10 employees. Appendix 1 classifies these firms into general contractors (residential and non-residential building construction), heavy and civil engineering contractors (non-building construction) and specialty trade contractors. This classification reflects the specialization by firms in a particular kind of construction work. According to the U.S. Bureau of Census an establishment specializes in a given type of construction when fifty-one percent or more of the performed construction work is in this type of construction. Table 3 shows the main characteristics of general contracting firms (residential, non-residential and non-building), according to the data collected by the 2002 Census (U.S. Bureau of Census, 2004 and 2005). These firms operate in three main markets that accounted for 31% (Non-residential building construction), 49% (Residential building construction) and 20% (Non-building construction) of the total output of the U.S. construction industry in 2002 (U.S. Bureau of Census, 2005).

Table 3: Selected characteristics of U.S. general contracting firms (Source: *U.S. Census Bureau, 2002 Economic Census*)

	1	2	3	4	5	6
Residential Contractors	0,92	0,38	79	0,16	545	5,1
Non-Residential Building Contractors	0,45	0,54	353	0,15	1.956	19,7
Non Building Contractors	0,75	0,19	1.255	0,26	2.065	22,9
Total US construction industry	**0,70**	**0,39**	**345**	**0,18**	**1051**	**10,7**

(1) Amount of specialization
(2) Work subcontracted out/value of construction work
(3) Average book value/firm (thousand dollars)
(4) Work subcontracted in/value of construction work
(5) Average added value/firm (thousand dollars)
(6) Average number of workers/firm

Among general contracting firms, residential contractors have the highest specialization rate. Enterprises specializing in single family homes are most likely to perform this type of work exclusively to the exclusion of all other building projects. Wood-related technologies (shell and fit out work), as stated before, are seldom required in other types of construction. Their specificity leads firms to internalize them, with a consequent lower subcontracting rate (although relevant in absolute terms), if compared to that of non-residential building contractors. Their small size and fixed assets show that these firms are the natural evolution of a construction trade, carpentry, similarly to specialty trade contractors. The small average value added per firm reflects the high fragmentation of the residential market and the limited geographic extent of the firms' operations. Residential contractors tend to invest in human resources. Their human asset specificity has two dimensions: the specific know-how for wood-related construction and the coordinating capability of the work that is subcontracted to specialty trade contractors.

Non-residential building contractors have the lowest specialization rate among general contracting firms. Specialization and subcontracting are correlated. Rather than achieve expertise in one type of building project only, contractors tend to specialize in related projects (that share the same technological bandwidth) by subcontracting much of the work to specialty trade contractors. A high subcontracting rate leads firms to develop coordination capabilities to be applied to the varying technological requirements of building projects. However this type of human asset specificity differs from that of residential contractors, because coordination capabilities are applied to a wide range of projects and not to a single type such as homebuilding.

The average book value of non-building contractors is the highest among the considered firms, given the machine intensiveness of their construction work. A high rate of specialization reflects the technological and know-how dissimilarity of the projects undertaken by these firms. The specificity of the costly machinery leads firms to internalize a large part of production and develop human assets aimed at achieving production efficiencies. High fixed costs (amortization and salaries) create the need to keep capital and human resources productive all the time. Therefore, in addition to a high rate of self-performance, firms may act as subcontractors (26% of production value) and seek work over a large geographical area. Differently from the other two types of considered contractors, non-building construction firms are characterized by physical asset specificity.

CHARACTERISTICS OF SPECIALTY TRADE CONTRACTORS

The U.S. Bureau of Census identifies 19 types of specialty trade contractors (see Appendix 1), mainly involved with building construction. These contractors are grouped according to

the four main sets of activities that characterize the making of a building: the construction of the shell (foundation, structure, etc.), the installation of service systems (electrical, HVAC, plumbing, etc.), fit-out construction (finishing) and site preparation and improvement. This last type of firms, “other specialty trade contractors”, is involved with many miscellaneous jobs (private driveways and parking, swimming pools and fences) and crane rentals. The list is not exhaustive. Other specialty contractors are to be found in the heavy and civil engineering construction sector (e.g., highway line painting), and in other industry and service sectors of the U.S. economy. This type of contractor provides services and work such as asbestos removal and chemical remediation, traffic controls, decommissioning and site development (The Top 600 Specialty Contractors, 2006).
Table 4 shows the main characteristics of US specialty trade contractors according to the 2002 census data (U.S. Bureau of Census, 2004 and 2005). Their overall average specialization rate (53%) is lower than that (70%) of all general contractors. Most of their

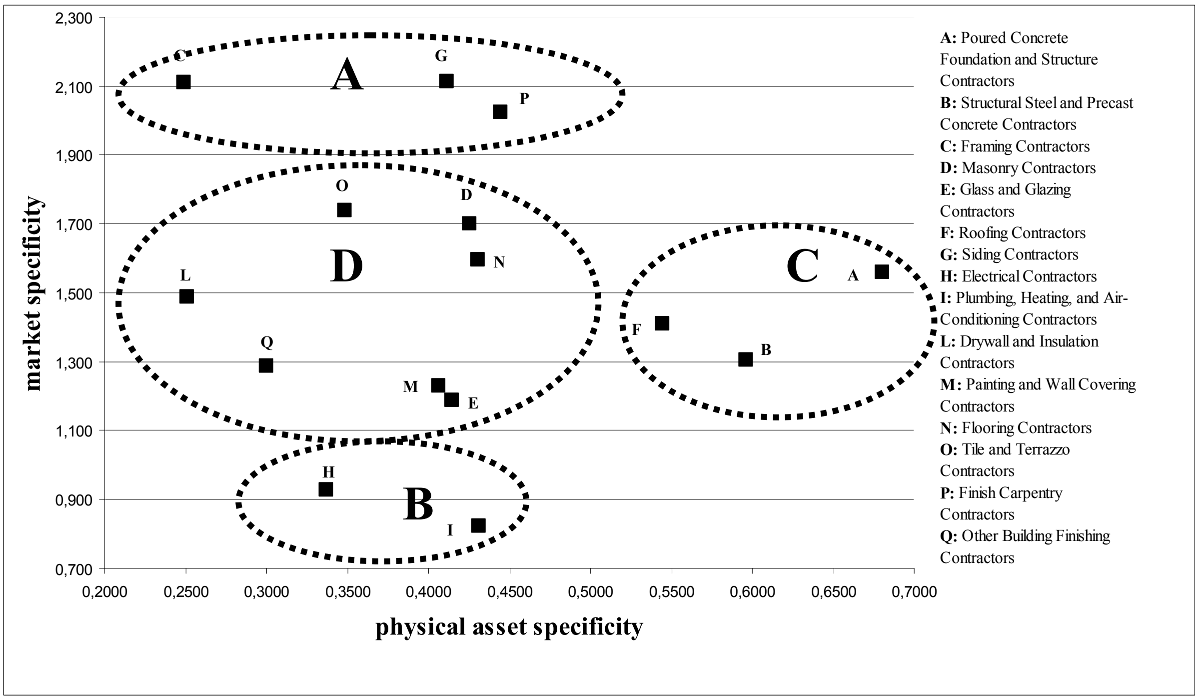
Table 4: Selected characteristics of U.S. specialty trade contractors (Source: *U.S. Census Bureau, 2002 Economic Census*)

	1	2	3	4	5	6	7	8
Shell	0,57	0,09	0,64	156	10,3	0,44	0,50	0,06
Building equipment	0,46	0,08	0,55	170	11,7	0,25	0,71	0,04
Building finishing	0,61	0,11	0,64	76	7,4	0,49	0,51	0,00
Other specialty contractors	0,61	0,13	0,47	436	8,4	0,17	0,25	0,57
Total specialty trade contractors	**0,53**	**0,09**	**0,58**	**179**	**9,8**	**0,33**	**0,56**	**0,11**

(1) Amount of specialization	(5) Average number of workers/firm
(2) Work subcontracted out/value of construction work	(6) Value of construction work in Res. Building/tot. value of construction work
(3) Work subcontracted in/value of construction work	(7) Value of construction work in Non Res. Building/tot. value of construction work
(4) Average book value/firm (in thousands of dollars)	(8) Value of construction work in Non Building/tot. value of construction work

capabilities, in fact, are deployed to meet the large variety of technological requirements of building projects (89% of sales). Differently, only a small portion of their production (11%) is employed in the non-building sector whose projects embody a narrower change of discrete technologies. In delivering their services, specialty trade contractors self perform most of their work, with little subcontracting (9% of production). The high rate of self-performance reflects labor efficiencies of repetitive work obtained from general contractors on a continuous basis. A sizeable amount of their sales (42%) is obtained by acting as a prime contractor.
The intensity of capital investments, or physical asset specificity, is the most notable difference among specialty trade contractors. The average book value of “building finishing contractors” is almost 1/6 that of “other specialty contractors”. The former, in fact, are engaged in labor intensive or craft-like activities, while the work undertaken by the “other specialty contractors” has a machine intensive nature, such as mass excavation. The physical asset specificity of a firm is correlated with the extent of the market in which the same firm tends to concentrate its efforts. This relationship is shown in Figure 2 which records the indicators of fifteen different types of specialty trade contractors. Three types were not included because of duplication of work activities. The indicator of a fourth type (site preparation) was outside the considered scale of representation.

Figure 2: Physical asset specificity and market extent of specialty trade contractors



The horizontal axis, physical asset specificity, is a rough proxy of the intensity of fixed investments (ratio between book value and total payroll). The higher the value within a firm, the more its operations are "vulnerable" to the uncertainty of new job acquisitions. Differently, the vertical axis, market specificity, indicates the market extent of a firm; whether its capabilities are applied to few types or many types of construction projects. This indicator is expressed by the ratio of the standard deviation and the average value of construction work put in place by each considered firm. Four groups of specialty trade contractors can be identified.

Group A (framing, siding and finish carpentry contractors) concentrate their efforts in a very specific market, single family homes. Their below-average physical asset specificity and small size compensate for the possibility of negative variations of housing demand, particularly at the local level. These contractors, in fact, operate in a geographically limited market, as shown in other studies (Eccles 1981; Costantino et al., 2001).

Group B (electrical, plumbing, heating and air conditioning contractors) concentrate their efforts on a wide range of non-residential building projects. These firms, with average physical asset specificity and size, probably operate in a geographically more diffused market to maintain a steady volume of production.

Group C (poured concrete foundations and structure, structural steel and roofing contractors) operate in building and non-building construction, given the wide applicability of their technologies (with the exception of roofing contractors who operate in building construction only). This characteristic compensates for their relatively high physical asset specificity.

Group D (7 remaining contractors) operate mainly in the finishing trades, a type of work that applies to residential and non-residential building projects only. Their fixed investments and size are similar to those of group A. However the firms of group D are less vulnerable than the others to job acquisition fluctuations because of the extent of their markets.

CONCLUSIONS

The U.S. construction market is composed of a series of sectors whose products vary according to their technological and know-how requirements. Such a variety is reflected in the capabilities of the firms that deliver these products. These capabilities have been addressed according to the TCT that identifies several asset specificity factors that play a major role in the way the four different types of construction firms organize their production and operate in the market.

Residential contractors, or homebuilders, are small firms with a very specific know-how that is deployed in a single type of construction, single-family homes. A high specialization rate leads these firms to internalize a sizeable part, mainly wood-related trades, of their production, also because these technologies are usually not deployable in other types of construction. Small size and fixed costs make these firms vulnerable to changes in the limited geographical market in which they operate.

Non-residential building contractors undertake a variety of projects with a wide technological bandwidth that require much broader coordination and more know how capabilities. This characteristic leads firms to not specialize too much in a single type of construction project in order to handle other types of technologically related projects. Coordination capabilities reflect extensive subcontracting. Differently from homebuilders, these firms operate in a geographically diffused market.

Non-building contractors undertake projects that are characterized by machine-intensive construction activities. These technologies are specific to a given construction task and usually cannot be deployed in other types of projects. Thus firms tend to internalize them with a coordination focus on achieving efficiencies in the use of in-house resources. High fixed costs lead non-building construction firms to seek work in a large geographical area and act as subcontractors in order to keep internal resources productive all the time.

Specialty trade contractors deploy most of the technologies that are used in building construction. The complexity of these technologies and related know-how vary depending on the type and size of building projects. Thus these firms do not aim at a high level of specialization in a given type of project, similarly to non-residential building contractors, but, differently from the latter, they self-perform most of their work in order to maintain labor efficiencies. In terms of size and capital investments, specialty trade contractors are similar to home builders but the former are more vulnerable to market changes given the fact that 60% of their production depends on the subcontracting decisions of building contractors.

Future research should address whether the observed production arrangements of the considered construction firms change according to the size of the undertaken projects, size of the firms and the geographical extent of the construction sector in which they operate. Lastly more research is needed to understand how the internal organization of firms (e.g., administrative, technical and clerical functions) changes depending on the type of projects or construction work that is generally undertaken by these firms.

REFERENCES

Albino, V., Costantino, N., and Sivo, G. (2000) Le costruzioni: mercato e impresa. Carocci, Roma.

Coase, R.H. (1937) The Nature of the Firm. Economica N.S., 4, 386-405.

Costantino, N., Pietroforte, R., and Hamill, P. (2001) Subcontracting in commercial and residential construction. Construction Management and Economics, (19).

Dioguardi, G.F. (1996) La natura dell' impresa tra organizzazione e cultura. Laterza, Bari.

Dioguardi, GF. (1983) Macrofirm: Construction firms for the computer age. Journal of Construction Engineering and Management, ASCE, 109, 13-24.

Eccles, R.G. (1981) The quasifirm in the construction industry. Journal of Economic Behavior and Organization, 2, 335-357.

Ekström, M, Björnsson, H., Kunz, J., Levitt, R. and Nass, C. (2003) The impact of rating systems on subcontracting decisions - A transaction cost analysis, CIFE Technical Report #135, Stanford University.

Gunnarson, S., and Levitt, R.E. (1982), Is a building construction project a hierarchy or a market?. Proceedings of the 7th Internet World Congress, Copenhagen, 12-17/9/1982, 521-529.

Lange, E.J. and Mills, Q.D. (1979) The construction industry. Lexington Books, Lexington, MA: USA.

McGuinness, T. (1994) Markets and Managerial Hierarchies. In G. Thompson, et al. (eds.), Markets, Hierarchies and Networks, Sage, London, England, pp. 66-81.

Means Square Foot Cost (2000), RS Means, Kingston, MA, U.S.A.

The Top 600 Specialty Contractors 2006 (2006). Engineering News- Record. October 16: 58-78.

U.S. Bureau of Census (2004) 2002 Economic Census – Construction. Industry series. Washington, DC: U.S. Department of Commerce.

U.S. Bureau of Census (2005) 2002 Economic Census – Construction. Subject series. Washington, DC: U.S. Department of Commerce.

Williamson, O.E. (1975) Markets and hierarchies: Analysis and antitrust implications. The Free Press, New York.

Williamson, O.E. (1979) Transaction costs economics: The governance of contractual relations. Journal of Law and Economics, 22, 233-261.

Williamson, O.E. (1991) Comparative economic organization: The analysis of discrete structural alternatives. Administrative Science Quarterly, 36, 269-296.

Williamson, O.E. (2008) Outsourcing: Transaction Cost Economics and Supply Chain Management. Journal of Supply Chain Management, 44 (2), 5-16.

APPENDIX

Building contractors

Residential building (single and multi-family housing)

Operative builders (1)

Residential remodeling

Industrial building construction

Commercial and institutional buildings

Heavy and civil engineering contractors

Utility system construction (2)

Land subdivision

Highway, street and bridge construction

Other heavy and civil engineering construction (3)

Specialty trade contractors

Shell

Poured concrete foundations and structure

Structural steel and precast concrete (4)

Framing

Masonry

Glass and glazing

Roofing

Siding

Other foundation, structure and building exterior (5)

Building equipment

Electrical

Plumbing, heating and air-conditioning

Other building equipment contractors (6)

Building finishing

Drywall and insulation

Painting and wall covering

Flooring

Tile and terrazzo

Finish carpentry

Other building finishing (7)

Other specialty contractors

Site preparation (8)

Other specialty trades (9)

(1) Speculative or merchant housing builders

(2) Water and sewer lines, oil and gas pipelines, power and communication lines

(3) Mass excavation, channels, heavy machinery rentals

(4) Includes concrete reinforcement

(5) Formwork, false work and fireproofing

(6) Millwright, machine rigging, HVAC insulation, elevators

(7) Specialty sheet metals, waterproofing, weather-stripping

(8) Excavation, demolition, construction equipment rentals

(9) Private driveways and parking, swimming pools, fences, crane rentals

SYSTEM DYNAMICS MODEL OF THE KNOWLEDGE MANAGEMENT PROCESS

Saif Ali Alkaabi
Griffith School of Engineering, Griffith University, Australia
saif.alkaabi@student.griffith.edu.au

Le Chen
Griffith School of Engineering, Griffith University, Australia
l.chen@griffith.edu.au

Sherif Mohamed
Griffith School of Engineering, Griffith University, Australia
s.mohamed@griffith.edu.au

To effectively manage the challenges being faced by construction organisations in a fast changing business environment, many organisations are attempting to integrate knowledge management (KM) into their business operations. KM activities interact with each other and form a process which receives input from its internal business environment and produces outputs that should be justified by its business performance. This paper aims to provide further understanding on the dynamic nature of the KM process. Through a combination of path analysis and system dynamic simulation, this study found that: 1) an improved business performance enables active KM activities and provide feedback and guidance for formulating learning-based policies; and 2) effective human resource recruitment policies can enlarge the pool of individual knowledge, which lead to a more conducive internal business environment, as well as a higher KM activity level. Consequently, the desired business performance level can be reached within a shorter time frame.

KEYWORDS: knowledge management, business performance, individual knowledge, system dynamics

INTRODUCTION

The importance of KM has been increasingly recognised in the construction context. However, due to the fragmented nature of the construction supply chains and the dynamic project-based structure of construction organisations, KM implementation in the sector is still facing some problems (McCaffer and Edum-Fotwe, 2006). While a growing number of organisations now perceive KM as an integral component for business improvement, there are major difficulties associated with its application, including establishing strategies, identifying resources and evaluating the benefits (Robinson et al., 2005). The primary cause of these difficulties is the intangible and tacit nature of knowledge. Additionally, the dynamic nature of the process for managing it, presents challenges for practitioners who need to visualize and understand the process (Fernie et al., 2003). From the findings of an empirical study and system dynamics (SD) simulation, this paper sheds light on the impact of human resource recruitment strategies upon the dynamic interactions between the KM process, the internal business environment and organisational business performance.

LITERATURE REVIEW

Knowledge has been recognised as one of the most important strategic resources (Sanchez, 2003), being defined as the "justified true belief" that increases an entity's capacity for effective action (Nonaka and Takeuchi, 1995). Accordingly, KM is perceived as a multi-disciplined approach that achieves organisational objectives by making the best use of knowledge; it focuses on processes, such as acquiring, creating, and sharing knowledge, along with the cultural and technical foundations that support them (Standard Australia, 2001). Human resources for a construction organisation ensure the existence of a large pool of individual knowledge, which can be viewed as a source of competitive advantage. This advantage occurs because employees' tacit knowledge, such as skills, experience and networks, that have accumulated through years of practice in a dynamic project environment, cannot be easily copied by rivals or transferred without cost (Pathirage et al., 2007). Thus employees with T-shaped skills, an important type of tacit knowledge (Baumard, 1999), are extremely valuable for creating knowledge. By integrating diverse knowledge assets, they become a crucial element in the successful KM process, through the systematic management of these skills (Lee and Choi, 2003). From Sanchez's (2001) view of sense-making, it appears that individual knowledge plays a key role in the organisational knowledge creation process, achieved through learning activities between employees at the individual, group and organisation level. Nonaka and Takeuchi's (1995) famous knowledge creation model also illustrates the critical role of individual knowledge, in particular tacit knowledge, in creating and enlarging organisational knowledge assets. As recruitment strategies vary according to project demand, the size of the individual knowledge pool within a construction organisation is continually changing over time, which means the the key human resource for the KM process is not static.

A KM process model, developed through an empirical study of a sample of construction organisations operating in Hong Kong (Chen and Mohamed, 2007, 2008), is illustrated in Figure 1. This model suggests that KM activities interact with each other and form a process that receives input from its context (i.e. the internal business environment), and produces outputs that can be justified by the business performance. In other words, the KM process can be influenced by organisational culture and policies, and is associated with variations in the business performance level.

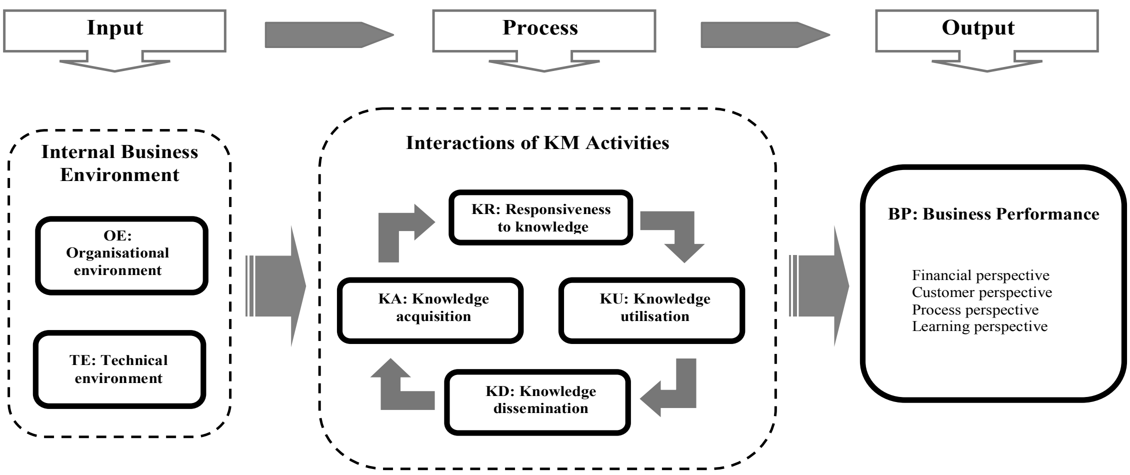


Figure 1 KM process model

While this empirical linear model is plausible for exploratory study it has a significant limitation. As Figure 1 shows, there is no feedback loop from the business performance to either the KM activities or the internal business environment. Thus the framework is an open system that can lead to exponential performance growth; however, this cannot continue forever. At issue then is the adoption by this model, of the Balanced Score Card (BSC), which is the measurement framework for its 'business performance (BP)' construct. The BSC was designed as a tool for formulating, communicating and implementing an organisation's strategy. In other words, the BSC is a dynamic tool that is able to change contents over time. According to Kaplan and Norton (1996), however, performance measurement should provide feedback and guidance for strategic decision making, including formulating learning-based policies and improving the business process. Thus it is expected that the BP level will change with strategy evolution; meanwhile the variations in the BP level also demands strategy adjustments (Wongrassamee et al., 2003). Therefore this study proposes that a variation in the business performance would affect the KM process and guide the formulation of internal policies. Hence the associations of the KM process, with the internal business environment and the business performance, are not linear, but are a loop. Moreover, the interactions between the key variables (e.g. the KM process and business performance) within the KM loop system vary over time.

To reveal the dynamic nature of the KM loop system, this study first provides empirical evidence for the KM loop through structural equation modelling (SEM) analysis; then it uses SD simulation to analyse the interactions between the variables of the loop under the impact of various recruitment strategies, within the context of a construction organisation, over time. SD was adopted for this study since: 1) it explains the behaviour of complex systems by focusing on non linear, recursive relationships among variables, explicitly modelling how these variables interact and influence each other (Forrester, 1994); 2) it is more prevalent in the management arena, where studies examine changes in technology, business processes, and policies by modelling their outcomes, productivity, and performance (Sterman, 2000); and 3) it has been employed in KM and human resource (HR) related studies (Hafeez and Abdelmeguid, 2003; Rich, 2002).

CAUSAL MODEL PROPOSITION

The primary research questions this study seeks to answer are: 1) Is there any empirical evidence for the KM loop? 2) How do KM activities interact dynamically with organisational context and business performance, within certain time frames? 3) How does knowledge of individual employees influence this KM process, over certain time frames? Based on the literature review, a KM dynamic model was proposed to facilitate the investigation, attempting to provide answers to these research questions. As illustrated in Figure 2, the causal loop diagram presents the inter relationships between five variables of the model: internal business environment (IBE), knowledge management activities (KM), and business performance (BP), as well as knowledge gain (KG) and knowledge loss (KL) within a construction organisation.

Based on the findings of previous empirical studies by Chen and Mohamed (2007, 2008), this study defines the above-mentioned variables as follows: IBE covers 1) the organisational creative environment (OEc), and policies that encourage and promote innovations; 2) the organisational supportive environment (OEs), and policies and strategies that support KM; and 3) the technical environment (TE), technological infrastructure and its ability to respond to technical change. KM includes four strategically classified activities: responsiveness to knowledge (KR), knowledge acquisition (KA), knowledge dissemination (KD) and knowledge utilisation (KU). Business performance (BP) represents the business performance from the four perspectives of the BSC (i.e. financial, customer, process and learning). KG represents the total knowledge of individual employees inside the organisation, plus the added knowledge, over time; whilst KL represents the removed individual knowledge due to the departure of an individual from the organisation and the unlearning process (Hafeez and Abdelmeguid, 2003; Rich, 2002).

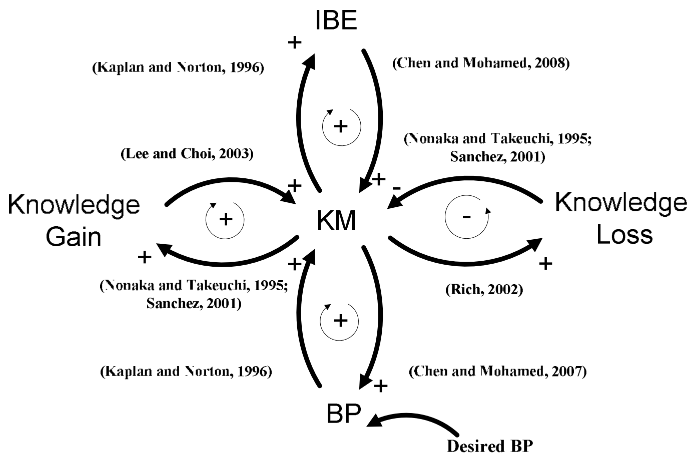


Figure 2: Causal loop diagram of the KM dynamic model

The causal loop diagram, shown in Figure 2, portrays the feedback loops in the KM dynamic model. The arrows indicate the direction of influence, and the plus/minus (+, -) signs indicate the type of the influence. This model proposes that, firstly, the more conducive the IBE, the higher the level of KM activities, which lead to better BP; a better BP enables an even higher level of KM that then demands and facilitates more KM friendly IBE; secondly, admitting new employees with desirable knowledge enables KM to exist at a higher level, whereas losing employees reduces the size of the individual knowledge pool and thus has a negative impact on the KM process. Additionally, active KM increases individual knowledge, reveals obsolete knowledge and triggers the unlearning process (Rich, 2002). Finally, the desired BP level, strategically targeted by an organisation, serves as a stimulus for the KM process (Kaplan and Norton, 1996).

SEM ANALYSIS

Based on the data collected, and the measurement scales developed by Chen's (2007) investigation, this study employed a SEM technique to analyse a path model, which incorporates the six constructs of the KM process model, and the potential causal links between them. In the final path model, the estimates of both the regression weights and variances were statistically different from zero, at the confidence level of 0.01. Figure 3 illustrates the significant paths (with standardised regression weights). The final path model presented the absolute fit indices (χ^2=9.169 with degree of freedom (df) of 5; p= 0.103;

GFI=0.979; AGFI= 0.913, RMR= 1.485), the incremental fit indices (χ^2/df= 1.834; NFI= 0.981; CFI= 0.991), and the parsimonious fit indices (RMSEA=0.065), which were all indicative of a very good fit to data (Byrne, 2001: 81-86). As presented in Figure 3, the final fitted path model provides statistical evidence that the variance of BP influences KM interactions, which in turn impact on IBE. Further, BP seems to have no direct association with IBE. In other words, the variance of the BP influences IBE through the KM activities. The fitted path model supports the existence of a KM Loop.

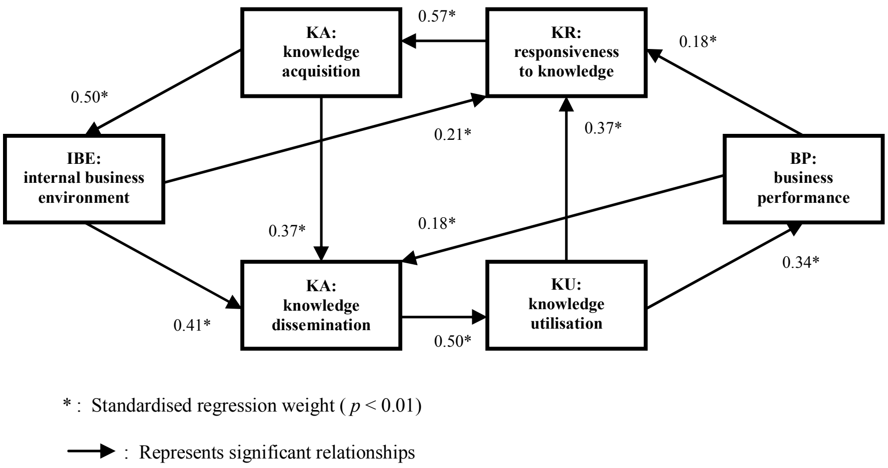


Figure 3: Fitted Path Model

SYSTEM DYNAMIC ANALYSIS

The SD model

The dynamics software "iThink/ STELLA" package was used as simulation tool, since it improves both the quality of the underlying mental models, and the reliability of the associated simulations (Richmond, 2004). With the empirical support of the path model (Figure 3), the dynamic relationships illustrated in the causal diagram (Figure 2) were translated into the SD model shown in Figure 4. The SD model has four main stocks: Employee, KM, IBE and BP. The Employee and KM stocks are designed for accumulative 10 employment years, divided equally into two time frames (Stage 1 and Stage 2). It is assumed, based on the literature review, that the contribution of the individual knowledge of employees to the organisational knowledge pool varies with their employment status within the organisation, over time. As employees enter the organisation, they bring with them their knowledge and skills previously learnt, which adds to the total organisational knowledge; the longer they work, the more experienced they become, and thus the more knowledge they can contribute. On the other hand, knowledge loss from the KM stock has two primary causes: firstly, the employees who leave the organisation take their knowledge with them; secondly, existing employees need to unlearn some obsolete knowledge and update it with new knowledge through the learning process.

The BP stock is perceived as an oven with a capacity of 1000. Desired BP represents the desired goal of performance and is set to 1,000 units. AT is the adjustment time for the desired BP level. The stock called Total KM, is designed to represent overall KM activity intensity in the organisation, which it delivers to the BP stock. The Net Performance Rate is the inflow of the BP stock, representing the total KM of the organisation, over the adjusting time selected. The difference between the actual and the desired level of BP constitutes a stimulus feeding into the KM Gap. The system needs to keep track of the KM gap, filling it so that it reaches the desired level of BP. The Policy Implementation Rate is the inflow of the IBE stock representing the implemented organisational policies that close the KM gap through Internal Effort (the combination of OEs, OEc and TE) and new staff recruitment. The IBE provides an environment for implementing KM strategies (the combination of KR, KA, KD and KU), while KM strategies decide the intensity of the KM activity. In addition, the feedback from the BP stock was designed with a delay mechanism to allow time for strategic decision making. Another delay mechanism was designed with the policy implementation, since corrective actions also need some time to take place.

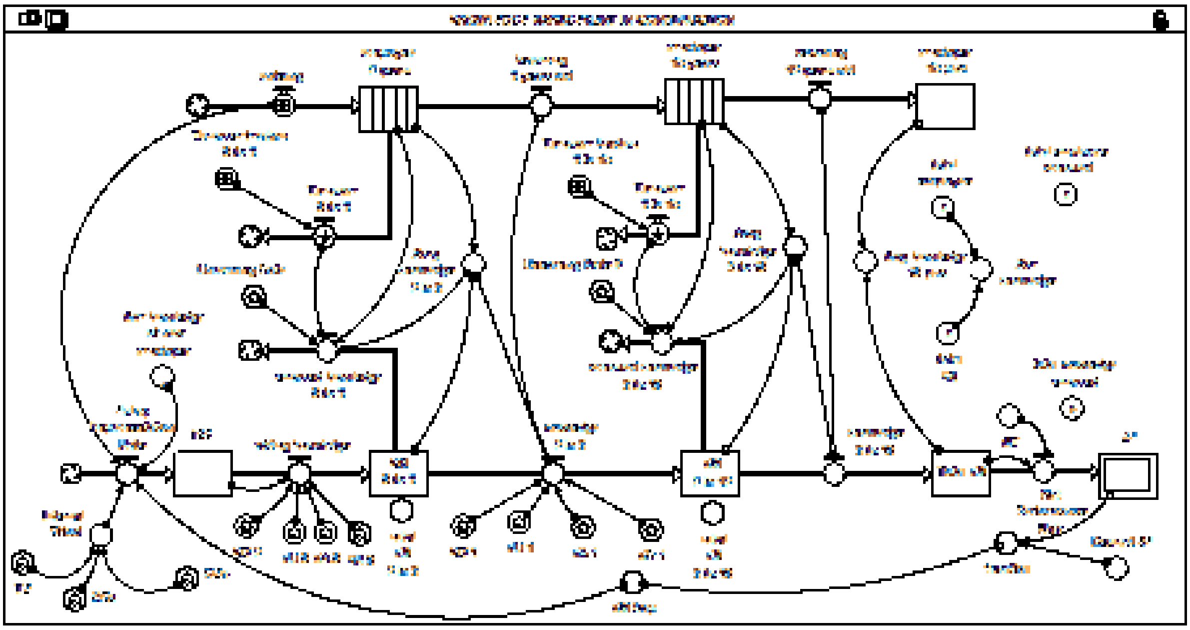


Figure 4: System dynamic model for the KM process.

Dynamic analysis

The SD model and simulation analyses, reported herein, relate to a hypothetical contracting company employing 300 staff (at the initial stage). The primary objective of the simulation is to develop various scenarios for assessing the impact of different recruitment policies on the KM loop and to illustrate the dynamic behaviour of the main stocks. Graphs are plotted to estimate the levels of the IBE, KM, and BP under dynamic market conditions. The simulation revealed that the variables reached equilibrium within a certain time frame, and the individual knowledge pool had a positive impact on the KM process; however, the strength of such an impact varied with IBE and KM strategies.

Four case scenarios, that respectively reflect organisational strategies in the boom-and-bust cycle of the construction market, are provided to demonstrate the model's capabilities. The simulations were undertaken within a 30 month timeframe, at a monthly time step. The Case A represents a scenario where the organisation operated in a booming market, and enjoyed a high employee entry rate and a low turnover rate; while its internal effort and KM strategy were kept at a medium level. In contrast, the Case B scenario, reflects a downturn situation, where the organisation had a low employee entry rate and a high turnover rate. In addition, in the Case B recruitment policy, scenarios I, II, and III respectively reflect the situations where the internal effort and KM strategy were set at three different levels (medium, high and low). Through this case design, the simulation could compare: 1) the dynamics of the main variables under the different recruitment policies of the boom-and-bust market conditions, when the organisation kept the internal effort and KM strategy at a medium level (i.e. Case A vs. Case B scenario I); 2) the behaviour of the main variables under a downturn recruitment policy, when different internal effort and KM strategies were employed by the organisation (i.e. Case B scenario II vs. III). The key simulation input and findings are summarised in Table 1 for easy comparisons.

Table 1: Key Simulation Results

Simulation input and key findings	Case A (booming market)	Case B (downturn market)		
		Scenario I	Scenario II	Scenario III
Employee entry rate	High	Low	Low	Low
Employee turnover rate	Low	High	High	High
Internal effort	Medium	Medium	High	Low
KM strategy	Medium	Medium	High	Low
Time to reach desired BP	10 months	26 months	15 months	> 30 months
Highest IBE	9,000	1,665	2,308	700
Highest KM (Junior staff)	11,500	2,217	3,036	1,310
Highest KM (Senior staff)	23,500	1,237	1,700	108
KM fluctuation following policy implementation delays	Slightly	Sharply	Sharply	Sharply

Figure 5 illustrates a simulation of Case A: a booming construction market (experienced in Hong Kong in the 1990s), where high employee entry rates and low turnover rates produce a rising individual knowledge rate. Under such a circumstance, where the internal effort and KM strategy for adding knowledge (KR, KA, KD, and KU) were kept just at a medium level, the BP reached the desired level (1,000 units) in just 10 months. The simulation revealed that, with a large inflow of employees, the IBE could reach 9,000 units, the highest of the four case scenarios, reflecting enormous initial efforts in promoting KM and innovation strategies. The delays in policy implementation caused fluctuations of the IBE; nevertheless, its lowest level within the 30 months simulation timeframe never dropped below 1,800 units. With the IBE becoming increasingly conducive, especially after the desired BP level was reached, the organisation continued to focus more on maintaining the level of the IBE, which stabilised at 2,800 units at the end of the 30 month period. Following the inductive IBE, the KM activity intensity of both the junior (with less than five years experience) and the senior (of more than five years experience) employees increased steadily, and varied slightly with the fluctuations of the IBE. Within the first 5 months of implementation the junior employees presented higher KM activity intensity than did the senior employees, apparently because they were following the policies and performing the tasks. With the progress of the implementation, the senior employees' functions of co-ordinating, monitoring, and planning, as well as internal and external networking, became increasingly intensive. As the performing of these functions requires much more human interactions, and hence involve more intensive KM activities, the senior employees' KM activity intensity rose above the level of their junior counterparts at the month 7 and reached around 20,000 units, to keep the BP at the desired level. The junior employees' KM intensity level varied between 11,500 to 3,500 units after the desired BP was achieved.

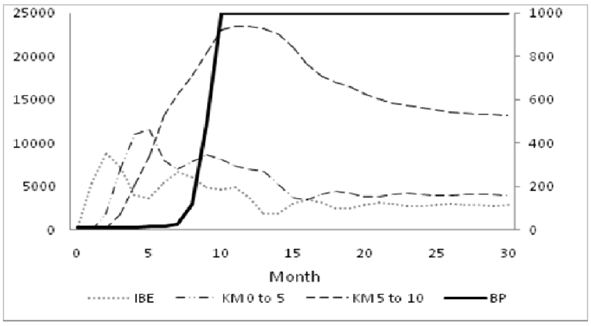


Figure 5 Case A Boom Scenario (High entry rate, low turnover rate; medium internal efforts; medium level KM strategy)

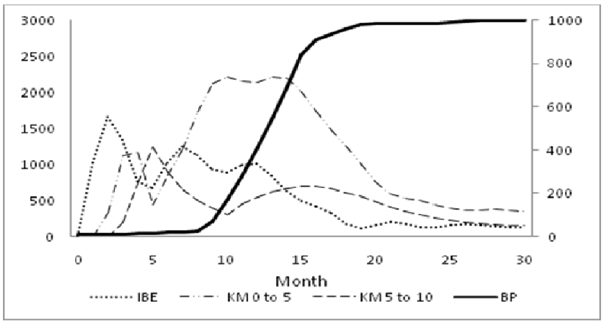


Figure 6 Case B Scenario I (Low entry rate; high turnover rate; medium internal efforts; medium level KM strategy)

In contrast, Figure 6 shows a simulation of Case B scenario I, a downturn situation, that suggests a declining individual knowledge rate caused by a low employee entry rate and a high turnover rate, which appears to delay the process of achieving the desired BP level. As Figure 6 and Table 1 show, even if the organisation kept the same medium level internal effort and KM strategy as those of Case A, it would take 26 months to reach the same BP target (1,000 units). The IBE level would swing around 1,000 units and never exceed 1,665 units within the 30 months time frame. With a high turnover rate, the KM activity intensity level of both the junior and the senior employees would decrease sharply following implementation delays in the IBE. The results of this simulation reflect the situation experienced by the Hong Kong construction sector between 2001 to 2004. During the downturn, and due to low project demand, most construction companies experienced difficulties in keeping a large workforce (Chan et al., 2005). Therefore, even though the KM strategy was kept at a medium level, the tacit knowledge pool of the organisation was shrinking. The simulation shows the difficulties encountered in keeping the intensity of KM activities at a high level to support BP. The pressing question, therefore, is: can such a situation be improved?

Case B scenarios II and III were simulated in accordance with two different types of strategies adopted by the contractors in Hong Kong during the downturn period (Chen and Mohamed, 2007). The data in Table 1, and Figures 7 and 8 reveal a sharp contrast in the BP level, as a result of adopting the two strategies under exactly the same recruitment policy. Under Case B scenario II (Figure 7), the organisation adopted a highly active KM and innovation strategy; they used existing resources to keep internal effort and KM strategy at a high level; they focused on saving costs through innovation and process improvement. The organisation was thus able to realise the desired BP within 15 months, and to keep their IBE and KM at a reasonable high level. Case B scenario III (Figure 8) reflects the results of a strategy adopted by some overseas contractors during the downturn period. They withdrew from the Hong Kong market due to the difficulties in meeting their profitability requirements. Most of their managerial and professional members were re-assigned back to their overseas headquarters or the other regional offices. The organisation's internal effort and KM strategy decreased to a low level. As a consequence, the organisation only reached a BP of merely 100 units at the end of the 30 month period, with both the level of the IBE and KM being very low.

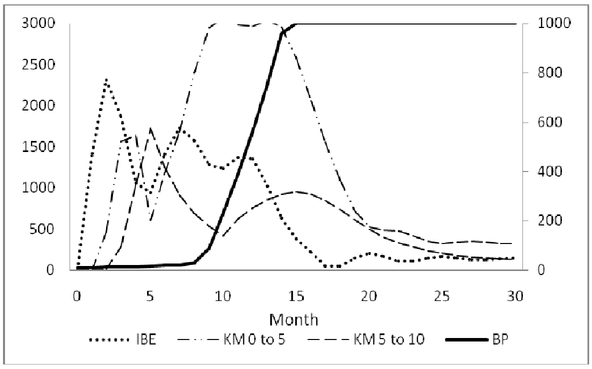


Figure 7 Case B Scenario II (Low entry rate; high turnover rate; high internal efforts; high level KM strategy)

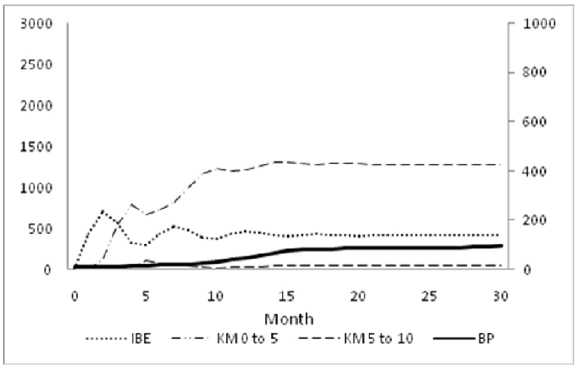


Figure 8 Case B Scenario III (Low entry rate; high turnover rate; low internal efforts; low level KM strategy)

CONCLUSIONS

This study provided statistical evidence for the KM loop, indicating that variations of business performance (BP) influence KM activity intensity, which in turn would provide feedback and guidance for modifying organisational policies. The SD analyses revealed that employees' knowledge (tacit knowledge in particular) contributes positively to the KM process. In line with previous study findings based on the Hong Kong construction market, the simulation's analysis of the four case scenarios reflected an organisation's KM implementation during the boom-and-bust cycle. The findings suggest that organisational policies cultivating a KM friendly environment and a well formulated KM strategy are the two success factors for achieving effective implementation, viz. to improve business performance. For this reason, human resource recruitment policies need to focus on enlarging and maintaining the tacit knowledge pool to achieve a successful long-term organisational strategy, rather than a short-term "overhead saving".

REFERENCES

Baumard, P. (1999) Tacit Knowledge in Organizations. London: Sage.

Byrne, B. M. (2001) Structual Equation Modeling with AMOS, Basic Concepts, Applications and Programming. London: Lawrence Erlbaum Associates, Publishers.

Chan, J. K. W., Tam, C. M. and Cheung, R. K. C. (2005) Construction firms at the crossroads in Hong Kong: Going insolvency or seeking opportunity. Engineering, Construction and Architectural Management, 12(2), 111-124.

Chen, L. (2007) Linking knwoledge management to organisational business performance in construction. PhD thesis, Griffith University, Queensland, Autralia.

Chen, L. and Mohamed, S. (2007) Empirical study of interactions between knowledge management activities. Engineering, Construction and Architectural Management, 14(3), 242-260.

Chen, L. and Mohamed, S. (2008) Impact of the internal business environment on knowledge management within construction organisations Construction Innovation: Information, Process, Management, 8(1), 61-81.

Fernie, S., Green, S. D., Weller, S. J. and Newcombe, R. (2003) Knowledge sharing: context, confusion and controversy. International Journal of Project Management, 21(3), 177-187.

Forrester, J. W. (1994) Policies, Decision, and Information Sources for Modeling. In Morecroft, J. D. W.and Sterman, J. D. (Eds.) Modeling for Learning Organizations. Portland, Oregan: Productivity Press.

Hafeez, K. and Abdelmeguid, H. (2003) Dynamics of human resource and knowledge management. Journal of Operational Research Society, 54(2), 153-164.

Kaplan, R. S. and Norton, D. P. (1996) Translating Strategy into Action - The Balanced Scorecard. Boston: Harvard Business School Press.

Lee, H. and Choi, B. (2003) Knowledge management enablers, processes, and organisational performance: an integrated view and empirical examination. Journal of Management Information System, 20(1), 179-228.

McCaffer, R. and Edum-Fotwe, F. T. (2006) Improving construction: why innovation tarries. Joint International Conference on Construction Culture, Innovation, and Management (CCIM), http://www.buid.ac.ae/conf/ Keynote Speeches

Nonaka, I. and Takeuchi, H. (1995) The Knowledge Creating Company. New York: Oxford University Press.

Pathirage, C. P., Amaratunga, D. G. and Haigh, R. P. (2007) Tacit knowledge and organisational performance: construction industry perspective. Journal of Knowledge Management 11(1), 115 - 126.

Rich, E. H. (2002) Modeling the Dynamics of Organisational Knowledge. PhD thesis, State University of New York, Albany.

Richmond, B. (2004) An Intoduction to System Thinking. ithink, isee systems.

Robinson, H. S., Carrillo, P. M., Anumba, C. J. and Al-Ghassani, A. M. (2005) Knowledge management practices in large construction organisations. Engineering, Construction and Architectural Management, 12(5), 431-445.

Standards Australia (2001) Knowledge Management : a framework for succeeding in the knowledge era. Sydney: Standards Australia International.

Sanchez, R. (2001) Managing knowledge into competence: the five learning circles of the competent organisation. In Sanchez, R. (Ed.) Knowledge Management and Organisational Competence. New York: Oxford University Press.

Sanchez, R. (2003) Knowledge Management and Organisational Competence. Oxford: Oxford University Press.

Sterman, J. D. (2000) Business Dynamics: systems thinking and modeling for a complex world Boston: Irwin/McGraw-Hill.

Wongrassamee, S., Gardiner, P. D. and Simmons, J. E. L. (2003) Performance measurement tools: the Balanced Scorecard and EFQM Excellece Model. Measuring Business Excellece, 7(1), 14-29.

Comparative performance of UK PFI and non-PFI hospitals

Jaw-Kai Wang
University of Reading, Reading, UK
j.k.wang@reading.ac.uk

Since the first PFI hospital was established in 1994, many debates centred on the value for money and risk transfer in PFIs. Little concern is shown with PFI hospitals' performance in delivering healthcare. Exploratory research was carried out to compare PFI with non-PFI hospital performance. Five performance indicators were analysed to compare differences between PFI and non-PFI hospitals, namely the length of waiting, the length of stay, MRSA infection rate, C difficile infection rate and patient experience. Data was collected from various government bodies. The results show that only some indexes measuring patient experience emerge statistically significant. This leads to a conclusion that PFI hospitals may not perform better than non-PFI hospitals but they are not worse than non-PFI hospitals in the delivery of services. However, future research needs to pay attention to reliability and validity of data sets currently available to undertake comparison.

Keywords: PFI, procurement, hospital, healthcare service, healthcare performance

INTRODUCTION

Since the first new built hospital project was approved under the Private Financial Initiative (PFI) scheme in 1997, 92 PFI hospital projects have been undertaken. Although PFI hospitals have become increasingly popular, they also raised many criticisms. PFI schemes were originally created with the aim to achieve three purposes: good value for money, risk transfer from public sector to private sector, and bringing in private sector management skills and innovation abilities. However, whether these purposes have been achieved is still debated.

Only now, a decade after its inception, longer-term problems are surfacing.

Pollock et al. (2002) and Broadbent et al. (2003) examined whether 'value for money' is achieved in PFI hospitals. The results show that this is debatable and requires further monitoring of the impact of change over time. Some evidence indicates that the number of beds and the size of the space in PFI hospitals are reduced (Pollock et al., 2001). Also, new built wards are more compact as the ratio of numbers of beds per ward has increased. The reduction in actual bed numbers and space are considered having significant impact on a hospital's capacity of admitting inpatients, infection control and patients' experience within the hospital environment.

Gaffney et al. (1999) argued that PFI is an expensive method of procuring a new hospital as it causes affordability problems at local and national level and inevitably cutting down services is a way of financing this. Shaoul (2005) argues that ambiguous concepts of risk transfer and value for money implemented for many of the projects without considering the whole system may have caused more problems for individual PFI projects.

Furthermore, some scholars (e.g. Pollock et al., 2002) are concerned that risks are not actually transferred from the public sectors to the private sectors. Although the private sector finances, builds, operates and maintains the building, the faults or delays in the design, construction and maintenance will impact on the delivery of healthcare services. The risks at the end would fall on the Trusts and the consortiums together. This is partially due to the nature of the risk as it is difficult to be identified and assigned as part of contractual arrangements. Therefore, the risks would not be completely transferred from the public sectors to the private sectors as initially suggested.

As most of the attention has been given to the above issues in the first wave of reviews of PFI hospitals, only little concern with whether PFI hospitals provide more efficient and effective healthcare services and safety has been voiced. Therefore, this paper looks at whether the PFI and non PFI hospitals show different performance in the delivery of healthcare services. The data presented in this paper is based on some exploratory research. The aim of the research was to begin identifying indicators against which the performance of PFI against non PFI hospitals can be compared. Whilst there is some literature on the value of PFI initiatives, little research provides evidence of the performance difference of the two procurement routes to services provision. In order to begin to identify measures, the research set out to explore the possibility of using existing and accessible performance indicators for hospitals to identify potential differences in performance of PFI and non PFI hospitals. The following research outlines the process and the questions that have been raised in beginning to uncover potential measurements of success.

PERFORMANCE OF HEALTHCARE SERVICE DELIVERY IN HOSPITALS

In order to achieve the aim of this paper, it is necessary to look at what performance is and how it is measured.

The performance of delivery of healthcare services at the hospital level is associated with many factors e.g. clinical practice, administration (Rosenthal, 1998), built environment (Mallak et al., 2003) etc. From a patient perspective an efficient and effective treatment may be of concern. By adopting this perspective, the term ‘performance’ in this paper therefore is defined as efficiently, effectively and safely delivering healthcare services by the hospitals.

In light of this perspective, how performance can be measured and what are the appropriate measures needs to be considered. There is extensive research that has tackled this issue in the last decades. For instance, Romano et al. (1995) use mortality, post-operative complication, post-operative length of stay and readmission to measure hospital outcomes. DesHarnais et al. (1990) employ risk-adjusted indexes of mortality, readmissions and complications to test hospital performances. Iezzoni et al. (1996), Austin et al. (2001), Werner et al. (2006) and Thomas et al. (1999) work on the development of mortality as a measure to evaluate a hospital's performance. However, this research argues that a single measure may not be suitable for determining a hospital's performance, especially since the delivery of healthcare service is this research's concern. Therefore, a set of multidimensional measures seems to be more appropriate for this research.

The UK government has set up 198 targets (DoH, 2004) as guidelines and monitoring indicators for the healthcare sector. Some targets are given priority in relation to current issues that ought to be quickly improved. For instance, length of waiting list is one of the priority targets. This indicator is considered as an appropriate performance measures for healthcare delivery. It is related to efficiently and effectively delivering healthcare services. However, a long waiting list is a result of multiple variables across a complex system in which hospital capacity and the communication between different tiers of healthcare providers are determinant. To improve a hospital's waiting list therefore involves improving a hospital's management practice as well as clinical practice. To tackle this problem, the length of waiting time is given as an indicator to monitor the mechanism of referral and admission of patients. Furthermore, the length of stay is also useful to monitor the use of beds within the hospitals to ensure that occupancy of beds is sustained at a reasonable level. Both length of waiting and duration of stay can be seen as appropriate measures for evaluating a hospital's efficiency.

Furthermore, a patient does not only expect an efficient treatment but also is concerned with the quality in terms of effectiveness and safety. However, what is effectiveness? One may say that not having to return to hospital again for a given health concern denotes a patient has been successfully treated. In this case readmission could be an indicator to measure effectiveness of treatment.

In addition to being efficiently and effectively treated, a patient could be infected during a hospital stay. A government report states that 9 per cent of patients have hospital acquired infection in the England (NAO, 2000). Most these cases occur after admission. Therefore, infection control is one prioritised target that the government intends to achieve. This suggests a considerable indicator for evaluating a hospital's performance.

RESEARCH METHODS

Study design and setting

This research compares the performance between PFI and non PFI hospitals. In the current hospital characterisation, hospitals can be divided into acute hospitals, mental hospitals, healthcare centres, treatment centres and specialist providers. Each type of provider carries different functions within the healthcare systems. In order to perform a consistent analysis, this research focuses on the National Health Service (NHS) acute hospitals. The research aims to compare various indicators that represent efficiency, effectiveness and safety of hospital care.

Performance indicators

Performance indicators are selected based on a perspective of how patients can be treated and cared for efficiently, effectively and safely. In terms of efficiency, the length of waiting time and the length of stay are adopted. The length of waiting is currently a priority target that is associated with cutting down the waiting list. The length of waiting is defined as the period from the date admission is decided to the actual date of admission.

The length of stay is defined as the period from the date of admission until the date of discharge. The length of stay is one of the factors that influence the length of waiting. However, one may argue that patients should not be discharged from hospital before full confidence is achieved that the patient has recovered. This research considers that community care and home care can share the responsibility of acute hospital care when a patient is suitable to be transferred. Thus, the length of stay can be reasonably managed to increase bed occupancy and reduce waiting time. This would be in line with current government initiative of shifting care away from acute providers to more community-based intervention (DoH, 2006).

In terms of effectiveness, readmission and complication are the indicators that are often discussed in the literature. However, these two indicators have no publicly available data. Being constraint in regards to access to data, this research leaves them out from further investigation.

In terms of safety, infection within hospitals is always a threat. It is considered a valid indicator to measure a hospital's safety. According to the Health Protection Agency (2006), there are four types of infections that are to be monitored on a regular basis: Meticillin-resistant Staphylococcus Aureus (MRSA) bacteraemia, Clostridium difficile associated diseases, Glycopeptide-Resistant Enterococcal (GRE) and surgical site infection. This research adopts MRSA and Clostridium difficile infection as the indicators.

In addition to the above indicators, this research also is concerned with patients' responses to the hospital services. According to new national targets published in 2006, the patient experience is included in the monitoring list. It contains five indexes: 'waiting and access', 'safe, high quality and coordinated care', 'better information and more choices', 'building relationship' and 'clean, comfortable and friendly place to be' (DoH, 2004). This research adopts this as an indicator to complement previous four indicators to ensure a consistent result generated.

Data collection

In this research, statistical data is used. Data was collected from a number of public sector organisations: Department of Health, Hospital Episode Statistics, Healthcare Commission, National Statistics and HM Treasury. The data was generated based on the daily activities of each Trust and then reported to related government bodies at the annual, seasonal or monthly basis. The data period covers nine years from 1998 to 2007 but some of the data is fragmented and only available for certain years. The indicators and the associated data are shown in Table 1.

Table 1: Indicator and data sources

Indicators	Data source	Data period (year)	Size of sample (N)	PFI sample (N1)	Non PFI sample (N2)
Length of waiting	Hospital episode statistics	9 (98/07)	214(98/99) 197(99/00) 198(00/01) 181(01/02) 172(02/03) 168(03/04) 171(04/05) 176(05/06) 166(06/07)	3(00/01) 10(01/02) 17(02/03) 23(03/04) 23(04/05) 30(05/06) 36(06/07)	214(98/99) 197(99/00) 195(00/01) 171(01/02) 155(02/03) 145(03/04) 148(04/05) 146(05/06) 130(06/07)
Length of stay	Hospital episode statistics	9 (98/07)	The same as the above	The same as the above	The same as the above
Patient experience	Healthcare commission	1 (06/07)	167	33	134
MRSA infection (rate per 10,000 bed days)	Department of health	5 (01/06)	173	9(01/02) 18(02/03) 24(03/04) 24(04/05) 30(05/06)	164(01/02) 155(02/03) 149(03/04) 149(04/05) 143(05/06)
Clostridium infection (rate per 1,000 bed days)	Department of health	2 (04/05)	178	23(04/05) 29(05/06)	155(04/05) 149(05/06)

Sample size fluctuates over the period of time is caused by data missing or incomplete data reporting from Trusts. An additional issue is the change of priorities during the study period. Government priorities are often shifting based on political climates. This is one of the reasons for a fragmented data set.

Statistical analysis

This is an exploratory and comparative piece of research which aims to distinguish whether PFI hospitals differ from non PFI hospitals in regards to specific performance indicators that relate to government priorities. Group differentiation analysis is performed using standard t-test. The use of t-test is an appropriate method to test the difference between two independent groups, as the comparison between PFI and non PFI hospitals is performed by comparing the mean of each indicator. All analysis is undertaken within SPSS.

Limitation

Some research argues that the reliability of those routinely collected data as part of the performance evaluation framework set out by the government is debatable. For instance, Luthi et al. (2004) used readmission as an indicator to examine the quality of care for the patients in the hospitals. The result shows that routinely collected data is not an accurate indicator to evaluate the quality of care. Clarke (2004) concurred such results and further indicated that those data do not particularly distinguish why a patient is readmitted as well as which incidences should be eliminated from readmission. Thus, the results generated from such data will be influenced by irrelevant information. Moreover, inconsistent data collection may occur between different institutions. Hence, one may have to be cautious about using such data in cross institutional comparison. However, this research argues that any data or data collection framework likely contain systematic bias through way data being generated. This restricts a researcher's interpretation of the results. Therefore, one should be conscious of the limitation of the use of routinely collected data and make the conclusions based on what the data can explain.

RESULTS

The first PFI hospital opened in 2000. The length of waiting for admission in the first year (2002/1) of PFI hospitals was, on average, longer than in non PFI hospitals. However, t test results at 95% confidence level show that t=0.613, df=196, p=0.540>0.05, indicating the difference is insignificant. In the following year, 2001/2, similar result can be observed. Between 2002/3 and 2006/7, the means of length of waiting in the PFI hospitals is on average lower than that in the non PFI hospitals. However, the differences are not significant. Meanwhile, the means between 1998/9 and 2006/7 show a trend that the length of waiting is decreasing in both groups except 2000/1 in PFI group.

Table 2: The length of waiting

Length of waiting		Mean				t-Test				
Year	Group	N	Mean	Std. deviation	Std. error mean	t	df	Sig. (2-tailed)	Mean difference	Std. error difference
1998/9	Non-PFI	212	103.0802	33.00019						
1999/0	Non-PFI	194	97.3402	40.61506						
2000/1	PFI	3	106.0000	17.77639	10.26320	0.613	196	0.540	11.67179	19.03365
	Non-PFI	195	94.3282	32.83519	2.35138					
2001/2	PFI	10	101.8000	20.90614	6.61110	0.472	177	0.638	4.48639	9.51314
	Non-PFI	169	97.3136	29.61081	2.27775					
2002/3	PFI	17	99.9412	24.11812	5.84950	-0.249	168	0.804	-1.93464	7.76587
	Non-PFI	153	101.8758	30.96163	2.50310					
2003/4	PFI	23	91.3478	28.78069	6.00119	-0.640	166	0.523	-4.04528	6.32398
	Non-PFI	145	95.3931	28.08279	2.33215					
2004/5	PFI	23	85.6087	18.87697	3.93612	0.152	169	0.879	0.83167	5.45737
	Non-PFI	148	84.7770	25.06531	2.06036					
2005/6	PFI	30	75.0333	21.12930	3.85766	-0.564	174	0.573	-2.71324	4.80851
	Non-	146	77.7466	24.51961	2.02926					

	PFI									
2006/7	PFI	36	70.7500	23.66115	3.94352	-0.970	164	0.333	-4.48846	4.62674
	Non-PFI	130	75.2385	24.80648	2.17567					

In terms of the length of stay, patients in the PFI hospitals, on average, have shorter length of stay than patients in the non PFI hospitals between 2000/1 and 2006/7. However, t test at 95% confidence level shows that the differences are not statistically significant (p value>0.05). Meanwhile, the means between 1998/9 and 2006/7 show a trend of decreasing in both PFI and non PFI groups except an inflation in 2001/2 and 2002/3 in non PFI group.

Table 3: The length of stay

Length of stay		Mean				t-Test				
Year	Group	N	Mean	Std. deviation	Std. error mean	t	df	Sig. (2-tailed)	Mean difference	Std. error difference
1998/9	Non-PFI	214	6.1565	1.68203						
1999/0	Non-PFI	197	5.9655	1.38008						
2000/1	PFI	3	5.3000	0.87178	0.50332	-0.848	196	0.397	-1.08769	1.28211
	Non-PFI	195	6.3877	2.21335	0.15850					
2001/2	PFI	10	5.6000	1.05409	0.3333	-1.098	179	0.274	-7.77602	0.70679
	Non-PFI	171	6.3760	2.21597	0.16946					
2002/3	PFI	17	5.5824	0.77801	0.18869	-1.246	170	0.215	-0.37120	0.29801
	Non-PFI	155	5.9535	1.19958	0.09635					
2003/4	PFI	23	5.5261	0.75812	0.15808	-0.464	166	0.643	-0.10564	0.22758
	Non-PFI	145	5.6317	1.04760	0.08700					
2004/5	PFI	23	5.1739	0.66279	0.13820	-0.878	169	0.381	-0.18825	0.21452
	Non-PFI	148	5.3622	0.99368	0.08168					
2005/6	PFI	30	4.9433	0.57336	0.10468	-0.450	174	0.654	-0.06009	0.13344
	Non-PFI	146	5.0034	0.99996	0.08276					
2006/7	PFI	36	4.7306	0.72302	0.12050	0.228	164	0.820	0.03825	0.16744
	Non-PFI	130	4.6923	0.92900	0.08148					

The infection control measures in this research include MRSA and Clostridium difficile infection. The mean of MRSA at 2001/2 period is not different between the two groups. From 2002/3 to 2005/6 the means of PFI group is consistently higher than non PFI group based on 10,000 bed-days calculation. However, t test shows that the differences between these two groups within this period are not statistically significant (p values>0.05 between 2001/2 and 2005/6).

Table 4: MRSA infection rate

MRSA infection		Mean				t-Test				
Year	Group	N	Mean	Std. deviation	Std. error mean	t	df	Sig. (2-tailed)	Mean difference	Std. error difference
2001/2	PFI Non-PFI	9 163	1.5500 1.5928	0.70388 0.90758	0.23463 0.07109	- 0.139	170	0.890	-0.4276	0.30784
2002/3	PFI Non-PFI	18 155	1.9322 1.6555	0.65000 0.89868	0.15321 0.07218	1.267	171	0.207	0.27667	0.21841
2003/4	PFI Non-PFI	24 149	1.7817 1.6640	0.70927 0.80559	0.14478 0.06600	0.674	171	0.501	0.11764	0,17449
2004/5	PFI Non-PFI	24 149	1.7900 1.5826	0.60860 0.77711	0.12423 0.06366	1.247	171	0.214	0.20745	0.16642
2005/6	PFI Non-PFI	30 143	1.8380 1.5522	0.60545 0.74877	0.11054 0.06262	1.959	171	0.052	0.28583	0.14588

A similar result appears with the clostridium difficile infection rate. PFI group's means in 2004 and 2005 were higher than non PFI group's. However, t test shows that these differences are statistically insignificant (p values>0.05). Infection rate was calculated based on per 1,000 bed-days and a patient age of over 65 years.

Table 5: Clostridium difficile infection rate

Clostridium difficile infection		Mean				t-Test				
Year	Group	N	Mean	Std. deviation	Std. error mean	t	df	Sig. (2-tailed)	Mean difference	Std. error difference
2004	PFI Non-PFI	29 134	2.3852 2.1220	0.94384 1.07621	0.17527 0.09297	1.219	160	0.225	0.26316	0.21594
2005	PFI Non-PFI	23 139	2.0443 1.8488	0.61050 0.89006	0.12730 0.07549	1.013	161	0.312	0.19550	0.19293

Patient experience includes five indicators. The results show that three out of five patient experience indicators in the PFI group have statistically lower scores than non PFI group in 2006/7. This means that patients in the PFI hospitals seem to have less satisfaction in 'access and waiting' (p=0.05), 'safe, high quality, coordinated care' (p=0.027<0.05) and 'building relationships' (p=0.021<0.05) than patients in the non PFI hospitals. T test results show that differences in the indicators 'better information, more choice' and 'clean, comfortable, friendly place to be' are statistically insignificant (p=0.309>0.05 and p=0.26>0.05).

Table 6: The experiences of patients 2006/7

Patient experience		Mean				t-Test				
Indexes	Group	N	Mean	Std. deviation	Std. error mean	t	df	Sig. (2-tailed)	Mean difference	Std. error difference
Access and waiting	PFI Non-PFI	33 134	83.6962 85.1101	3.17125 3.380454	0.55204 0.32866	-1.973	165	0.050	-1.41500	0.71714
Safe, high quality, coordinated care	PFI Non-PFI	33 134	67.8367 69.5762	4.16714 3.96725	0.72541 0.34272	-2.234	165	0.027	-1.73953	0.77866
Better information, more choice	PFI Non-PFI	33 134	66.5021 67.4530	4.87322 4.77484	0.84832 0.41248	-1.021	165	0.309	-0.95086	0.93165
Building relationships	PFI Non-PFI	33 134	81.8903 83.3741	3.54864 3.20684	0.61774 0.27703	-2.331	165	0.021	-1.48380	0.63662
Clean, comfortable, friendly place to be	PFI Non-PFI	33 134	76.2352 77.7373	2.83877 3.56017	0.49417 0.30755	-2.252	165	0.26	-1.50216	0.66698

DISCUSSION

The indicator "length of waiting" appears to show a decreasing trend from 1998 onwards in both PFI and non-PFI groups. Also, the means of the length of waiting in the PFI group is lower than that in the non-PFI group between 2002/3 and 2006/7. The reasons of causing a decreased trend in the length of waiting could be explained by two factors. Firstly, cutting down waiting list is a priority target for government. This would decrease the length of waiting gradually over the period of time. Secondly, the occupancy of beds has been managed in more efficient ways. This also decreases the second indicator, the length of stay, as Table 3 shows a trend since 1998. However, in the PFI group this trend has been consistently carried out over time. In contrast, there is a fluctuation that appears in 2000 and 2001 in the non-PFI group, even though in the long term a decreasing trend can be observed.

Interestingly, PFI hospitals have been criticised (e.g. Broadbent et al., 2003) that they provide smaller numbers of beds. This may result in an increase of the length of waiting. However, data does not support such assumption. Conversely, it shows a consistently decreasing trend in the PFI group in both the length of waiting and stay. A possible reason for such a result may be attributed to PFI hospitals benefiting from importing private sector management skills and adopting new facilities which enable them to efficiently manage bed occupancy and cut down waiting time. However, this justification requires further research to provide evidence.

Although statistical results show that the infection rates of MRSA and Clostridium difficile are no different between PFI and non PFI hospitals, this result raises a question why new built hospitals are not performing better than old hospitals in infection control. They are expected to have a higher performance due to the new installations and the application of new technologies. The arguments (e.g. Pollock et al., 2001; Pollock and Gaffney, 1997) that have emerged suggest that the designs of PFI hospitals have to be affordable and therefore, reduction of bed number or more compact design are adopted. Thus, the distance between the beds has to be compromised (Wilson and Ridgway, 2006). This may be against professional advice from infection control professionals and increase the risk of cross-infection (Kibbler et al., 1998). Furthermore, cleaning is considered an important determinant in controlling infections. Cleaning work in the PFI hospitals is outsourced to the PFI consortiums. Therefore, whether outsourcers follow the guidelines and work to the standard is unclear. Moreover, air flow and air pressure are considered important factors associated with infection control within the hospitals. Both need to be taken into consideration at the planning and designing stages of a hospital. However, the above causes are theoretical attributions. Further research may be required to explore what the actual causes are.

In terms of patient experience, Table 6 shows that PFI hospitals in general obtain a lower score than non PFI hospitals in the three out of five indicators. This may be a caution that PFI hospitals do not adequately address patient expectation. Especially, a conflict appears in the first indicator, access and waiting. Although Table 2 shows that the length of waiting in the PFI group is insignificantly shorter than it in the non PFI group, PFI group obtains a lower score in this indicator than non PFI group. One possible explanation is that most new built PFI hospitals are located in the suburbs which may cause issues in relation to access. In the survey, waiting time and access are not specifically separated. This causes an ambiguity in the explanation of the differences.

Moreover, the results of ‘safe, high quality, coordinated care’ and ‘building relationships’ show that patients seem to be more satisfied in the non PFI hospitals. This may show that new built PFI hospitals may still be at the stage of adapting to the new systems and environment. Therefore, it requires a continuous observation to see whether this is improved over time.

Furthermore, although t test results in ‘clean and comfortable place to be’ and infection rates show insignificant differences between PFI and non PFI groups, it may be worth noting that there is a correlation. Hospital acquired infections can be caused by many factors such as uncleanliness, staff training, visitors to patients, etc. This raises the questions whether outsourcing of PFI hospitals’ cleaning work is appropriate or whether outsourcers follows the guidelines of hospital cleaning theist related standards.

The overall results from patient experiences show that there is a room for PFI hospitals to improve their services and provide a clean and comfortable place for the patients.

CONCLUSION

In conclusion, this research found that there are only three indicators in the patient experience category that produce statistically significant results. However, it is unclear what factors cause the differentiations between the groups in these three indicators. All other indicators appear statistically insignificant. This can be interpreted that there is no significant difference between two groups in performance according to governmental performance indicators. This may result from two factors. Firstly, healthcare performance is a complex system and derives from many attributes which may be correlated and difficult to be clearly separated. Secondly, the nature of data also causes a limitation on the interpretation of the results as data itself contains systematic errors which cannot be eliminated. This may deteriorate the generalisation of the results. Therefore, this paper suggests further research to be implemented, which may seek for the explanations of what causes difference/no difference in the results of this research. It also raises a number of questions regarding the type of indicators that may adequately describe the performance of hospitals. Whilst the data sets may have flaws, these are indicators that are accepted to tell government about performance issues. Whilst difference can not be confidently determined, it seems that there is a need to find appropriate indicators to assess and evaluate the performance of hospitals in a more accurate and appropriate format.

REFERENCES

Akintoye, A., Hardcastle, C., Beck, M., Chinyio, E. and Asenova, D. (2003) Achieving best value in private finance initiative project procurement. Construction Management and Economics, 21, 461-470.

Akintoye, A., Taylor, C. and Fitzgerald, E. (1998) Risk analysis and management of private finance initiative projects. Engineering, Construction and Architectural Management, 5 (1), 9-21.

Austin, P. C., Naylor, C. D., Tu, J. V. (2001) A comparison of a Bayesian vs. a frequentist method for profiling hospital performance. Journal of Evaluation in Clinical Practice, 7 (1), 35–45.

Bradley, E. H., Herrin, J., Mattera, J. A., Holmboe, E. S., Wang, Y., Frederick, P., Roumanis, S. A., Radford, M. J. and Krumholz, H. M. (2005) Quality Improvement Efforts and Hospital Performance: Rates of Beta-Blocker Prescription After Acute Myocardial Infarction. Medical Care, 43(3), 282-292.

Broadbent, J., Gill, J. and Laughlin, R. (2003) Evaluating the private finance initiative in the national health service in the UK. Accounting, Auditing & accountability Journal, 16 (3), 422-445.

Clark, A. (2004) Readmission to hospital: a measure of quality or outcome? Qual Saf Health Care, 13, 10-11.

Department of Health (2004) National Standards, local action: health and social care standards and planning framework2005/6 - 2007/8. London: Stationary Office

Department of Health (2006) Our health, our care, our say. London: Stationary Office.

DesHarnais, S. I., McMahon, L. F., Wroblewski, Jr. R. T. and Hogan, A. J. (1990) Measuring Hospital Performance: The Development and Validation of Risk-Adjusted Indexes of Mortality, Readmissions, and Complications. Medical Care, 28 (12), 1127-1141.

Gaffney, D., Pollock, A. M., Price, D. and Shaoul, J. (1999) The private finance initiative: NHS capital expenditure and private finance initiative-expansion or contraction? BMJ, 319, 48-51.

Health Protection Agency (2006) Mandatory surveillance of healthcare associated infections report 2006. London: Health Protection Agency.

Iezzoni, L. I., Shwartz, M., Ash, A. S., Hughes, J. S., Daley, J., Mackiernan, Y. (1996) Severity Measurement Methods and Judging Hospital Death Rates for Pneumonia. Medical Care, 34(1), 11-28.

Kibbler, C.C., Quick, A. and O'Neill, A.M. (1998) The effect of increased bed numbers on MRSA transmission in acute medical wards. Journal of Hospital Infection, 39(3), 213-219.

Luthi, J. C., Burnand, B., McClellan, W. M., Pitts, S. R. and Flanders, W. D. (2004) Is readmission to hospital an indicator of poor process of care for patients with heart failure? Qual Saf Health Care, 13, 46-51.

Mallak, L. A., Lyth, D. M., Olson, S. D., Ulshafer, S. M., Sardone, F. J. (2003) Culture, the built environment and healthcare organizational performance. Managing Service Quality, 13(1), 27-38.

National Audit Office (2000) The management and control of hospital acquired infection in acute trusts in England. London: Stationary Office.

Pollock, A. and Gaffney, D. (1997) Capital charges: a tax on the NHS. British Medical Journal, 317, 157-158

Pollock, A., Shaoul, J., Rowland, D. and Player, F. (2001) Public services and the private sector: a response to the IPPR. London: The Catalyst Trust Ltd.

Pollock, A. M., Shaoul, J., and Vickers, N. (2002) Private finance and 'value for money' in NHS hospitals: a policy in search of a rationale? BMJ, 324, 1205-1209.

Romano, P. S., Zach, A., Luft, H. S., Rainwater, J., Remy L. L. (1995) The California Hospital Outcomes Project: using administrative data to compare hospital performance. Joint Commission Journal on Quality Improvement, 21(12), 668-682.

Rosenthal, G. E., Hammar, P. J., Way, L.E., Shipley, S.A., Doner, D., Wojtala, B., Miller, J. and Harper, D. L. (1998) Using hospital performance data in quality improvement: the Cleveland Health Quality Choice experience. Joint Commission Journal on Quality Improvement, 24(7), 347-360.

Shaoul, J. (2005) A critical financial analysis of the private finance initiative: selecting a financing method or allocating economic wealth? Critical Perspective on Accounting, 16, 441-471.

Thomas, J. W. and Hofer, T. (1999) Accuracy of Risk-Adjusted Mortality Rate As a Measure of Hospital Quality of Care. Medical Care, 37(1), 83-92.

Werner, R. M. and Bradlow, E. T. (2006) Relationship Between Medicare's Hospital Compare Performance Measures and Mortality Rates. JAMA, 296, 2694-2702.

Wilson, A. P. R. and Ridgway, G. L. (2006) Reducing hospital-acquired infection by design: the new University College London Hospital. Journal of Hospital Infection, 62(3), 264-269.

OUTLINING A KNOWLEDGE MANAGEMENT SYSTEM SUPPORTIVE OF URBAN SUSTAINABILITY ASSESSMENT

Craig S. Thomson
School of the Built and Natural Environment, Glasgow Caledonian University, UK
craig.thomson@gcal.ac.uk

Mohamed A. El- Haram and R. Malcolm W. Horner
Construction Management Research Unit, Division of Civil Engineering, University of Dundee, UK
m.elharam@dundee.ac.uk
r.m.horner@dundee.ac.uk

Cliff Hardcastle
University of Teesside, UK
C.Hardcastle@teesside.ac.uk

As sustainability assessment is increasingly viewed as contributing to a wider subjectively based approach to decision-making within building projects, growing value is attached to managing the flow of knowledge that surrounds them. In order to support this, a need is identified to manage the knowledge generated during assessment, through the facilitation of its flow and transfer between those involved within individual assessments and between those of different assessments. This paper presents the requirements for developing a knowledge management system that responds to the challenges of applying it as an approach within this context. These principles are illustrated around an Integrated Sustainability Assessment Toolkit (ISAT) currently being developed to aid practitioners in the management of assessment, by assisting in the identification of sustainability issues, selection of appropriate tools and in the consideration of the assessment outputs, in a manner that is reflective of the assessment context.

Key words- sustainability assessment; knowledge management; stakeholder engagement; learning

INTRODUCTION

The social, economic and environmental consequences associated with the way we design, build, operate, maintain and ultimately dispose of buildings and their support systems has emerged as a key focus of significance for delivering sustainability (El- Haram et al., 2007). However, recent concern has emerged over the lack of integration between current assessment practice and the decision-making processes at all stages of the lifecycle and scales of urban development (Lee, 2005). Kaatz et al. (2006) advances this, by arguing that only when sustainability is integrated with the building process, and not regarded purely as an element of it, can both the concept and its implications begin to be understood. In order to achieve this, sustainability assessment requires to be viewed as contributing towards a decision-making process that is predominantly subjective by nature (Pahl-Wostl, 2002). Essential in fostering such an approach, is the accessibility and availability of knowledge amongst those involved (Wilkins, 2003). Managing knowledge within this context is traditionally difficult due to the fragmented and temporary nature of the project environment. This problem is compounded by the high degree of uncertainty regarding sustainability as a concept and its practical implications; in addition to the general lack of experience and poor knowledge base regarding assessment tools, methodologies and the absence of a recognisable framework within which it operates (Deakin et al., 2002). Matsumoto et al. (2005) observed that the primary means of developing knowledge was through its acquisition over time through experience, thus advocating an approach that is based on the long term development of a dynamic knowledge base amongst practitioners. Central to such an approach is the exposure of stakeholders to the principles and implications of sustainability during its assessment, through involvement in the discourse and practices that surround it. If sustainability assessment is to evolve as a mechanism for stimulating learning amongst stakeholders, the effective transfer of knowledge and experience between those involved during both an assessment, and future assessments plays a significant role.

This paper discusses the role of a suggested integration of the knowledge management strategies of codification and personalisation, and outlines the delivery of these in a compatible knowledge management system (KMS). The system aims to assist in the management of knowledge generated during assessment, by facilitating its flow and transfer between relevant stakeholders involved in present and future assessments. The principles will be demonstrated around an Integrated Sustainability Assessment Toolkit (ISAT) which is being developed to aid practitioners in the management of assessment as part of the EPSRC funded SUE-MoT (Sustainable Urban Environment- Metrics, Models and Toolkits) research consortium involving Dundee, Glasgow Caledonian, Loughborough and St. Andrews Universities. Discussed around each phase of the ISAT is the integration of codification and personalisation strategies to knowledge management and the mechanisms identified to aid the transfer of knowledge amongst stakeholders both during and between sustainability assessments.

A SPECIFICATION FOR A SUPPORTIVE KMS

Thomson et al. (2007) argued that through the application of knowledge management strategies, the potential is offered to develop a system that is supportive of this goal, by ensuring the flow of knowledge amongst stakeholders is facilitated and managed. In outlining a specification for a knowledge management system (KMS) that supports sustainability assessment, it is necessary to incorporate an integration of two basic knowledge management strategies; personalisation strategy (where knowledge is seen as tied to those who develop it and is shared through personal interaction) and codification strategy (based on the codification of knowledge and storing it in artefacts and databases where it can be accessed) (Kasvi et al., 2003).

Personalisation Strategy

The delivery of effective stakeholder engagement has the potential to represent the mechanism by which a personalisation strategy can be delivered in the context of assessment. By encouraging discourse between stakeholders through a range of mechanisms, it is anticipated that these pathways and channels of communication will aid the necessary transfer of implicitly held knowledge by individuals to the others involved. The practice of ‘social learning’ is increasingly promoted as an essential element of sustainability assessment and is dependent on the effective transfer of knowledge and experience through discourse encountered during the process of ‘doing an assessment’ (Kaatz et al., 2006). This provides individuals exposure to the experience held by other stakeholders regarding sustainability as a concept, its practical implications and the methods surrounding its assessment; in addition to the collective sharing of new experiences over the course of the assessment. Shelbourn et al.'s (2006) understanding of the subjectivist approach to knowledge management aligns itself with this, where knowledge is identified as linked to human experience and the social practice of 'knowing'. Given the subjective nature and predictive inaccuracy of the outputs of many assessment tools, facilitating discourse between stakeholders has the potential to create an environment within which potential trade-offs regarding sustainability can be made in a transparent and context reflective manner. In developing a KMS that is reflective of this context, a need exists to provide mechanisms that facilitate the access and participation of stakeholders in the channels of discourse regarding sustainability, its assessment and its practical implications, by maximising the transfer of knowledge between individuals during it.

Codification Strategy

The high degree of uncertainty and general lack of experience amongst those involved in sustainability assessment, provides the potential for a KMS that can supplement the knowledge base of those involved through the capture of experience and expertise generated by individuals during an assessment, in order that it can be accessed and drawn upon by those involved in future assessments. The development of such a system embodies the principles surrounding a codification strategy to knowledge management understood by the likes of Kasvi et al. (2003). Through the provision of such a resource; an environment would be created for stimulating collective learning without the need for active engagement in the channels of discourse between those seeking and those holding knowledge. The development of systems supportive of this principle are increasingly common for supporting the capture and access to knowledge within project management as a tool for combating the problems associated with its retention due to the transient nature of projects. These systems, act as resources for capturing an individual's knowledge and experience, so it can be drawn upon by others who are no longer involved in or part of the discourse surrounding it. This resource would prove valuable in the context surrounding the delivery of sustainability assessment within the multi- team environment of the building process.

Information and Communication Technology (ICT) is widely recognised as the indisputable enabler for implementing such a strategy, as it offers 'rapid search, access and retrieval of information, and can support collaboration and communication pathways' (Wong, 2005). Figure 1 illustrates the principles around which a codification strategy can be achieved. However, the purely objectivist nature of many existing approaches delivered using ICT systems have been criticised for ignoring the subjective dimension of knowledge so vital in achieving effective knowledge transfer and learning (Cushman et al., 2002). Knowledge is recognised to exist in two principle forms; explicit which is documented and public, structured, fixed-content, externalised and conscious (Egbu and Botterill, 2002), and tacit which is personal knowledge used by individuals to perform their work and to make sense of the world (Mohamed et al., 2006) that is informal, contextual and difficult to communicate. Egbu and Botterill (2002) criticised many ICT approaches for failing to interact with the tacit knowledge that reflects the situation or context within which it is found. Whilst, explicit knowledge such as assessment outputs and associated documentation are necessary to inform decision-making, it is the tacit knowledge connected to the experience gained during the contextual circumstances of the assessment i.e. in the selection, implementation and interpretation of particular tools, that proves valuable in reducing the levels of uncertainty during future assessments. Mechanisms aimed at the facilitation of both explicit and tacit forms of knowledge require to be considered in the development of a KMS.

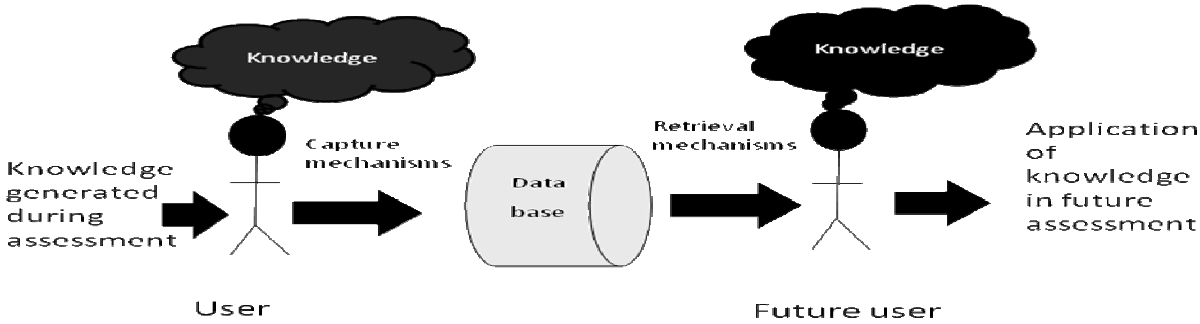


Figure 1: Illustrating the principles of the codification strategy

In developing a KMS that is compatible with the outlined approach to sustainability assessment, an integration of the personalisation and codification strategies is required. In order to achieve this, many of the mechanisms designed to facilitate the discourse between individuals require to be interlinked with the capture and retrieval mechanisms delivered through the ICT. This aligns with Cushman et al.'s (2002) 'constructionist approach' to knowledge management and has the potential to aid the transfer of knowledge between assessments in a manner that facilitates learning. Figure 2, illustrates how the principles of the personalisation strategy are delivered through an ICT based KMS, highlighting the integration of the capture and retrieval mechanisms associated with the codification strategy.

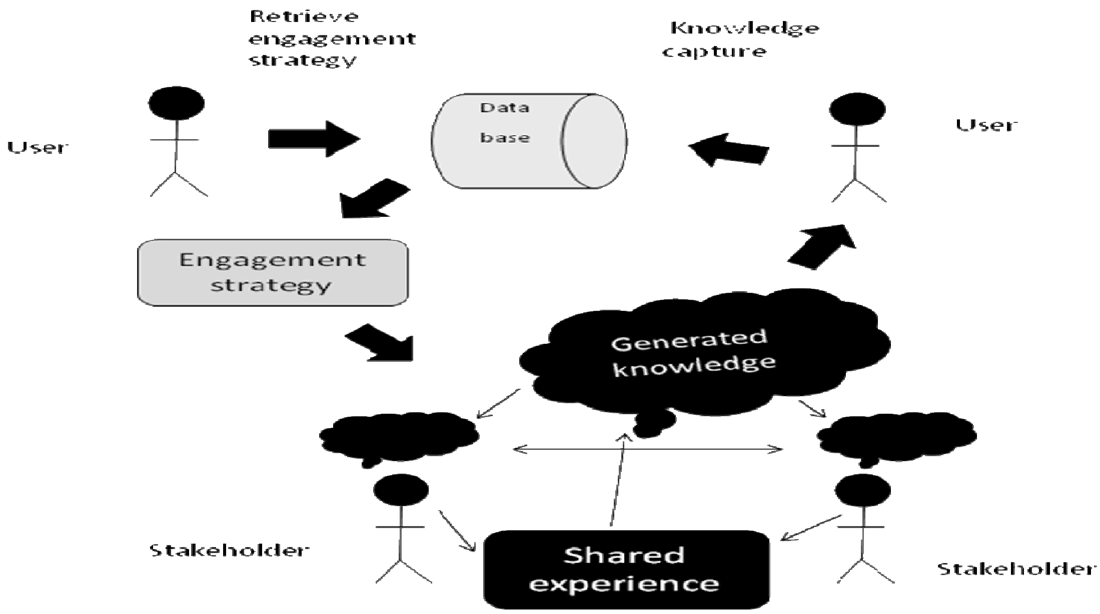


Figure 2: Illustrating the principles of the personalisation strategy

THE ISAT AND INTEGRATING A COMPATIBLE KMS

The SUE-MoT research consortium has set out to develop a comprehensive and transparent framework that encourages key decision-makers to systematically assess the sustainability of urban developments taking into account scale, lifecycle, location, context and stakeholder values. Central to the research programme is the development of an integrated sustainability assessment toolkit (ISAT) that is reflective of the requirement to integrate the environmental, economic and social dimensions of sustainability during assessment. The toolkit aims to facilitate in the selection of assessment tools appropriate to the scale, lifecycle, location, context of the development project and to integrate their outputs in a meaningful manner. In order that the ISAT reflects the recognized emergence of the role of aiding understanding and participation amongst those involved during sustainability assessment, it will be integrated with a KMS that is reflective of the approach described in the previous section. The ISAT is to be developed as an ICT web based application, with the user presented in terms of functionality with both the toolkit and the KMS within an integrated platform.

The research aims to develop a KMS that delivers the functionality to enable those using the ISAT to access and transfer the knowledge and experience of others, whether they are part of the same project or a future assessment. In order to achieve this, a codification strategy will be developed and supported with mechanisms for aiding stakeholder engagement in order to facilitate a personalisation strategy. In supporting the user of the ISAT in terms of supplementing their knowledge base through the system and in suggesting a strategy for aiding their engagement with other stakeholders, it is hoped that a better understanding of sustainability, its implications and assessment is fostered through learning, in a manner that is reflective of Pope's (2006) advocated approach of 'learning by doing'.

In developing a system around these principles, it is necessary to ensure that the nature of its flow, interface, capture/ retrieval mechanisms and the suggested engagement strategies, are representative of the requirements of its potential users. Five case studies reflective of contrasting sectors and procurement routes (i.e. housing, schools, office, hospital and an example of best practice) were identified and analysed to provide the empirical basis for capturing the requirements for the system. Interviews were conducted with relevant stakeholders contributing to the assessment within each case study, and a series of knowledge maps developed to identify the key drivers, barriers and facilitators, influencing factors surrounding the flow of knowledge during the selection of issues, tools, assessment and the consideration of the assessment outputs. This was supported through an emerging understanding of the proficiencies and competencies of the individual stakeholders involved, allowing for an awareness of who is involved, their role, the knowledge they bring, the knowledge they require, its preferred method of transfer and the nature of their relationship reflective of lifecycle stage to be established. These findings were used to inform the development of the flow, interface and requirements for the mechanisms for knowledge capture and retrieval system outlined in the following sections.

Developing a KMS supportive of the ISAT

The ISAT is structured to replicate the phases of a sustainability assessment. The research identified five main iterative phases of assessment that run across a projects lifecycle- i.e. scoping, sustainability planning, assessing, monitoring and auditing (Thomson et al. 2007). These formed the basis for the number of key activities around which the development of the ISAT would be centred. The identified activities aim to allow for the selection of appropriate assessment tools based on the context of assessment (defined by a criteria i.e. object of assessment, lifecycle stages) and a selection of sustainability issues (identified and prioritised reflective of the values of the stakeholder); and to bring the outputs from their implementation together where meaningful to give an integrated, holistic sustainability assessment reflective and considered on the basis of stakeholder values. These activities are represented in 5 modules: issues selector, tool selector, assessment, integration and output assessment around which a functional integration of the ISAT and KMS is developed. Figure 3 displays these modules within a representation of the ISAT and KMS framework. The user can either interact with the system as a series of one off assessments, or as part of a wider project where individual assessments are presented and managed together. The tools suggested vary with project lifecycle, reflecting the evolution of the stages of the project, and the different function of the tools.

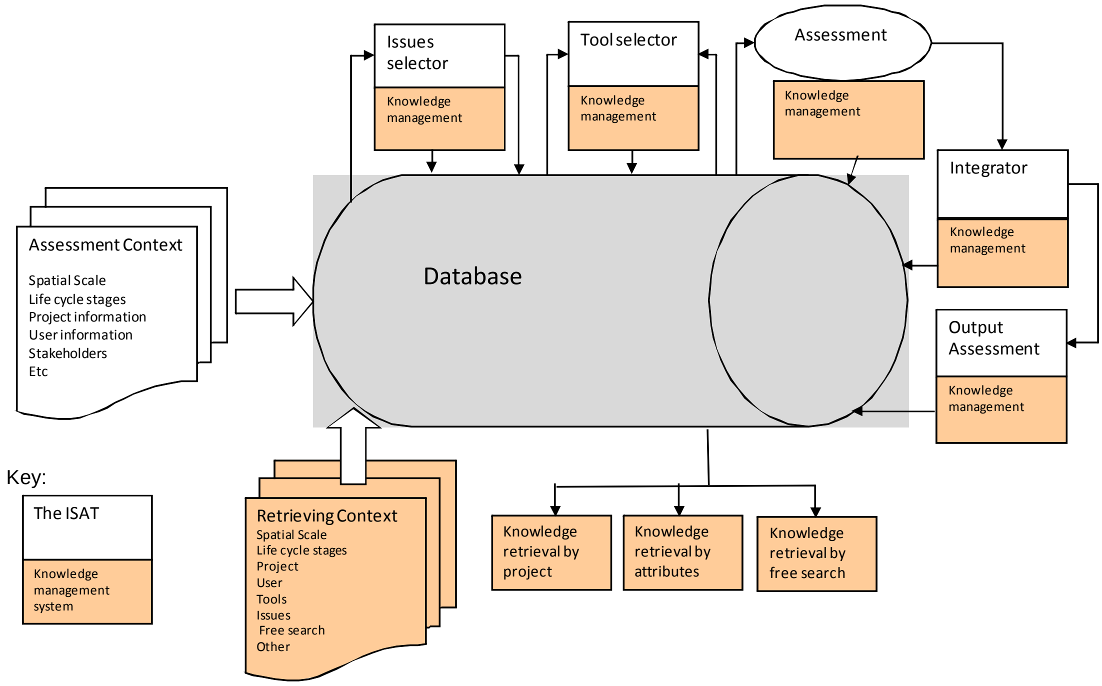


Figure 3: A functional specification for the integration of the ISAT and KMS

For each module displayed in figure 3, a range of knowledge capture mechanisms are incorporated to ensure that both the explicit and tacit knowledge generated by those involved in delivering each of these activities is captured and stored. A range of mechanisms are provided to capture explicit knowledge (e.g. assessment output data, information, reports), and a variety of mechanisms geared towards capturing the tacit knowledge accumulated by the user i.e. structured questions/ prompts, questionnaires (e.g. reviewing the performance of the assessment tool) and free/ open text (allowing for an unstructured record of experience). These are developed in response to the contextual requirements of the individual modules. The captured knowledge is stored and tagged within a database (displayed in figure 3), with the aim of providing access to future users of the system either for its retrieval as knowledge associated directly with the activities relating to the individual modules or as part of a generic knowledge hub, set and accessed out with the modules and displayed at the bottom of figure 3. Within the later, the user will retrieve knowledge relevant to their assessment context either by considering knowledge generated during similar projects (i.e. viewed like a case study), knowledge tied to an attribute (i.e. specific to a tool or an issue) or through a free search for knowledge (rather like an internet search). The described capture and retrieval mechanisms form the basis of the codification strategy and the principles of its delivery are displayed in figure 1. In addition to this ‘user generated’ knowledge, a proportion of static knowledge will be provided upon the findings of the wider SUE-MoT research programme. An example of this would be the profiles of each assessment tool held in the database, to aid the user’s comparison of the tools. Such information is to be updated and managed centrally. The retrieval mechanisms are developed to allow a user to consider both the static and the ‘user generated’ knowledge held in the database in a complementary manner, thus informing the actions and decisions surrounding the assessment and stimulating learning from a variety of sources and forms of knowledge.

Within each module, an engagement strategy is presented in a static form (developed within the research), providing the user with recommendations for managing an appropriate level of engagement with relevant stakeholders for the associated module. This has a number of functions: to ensure that their values are elicited within choices or decisions taken during assessment, participation and contribution in the activities of assessment, and to encourage the discourse and social interaction required to facilitate social learning. This represents the delivery of the personalisation strategy discussed earlier and around the principles displayed in figure 2. The following section discusses the breakdown of the modules, illustrating the integration of the two strategies.

Issues Selection

Prior to the selection of any tool, the ISAT aims to aid the user in the selection of relevant sustainability issues reflective of the context of assessment (i.e. object of assessment, lifecycle stage). This can be delivered either as a one off assessment (at any stage of the lifecycle) or as part of the wider scoping exercise which forms the basis of the sustainability management for the project. Presented is a list of sustainability issues, from which the user selects those that are appropriate to the context of assessment. The SUE-MoT team identified over 600 sustainability issues and indicators associated with the life-cycle stages of an urban development, in addition to those relating to the manufacture and transport to-site of construction materials. These were reduced by a consolidation exercise to major impact categories, and verified through workshops and questionnaire surveys. The sustainability impacts represented in the list are environmental (material use, energy, water, land use, pollution to air, global air quality, pollution to land, pollution to water, ecological health, waste, environmental quality); social (crime and security, health and wellbeing, social capital, social inclusion, culture and heritage); and economic (whole life value, economic multiplier effect on jobs) and this work is reported in Xing et al. (2008).

In order to aid the selection process, the user will be provided with the ability to draw on sustainability issues selected during previous assessments; either as part of the wider project, or from previous projects that share a similar context. This allows users to consider the sustainability issues that are traditionally selected for a variety of different contexts, enabling them to question why the selected issues may differ in relation to context and how their assessment relates to this. Support is provided through the provision of definitions for each issue and the opportunity provided to search the knowledge hub for comments that have been captured from previous users by searching the issue as an attribute. The provision of stakeholder engagement tools is a significant element of the support offered to the user in stakeholder identification; and the identification and prioritisation of the sustainability issues. A variety of engagement tools will be suggested, from which if appropriate the user can select those that match their needs. Each will be supported with a profile, and access provided to the experiences of previous users during their application in practice. Whilst the system advocates stakeholder engagement and suggests an approach to managing sustainability across the lifecycle of the project, this is not prescriptive and can be ignored by the user if they see fit (i.e. they have already selected their issues prior to coming to the system). Mechanisms are provided to capture the selections made in order that it can be tagged within the database relative to its assessment context, but also to ensure that the tacit knowledge surrounding the reasoning for the selection is captured for the benefit of future users.

Tool Selector and Assessment

Based on the context of assessment and the sustainability issues identified, the system suggests a range of relevant sustainability assessment tools (e.g. BREEAM, LEED). The user is supported through the provision of a profile for each tool, statically held within the database, and the 'user generated' knowledge that is captured from previous users their experience of the tool in practice. The database allows for the search against individual and multiple criteria (e.g. cost, complexity, scale of application), allowing users to make decisions based on a strong evidence base. A direct comparison of similar tools will be possible against the set criteria, with a range of visual aids to help present the information in the most suitable form. The capture of previous experience regarding the performance of the tools during assessment is an important element of the ISAT. Whilst a need has not been identified for formal stakeholder engagement within this module, the system will suggest mechanisms to help maximise the knowledge transfer between the user and other relevant stakeholders involved. Once the tool/s are selected, the system will capture that decision, and ask for an explanation of the reasoning through a series of questions designed to capture the tacit knowledge for the benefit of future users.

The system aims to support users during the application of the tool/s in practice, by enabling access through retrieval mechanisms to the experience of those involved in the previous application of the tool in practice. This will allow users to benefit from the tacit knowledge generated during past assessments, enabling them to identify and provide the potential to overcome problems. The system encourages a history of the assessment to be recorded, enabling the assessment to be viewed as transparent and updated as it progresses, in addition to facilitating the capture the necessary tacit knowledge.

Integration and Assessment Outputs

Following the assessment, the ISAT aims to provide a facility for users to manage the outputs of the tools, and if appropriate to integrate these outputs in a meaningful way. Depending on the nature of the assessment and tools applied, this can be as simple as a place to store, access and present the outputs from the assessment in order that it can be viewed and understood in one place and by multiple users. It is structured to provide a report of the overall assessment, with the capacity to be incorporated into a wider assessment report of all the individual assessments conducted over the entire project. The SUE-MoT research is currently considering the value of advancing the function of the system to potentially integrate outputs using e.g. multi criteria analysis and the development of visual methods for presenting the outputs. A series of appropriate stakeholder engagement tools are suggested to support the decision-making process surrounding the consideration of the outputs of the assessment. Increasingly this is becoming a necessary element of the assessment, as through engagement, stakeholders become exposed to the decision-making process surrounding sustainability within the built environment, thus increasing its transparency and providing the basis to stimulate learning amongst those involved. A by- product of such an environment is the resultant discourse between stakeholders regarding the implications of the findings of the assessment, and thus the creation of an environment for mediation can be fostered between the differing values. Following the assessment, the user is provided with the opportunity to review the individual tools that they have used (each against set criteria) in order that it can be captured for the benefit of future users and displayed in the manner discussed in relation to tools selection. In addition, a means is provided for the user to record the contribution made by the assessment to the wider decision-making of the project. This is useful, as it provides a transparent record for future users to consider and learn from, when making decisions during future assessments.

Further research

Over the next 12 months, a pilot system will be developed as a web- based application. Practitioner input will be sought through a series of workshops and interviews with refinements made to ensure its continued development meets the requirements of the potential user.

CONCLUSION

In developing an integrated system in this manner, the potential exists for the ISAT to be applied by the user within a system that replicates the phases of assessment and supports the management of the knowledge requirements encountered by the user during its application. By integrating the KMS with the ISAT, the system aims to comply with the evolution of sustainability assessment towards a process-orientated approach, where knowledge generated during assessment guides decision-making, and is not constrained by it. Knowledge management plays a significant role in ensuring that the knowledge retrieved through the system is both relevant and viewed within the contextual environment it was generated. By emphasizing the value of the situation and subjective dimensions of knowledge, the users of the system can view the experiences of others and apply the lessons learnt in their own context. In providing a strategy to aid participation, users of the system can facilitate the flow of knowledge between those involved in assessment, in a manner that is supportive of participation and knowledge transfer. Mechanisms are provided through the system to facilitate this transfer of knowledge so that individuals develop an understanding of sustainability, its implications, the issues faced during its assessment and the values held by different stakeholders. Through this, the system aims to provide the sharing of experience and expertise amongst those involved whether through social interaction or by an attempt to replicate this between assessments through a codification strategy of the nature outlined in order to stimulate the desired learning.

ACKNOWLEDGEMENTS

The authors gratefully acknowledge the financial support of the UK EPSRC (grant reference: EP/C008030/1) and the contribution of all the participating researchers from Dundee, Glasgow Caledonian, Loughborough and St. Andrews Universities who make up the SUE-MoT research consortium.

REFERENCES

Cushman, M., Venters, W., Cornford, T. and Nathalie, M. (2002) Understanding sustainability as knowledge practice. Presented to British Academy of Management Conference: Fast-tracking performance through partnerships, London, 9-11 September 2002

Deakin, M. Huovila, P., Rao, S., Sunikka, M. and Vreeker, R. (2002) The assessment of sustainable urban development. Building Research & Information, 30(2), 95-108.

El-Haram, M., Walton, J.S., Horner, R.M.W., Hardcastle, C., Price, A., Bebbington, J., Thomson, C.S. and Atkin- Wright, T. (2007) Development of an Integrated Sustainability Assessment. Proceedings of the International Conference on Whole Life Urban Sustainability and its Assessment, Glasgow, June 2007.

Egbu, C.O. and Botterill, K. (2002) Information technologies for knowledge management: their usage and effectiveness. ITcon, 7, 125-136.

Kaatz, E., Root, D.S., Bowen, P.A. and Hill, R.C. (2006) Advancing key outcomes of sustainability building assessment. Building Research & Information, 34(4), 308-320.

Kasvi, J.J.J., Vartiainen, M. and Hailikar,i M. (2003) Managing knowledge and knowledge competencies in projects and project organizations. International Journal of Project Management, 21, 571-582.

Lee, N. (2005) Bridging the gap between theory and practice in integrated assessment. Environmental Impact Assessment Review, 26, 57-78.

Matsumoto, I.T., Stapleton, J., Glass, J. and Thorpe, T. (2005) A knowledge-capture report for multidisciplinary design environments. Journal of Knowledge Management, 9(3), 83-92.

Mohamed, M., Stankosky, M., and Murray, A. (2006) Knowledge management and information technology: can they work in perfect harmony? Journal of Knowledge Management, 10(3), 103-116.

Pahl-Wostl, C. (2002) Towards sustainability in the water sector- the importance of human actors and processes of social learning. Aquatic Sciences, 64, 394- 411.

Pope, J. (2006) Sustainability assessment: A 'dialogue of the deaf' or a social learning process? Proceedings of the 26th Annual Meeting of the International Association for Impact Assessment, Stavanger, Norway, 23-26 May 2006.

Shelbourn, M.A., Bouchlaghem, D.M., Anumba, C.J., Carillo, P.M., Khalfan, M.K. Glass, J. (2006) Managing knowledge in the context of sustainable construction. IT con, 11, 57-71.

Thomson, C.S., El- Haram, M., Walton, J.S., Hardcastle, C., Sutherland, J.S. (2007) The role of knowledge management in urban sustainability assessment. Proceedings of the International Conference on Whole Life Urban Sustainability and its Assessment, Glasgow, June 2007.

Wong, K.Y. (2005) Critical success factors for implementing knowledge management in small and medium enterprises. Industrial Management & Data Systems, 105(3), 261-279.

Wilkins, H. (2003) The need for subjectivity in EIA: discourse as a tool for sustainable development. Environmental Impact Assessment Review, 23, 401-414.

Xing, Y., Horner, R.M.W., El-Haram, M. A., Bebbington, J. (2008) A framework model for assessing sustainability impacts of a built environment. Accounting Forum Journal (in press)

FACTORS INFLUENCING STEEL REINFORCEMENT LABOR PRODUCTIVITY

Jamil José Salim Neto
University of São Paulo, São Paulo, Brazil
jamil.salim@poli.usp.br

Ubiraci Espinelli Lemes de Souza
University of São Paulo, São Paulo, Brazil
ubiraci.souza@poli.usp.br

Rodrigo Rosa Tomazetti
University of São Paulo, São Paulo, Brazil
rodrigo.tomazetti@poli.usp.br

Reinforced concrete structures are largely used in Brazilian building construction. The use of prefabricated steel pieces are supposed to improve labor productivity. This paper evaluates the factors that are considered to have influence on the labor efficiency, based on 9 construction sites studies. During more than one year the authors run a data collection about steel reinforcement. Statistical analysis helped to define the factors and their influence on the rebar labor productivity. The results can help organize production and to set recommendations for the steel reinforcement design in order to reach improved labor productivity.

KEYWORDS: steel reinforced concrete structures, steel reinforcement design, labor productivity.

INTRODUCTION

Productivity

Researchers from several countries, including researchers from Brazil, have been studying the productivity in the civil construction for a long time. Among some international work it can be mentioned the of Abdelhamid and Everett (1999) that utilizes a tool called Time Series Analysis to improve construction productivity; the of Teicholz et al. (2001) that approaches the productivity using typical tasks from the building construction process and analyzing the labor costs and output productivity trends utilizing root-squaremeans; the of Thomas and Napolitan (1995) that details, in quantitative terms, the effects of changes and change orders on labor productivity and efficiency.

Labor productivity has been studied around the world; a CIB report (Thomas et al, 2002) describes the results of an international research project conducted by researchers of several countries. In Brazil there are several researchers who study labor productivity such as: Souza (1996), Carraro (1998), Obata (2000), Araújo (2000), Librais (2001), Silva (2002), Maeda (2002), Reis (2005), Dantas (2006), Araújo (2005) among others.

According to Liou and Borcherding (1986) the term “productivity” is generally used to denote a relationship between output and the associated inputs used in the production process. He also mentions that in the construction industry, man-hours per unit produced is popularly used as a productivity index because of the concentration of manpower needed to complete a specific task.

The definition of productivity adopted by the researchers of this article is the proposed by Souza (2006) that defined labor productivity as being the efficiency/efficacy in the transformation of inputs in outputs.

The indicator used in this paper to measure the labor productivity is the proposed by Souza (1996) called Razão Unitária de Produção (RUP), where:

$$RUP = \text{man-hours}/\text{quantity of service}$$

RUP = Production Unit Reason
Man-hours = man-hours spent for the service (input)
Quantity of service = quantity of service performed (output)

Productivity Modeling

There are several methods of productivity modeling, for example, the Total Productivity Model (Sumanth, 1979), the Hierarchy Model of Construction Productivity (Kellogg et al., 1981), the Factor Model of Construction Productivity (Thomas and Yiakoumis, 1987) among others.

The authors of this research utilized the Factor Model of Construction Productivity, proposed by Thomas and Yiakoumis in 1987, because they understand that it is the best model to understand and analyze the variation of productivity that occurs in the civil construction.

Thomas and Yiakoumis (1987) affirm that the Factor Model takes into consideration productivity improvements due to repetitive operations and can be used to perform rigorous statistical analyses of the factors affecting the productivity of labor-intense construction activities.

Thomas et al. (1990) mention that the essential characteristics of the Factor Model are: a) unlike work study, the Factor Model measures productivity not as a function of time, but as a function of output; b) the focus is on the crew, as the basic work unit, rather than on individual crew members; c) the ideal productivity required to perform the work is time-dependent, i. e., improvements resulting from repetition can be modeled; d) the model includes the major factors that affect productivity. The form of the model permits statistical validation, and factors can be added or deleted as appropriate.

Souza (1996) affirms that the labor productivity can be influenced by a large number of factors. Thomas and Smith (1990) apud Souza (1996) classify that large number of factors in two big groups: the factors related to the “content of the work” and the factors associated to the “context of the work”.

Souza (1996) explains that understanding the nature of the factors that can interfere significantly on the productivity, the following step involves the prior election those it will be observed during the data collection. The following phase is characterized by the correlation between the factors based on statistics in order to identify what the factors that influence the analyzed labor productivity are.

Design of reinforced concrete structures

The design of reinforced concrete structures, analyzed as a product, can be defined as being the document that contains technical information, descriptive and graphic elements, for the crew that is going to perform the reinforced concrete structure.

In Brazil the designs of reinforced concrete structures are basically constituted by the formwork design and steel reinforcement design.

The steel reinforcement design can be defined simply as being the technical document that contains information about the features of the pieces (diameter, unit length, number of pieces, arrangement of the piece in the steel reinforcement etc) that integrate the steel reinforcement of the reinforced concrete structures. The steel reinforcement design is constituted by the designs of column, beam, slab and stair.

Technology of prefabricated steel pieces

In Brazil for many years the use of the steel bars prevailed, those steel bars were cut and fold in the construction site. However it has had a constant substitution in this way of supply by the supply of steel pieces cut and fold (technology of prefabricated steel pieces) that only needs to be mounted in the construction site.

The technology of prefabricated steel pieces can be defined as being simply the transference of the phases of cut and fold of the construction site for the factory, in the case of Brazil this factory belongs to the steel manufacturer.

Araújo (2005) mentions that the main advantages of utilizing the technology of prefabricated steel pieces are: a) reduction of the intensive use of workers in the construction site; b) high rationalization in all process of reinforcement production.

Although prefabricated steel pieces are used in many Brazilian construction sites, the steel bars are still an alternative to produce concrete structures. In this context, labor productivity evaluation is necessary to justify the adoption of prefabricated pieces.

OBJECTIVE

The objective of this article is to evaluate, that is, detect, quantify and analyze statistically, the factors related to the content of the work that influence in the productivity improvement in the labor of steel reinforcement assembling utilizing only the supply of steel called technology of prefabicated steel pieces.

METHODOLOGY

This research involved the following phases: a) characterization of the construction sites; b) collection method; c) results and analysis. Each phase will be explained below.

Characterization of the construction sites

Nine construction sites were studied in this research. The main and common characteristics that those construction sites had were: a) they belonged to the segment of multiple floor buildings; b) the buildings were be constituted by reinforced concrete structures; c) they utilized the technology of prefabricated steel pieces; d) the main tower was being executed; e) they belonged to different construction firms (in the maximum two towers of an only construction firm).

The authors of this paper decided to preserve the identify of the construction firms involved in this research with the use of codes for the identification of the buildings studied (example: Building SP 11).

Collection Method

The collection method of the data basically included three phases. Those phases will be explained in the following paragraphs.

The first phase was constituted by the analytic understanding of the steel reinforcement assembling for each structural member (column, beam and slab); and to the study of the steel reinforcement design for each structural member with the detection and measurement of the several factors that could influence in the labor productivity, for each one of these structural members, based on the autors' experience and the literature revision.

The second phase was characterized by daily visits to the nine towers (Building SP 11a, Building SP 11b, Building SP 52, Building SP 83a, Building SP 83b, Building SP 101, Building SP 121, Building SP 145 and Building SP 169) during the execution of three consecutive floors in each tower, aiming at quantifying the man-hours involved in the steel reinforcement assembling and also verifying the quantity of service performed by the crew daily for each structural member. With those information was possible to measure the labor productivity with the indicator denominated RUP for each structural member.

The third phase was constituted by the activity of correlating the factors studied with the labor productivity for each structural member based on statistical analysis, enabling to detect the factors that really influenced significantly the labor productivity.

Results and Analysis

After statistical analysis was established the factors (Table 1 lists and explains them) that influenced significantly the labor productivity in the steel reinforcement assembling to each structural member (column, beam and slab).

Table 1: Factors that influenced significantly in the steel reinforcement assembling

Factors	Abbreviation	Structural members	Influence in the labor productivity
Equivalent Diameter of the steel reinforcement pieces	Dequiarm	Column, Beam and Slab	The bigger the equivalent diameter of the steel bars of a labor, it will be necessary more Kg of steel for each linear meter processed. Supposed that the demanded work associated to the processed length of reinforcements, bigger equivalent diameters would lead to better productivity.

Equivalent Diameter of the longitudinal pieces	Dequilon	Column	Analogous definitions to the previou factor. It is defined as being limited for the case of the longitudinal pieces.
Equivalente Diameter of the cross pieces	Dequitrans	Column	Analogous definitions to the factor called Equivalent Diameter of the steel reinforcement pieces. It is defined as being limited for the case of the cross pieces.
Mass of longitudinal pieces by total mass	$Kg_{longit.}/Kg_{total}$	Column	The bigger the reason $Kg_{longit.}/Kg_{total}$ there will be with the same effort, the bigger quantity (in mass) of reinforcement produced, having as a result the obtaining of better productivity index.
Percentage of columns with stirrups "chained"	%estracor	Column	The minor the quantity of columns with stirrups chained, the smaller will be the necessary effort in the assembly, having as a result the obtaining of better productivity index.
Mass of longitudinal pieces by the number of longitudinal pieces	$Kg_{longit.}/N_{longit}$	Beam	The bigger the reason $Kg_{longit.}/N_{longit.}$ there will be smaller RUP (better productivity) because of this for each piece mounted there will be a bigger weight of reinforcement made.
Equivalent Diameter of the stirrups	Dequiestr	Beam	Analogous definitions to the factor called Equivalent Diameter of the steel reinforcement pieces. It is defined as being limited for the case of the stirrups.
Equivalent Diameter of the negative pieces of the reinforcements	Deq-	Slab	Analogous definitions to the factor called Equivalent Diameter of the steel reinforcement pieces. It is defined as being limited for the case of the negative pieces of the reinforcements.
Mass of the reinforcements of the slabs by the m^2 of area of slab	Kg/m^2	Slab	The bigger the quantity (in mass) of steel by area of slab, the bigger the quantity of service performed resulting in a better productivity.

In the Tables 2, 3 and 4 (respectively for the structural members column, beam and slab), are shown, based on the 9 towers studied, the relations between each factor (explained in the Table 1) and the labor productivity, through the use of values (minimum, median and maximum) relating those values with the tendency of better or worse labor productivity (☺ = better productivity and ☹ = worse productivity).

Table 2: Relation between the factors and the productivity – Column

RUP (Hh/ton)	Factor	Values		
		Minimum	Median	Maximum
☹ 57	Dequilon (mm)	10,05 ☹	12,50	20,12 ☺
😐 41	$Kg_{longit.}/Kg_{total}$ (%)	65,85 ☹	74,76	88,43 ☺
	Dequitrans (mm)	5,04 ☹	5,04	5,78 ☺
☺ 30	%estracor	0,00 ☺	0,00	37,00 ☹

Table 3: Relation between the factors and the productivity – Beam

RUP (Hh/ton)	Factor	Values		
		Minimum	Median	Maximum
☹ 60	Dequiestr (mm)	5,46 ☹	5,46	6,80 ☺
😐 40	$Kg_{longit.}/N_{longit}$	2,77 ☹	4,46	7,74 ☺
☺ 31				

Table 4: Relation between the factors and the productivity – Slab

RUP (Hh/ton)	Factor	Values		
		Minimum	Median	Maximum
☹ 49	Deq- (mm)	7,79 ☹	9,39	11,23 ☺
😐 24	Kg/m^2	4,95 ☹	7,42	15,10 ☺
☺ 18				

FINAL CONSIDERATIONS

This article dealt with the detection, measurement and statistical analysis of the factors of content influencing labor productivity of steel reinforcement assembling in reinforced concrete structures. This is very important to help construction managers to adopt and to improve the use of the technology of prefabricated steel pieces.

This research is part of a more comprehensive research to propose guidance to the steel reinforcement design, taking into account the features that improve labor productivity.

REFERENCES

Abdelhamid, T. S., and Everett, J. G. (1999) Time series analysis for construction productivity experiments. Journal of Construction Engineering and Management, 125(2), pp. 87-95.

Araújo, L. O. C. (2005) Método para a proposição de diretrizes para melhoria da produtividade da mão-de-obra na produção de armaduras. 503pp. Doctor Thesis – Polytechnic School, University of São Paulo, São Paulo, 2005.

Araújo, L. O. C. (2000) Método para a previsão e controle da produtividade da mão-de-obra na execução de fôrmas, armação, concretagem e alvenaria. 385pp. Dissertation Thesis – Polytechnic School, University of São Paulo, São Paulo, 2000.

Carraro, F. (1998) Produtividade da mão-de-obra no serviço de alvenaria. 226pp. Dissertation Thesis – Polytechnic School, University of São Paulo, São Paulo, 1998.

Dantas, M. M. (2006) Proposição de ações para melhoria da produtividade da concretagem em edifícios verticais. 162pp. Dissertation Thesis – Polytechnic School, University of São Paulo, São Paulo, 2006.

Kellogg, J. C., Howell, G. E., and Taylor, D. C. (1981) Hierarchy model of construction productivity. Journal of the Construction Division, 107(1), pp.137-152.

Librais, C. F. (2001) Método prático para estudo da produtividade da mão-de-obra no serviço de revestimento interno de paredes e pisos com placas cerâmicas. 117pp. Dissertation Thesis – Polytechnic School, University of São Paulo, São Paulo, 2001.

Liou, F., and Borcherding, J. D. (1986) Work sampling can predict unit rate productivity. Journal of Construction Engineering and Management, 112(1), pp.90-103.

Maeda, F. M. (2002) Produtividade da mão-de-obra nos serviços de revestimento interno de paredes e tetos em argamassa e em gesso. 177pp. Dissertation Thesis – Polytechnic School, University of São Paulo, São Paulo, 2002.

Obata, S. H. (2000) Indicadores de produtividade da mão-de-obra para a moldagem de estruturas de concreto armado e indicadores de qualidade dos produtos moldados. 340pp. Dissertation Thesis – Polytechnic School, University of São Paulo, São Paulo, 2000.

Reis, F. S. B. (2005) Produtividade da mão-de-obra e consumo unitário de materiais no serviço de coberturas com telhado. 266pp. Dissertation Thesis – Polytechnic School, University of São Paulo, São Paulo, 2005.

Silva, L. L. R. (2002) Método de intervenção para a melhoria da eficiência na execução de revestimentos de argamassa de fachada. 199pp. Dissertation Thesis – Polytechnic School, University of São Paulo, São Paulo, 2002.

Souza, U. E. L. (1996) Metodologia para o estudo da produtividade da mão-de-obra no serviço de fôrmas para estruturas de concreto armado. 280pp. Doctor Thesis – Polytechnic School, University of São Paulo, São Paulo, 1996.

Souza, U. E. L. (2006) Como aumentar a eficiência da mão-de-obra – manual de gestão da produtividade na construção civil. São Paulo: Editora Pini

Sumanth, D. J. (1979) Productivity measurement and evaluation models for manufacturing companies. 291pp. Dissertation Thesis – Illinois Institute of Technology, University Microfilms International, Chicago, 1979.

Teicholz, P., Goodrum, P. M., and Haas, C. T. (2001) U. S. construction labor productivity trends – 1970-1998. Journal of Construction Engineering and Management, 127(5), pp.427-429.

Thomas, H. R., and Yiakoumis, I. (1987) Factor model of construction productivity. Journal of Construction Engineering and Management, 113(4), pp.623-639.

Thomas, H. R., Maloney, W. F., Horner, R. M. W., Smith, G. R., Handa, V. K., and Sanders, S.R. (1990) Modeling Construction Labor Productivity. Journal of Construction Engineering and Management, 116(4), pp.705-726.

Thomas, H. R., and Napolitan, C. L. (1995) Quantitative effects of construction changes on labor productivity. Journal of Construction Engineering and Management, 121(3), pp. 290-296.

Thomas, H. R., Horman, M. J., Souza, U. E. L., and Zavrski, I. (2002) Benchmarking of labor-intensive construction activities: lean construction and fundamental principles of workforce management. CIB report. PTI, 2002. 156p.

ACKNOWLEDGEMENTS

The authors would like to thank the Coordenação de Aperfeiçoamento de Pessoal de Nível superior (CAPES) and the Group Arcelor Mittal Belgo by the financial support (scholarships) and the field support (visit the works, factories of steel cut and bend and arguments about the steel production etc) respectively.

A PRACTICAL DECISION MAKING TOOL: BID NO BID CASE STUDY

Mohammed Wanous
University of Bristol, Bristol, UK
M.Wanous@bristol.ac.uk

Leonardo Bruni
Università degli studi di Roma "La Sapienza", Roma, Italy
leonardo.bruni83@hotmail.it

Emiliano Scrivo
Università degli studi di Roma "La Sapienza", Roma, Italy

A novel decision making technique is described in this paper. The development of this technique starts with the identification of the important factors that characterise a particular decision. The identified factors are then analysed to select the most influential ones, which are then classified into encouraging and discouraging subgroups. Based on information collected from experts in the area under consideration, parametric profiles are developed for each of the considered decision factors. Real life examples are used to develop a probability distribution function for each parameter. This is to take the uncertainty inherent in most decision making situations into account. The proposed tool has many practical applications in the construction industry as demonstrated by a "bid" or "no bid" case study using data on real life project collected from Italian contractors. In this case study, the proposed tool predicted the actual bidding decisions made in 85% of unseen bidding situations.

KEYWORDS: Decision Making, Parametric Tools, Uncertainty, Bid no Bid, Italy.

INTRODUCTION

Nearly, every facet of life entails a sequence of decisions (Denardo, 1982). Different decisions involve different sequential activities. Nevertheless, they have some common features. Each has a purpose that interplay between constituent decisions. For instance, bidding for a new project consumes time and resources that cannot be invested in other projects. Moreover, some decisions must be made without knowing the outcomes. A contractor does not know in advance what the tender prices of possible competitors are. If this was possible, he/she would be able to adjust the tender price to win the contract or just make a "no bid" decision. Furthermore, uncertainty about the future lays at the heart of many decision problems. Nevertheless, that does not mean that the future can not be predicted. A contractor selects a mark up percentage for a new project that increases the probability of winning this project. When these probabilities can be assessed, rational decision making becomes possible. To increase the effectiveness of the decision-making process, there must be some systematic techniques (Tempelman 1982). The following section is devoted to provide a brief review of common decision-making methods before explaining the proposed practical decision making tool and providing an example application on the Bid no Bid decision making process in the Italian construction industry context. A basic computer model has been developed based on this proposed method to make it even more practical and easy to use.

A BRIEF REVIEW OF KEY DECISION MAKING TOOLS

The reviewed techniques are classified into five main categories. These are probability theory, utility theory, regression analysis, multicriteria decision analysis and artificial intelligence techniques. These categories are briefly outlined in the following sub-sections.

Basic Concepts of Probability Theory

In probability theory, an event is the term used for something, which may or may not occur. A decision problem might incorporate many events and the difficulty lies in determining the probability factor for each one of them. The probability theory is based on the concept of complementary events. For example, when a contractor submits a bid for a certain project, he might win the contract (event A) or might not win this contract (event A′). Therefore, it is always true that:

$$\text{Probability of (A)} + \text{Probability of (A}'\text{)} = 1$$

However, real life events do not usually occur in isolation but are strongly or weakly linked to other events (Smith et al, 1983).

The application of probability theory is based on assumptions that might not be appropriate in certain situations (Smith et al, 1983). This does not mean that this technique should not be used but merely that it should be applied carefully. The majority of traditional bidding strategy models were based on the probability theory. Many researchers have pointed out that these models are not suitable for practitioners in the construction industry because of their unrealistic assumptions and the complexity of their mathematical operations. Therefore, some researchers have approached the bidding process using the utility theory, the basic concepts of which are explained in the following section.

Basic Concepts of Utility Theory

Utility is a psychological concept, which is used to measure the desire of individuals to possess units of a given commodity (Teo, 1990). It provides the basic foundation for modelling the value system of a decision-maker. However, this approach has been criticised for failing to appreciate the non-linearity of the individual preferences.

Once the utility function is defined, the unit value can be transformed into expected utility. Utility functions can be composed from several sub-functions. For example, Ahmad (1988, 1990) used three segments; loss, general overhead and profit when developing a utility model for mark up estimation. In this model, the selected mark up corresponds to the maximum expected utility.

The utility theory approach provides a good representation of the value system of the decision-maker (Teo, 1990). Furthermore, it also accounts for the risk attitude of the decision marker. However, the utility theory is still regarded by practitioners as being theoretical and mathematically complex. Additionally, it is often difficult to accurately determine the utility function of decision markers especially in highly unstructured subjective problems such as the competitive tendering process, which is liable to be affected by large number of factors. To account for the influence of such multiple factors, multi-criteria decision analysis techniques can be more appropriate.

Multicriteria Decision Analysis Theory

Classical decision making theories deal with single criterion problems, e.g. maximising profit. But, single criterion techniques are incapable of dealing with most of the real world problems, which grow bigger in scope and complexity. Consequently, multicriteria decision making theories have evolved.

Analytical Hierarchy Process

The Analytical Hierarchy Process (AHP) is one of the most commonly used multicriteria techniques. The AHP was introduced by Saaty (1977) to compare alternatives considering multiple criteria. It is based on decomposition of a decision problem into a hierarchy of criteria and alternatives. Typically, the highest level of the hierarchy is the overall goal while the next level usually consists of the decision's criteria and the lowest level generally is made up of the decision's alternatives.

The relative importance is indicated at each level of the hierarchy by set of weights assigned to the criteria and alternatives. At a lower level, for every criterion, each alternative is given a weight based upon its relative contribution to the accomplishment of the final goal. The problem is, then, recomposed by multiplying the weights along each branch and summing the products for each alternative. The result is a set of multicriteria weights, one for each alternative. The alternatives are, then, ranked according to their weights and the one with the highest weight is designated as preferred. A good explanation of the AHP can be found in Bryson and Mobolurin (1994).

TheAHP enables subjective judgements to be made regarding the relative importance of criteria and the relative weighting of alternatives. However, the AHP models require a relatively large number of inputs, i.e. weighting the decision’s criteria and alternatives. An innovative simple technique called the Parametric Process (PP) is presented in this paper as a possible alternative decision making tool.

Basics of Regression Analysis Techniques

Regression analysis enables us to ascertain and utilise a relation between a variable of interest, called the dependent variable or response variable, and one or more independent, i.e. predictor, variable(s) (Montgomery and Runger, 1994). To understand the concept of regression analysis, it is important to understand a relation between two factors. It is useful to distinguish between functional and statistical relations. It is important to note that a statistical relationship between two variables X and Y is not necessarily exact.

The dependent variable is usually plotted along the Y- axis and an independent variable Xi along the X- axis. Many straight lines could appear to fit well the relation between Y and X. One of the widely used procedures to identify the best-fitting line and the corresponding equation is called the Least Square Approach (Jain, 1996).

Regressing analysis is widely used in marketing research (Jain, 1996). Also, it proved to be useful in many areas of construction management. For example, in the prediction of project duration (Chan and Kumaraswamy, 1999) and the estimation of the mark up size for new bids. The main disadvantage of the linear regression technique is being unable to account for the non-linearity that might exist in the relationship between the dependent variable and the independent variable(s). Non-linear regression attempts to model such relationships. But, it needs extensive intervention from the user.

Artificial Intelligence Techniques

Artificial Intelligence (AI) emerged in the 1950s and 1960s as an overlap of computer science and psychology. It covers such diverse areas as recognising and understanding language, recognising pictures and sounds, and robotics. Two of the most prominent approaches to AI are the "symbol manipulating" and the "connectionist" approaches. Expert systems, which are more correctly called Intelligent Knowledge Based Systems (IKBS), and Artificial Neural Networks (ANN) have emerged from the symbolic and the connectionist approaches respectively (Nikolopoulos, 1997).

Expert Systems

Expert Systems (ESs) are able to solve knowledge-intensive problems that are not easily addressed by conventional software. Numerous definitions have been proposed for the expert systems. The British computer society special interest group in expert systems (Alvey) has defined an expert system as follows:

"An expert system is regarded as the embodiment within the computer to a knowledge-based component from an expert skill in such a form that the system can offer intelligent advice or take an intelligent decision about a processing function".

Waterman (1986) has defined expert systems as "sophisticated computer programs that manipulate knowledge to solve problems". The knowledge of an expert system consists of facts and heuristics, i.e. rules of thumb. The facts constitute a body of information that is widely shared, publicly available, and generally agreed upon by experts in the field. Expert systems derive solutions based on heuristics rather than the algorithmic approach of conventional programs (Jackson, 1999; Waterman, 1986). An expert system solves problems in a narrow domain of expertise and can not be a general problem solver. Nevertheless, even in highly restricted domains, expert systems usually need large amounts of knowledge to arrive at a performance comparable to that of human experts in the field.

Artificial Neural Networks

The human brain is the most complex biological system with powerful capability of thinking, remembering and problem solving known to man (Fu, 1994). This unique capability inspired research in Artificial Intelligence to model the human brain as a computing paradigm known as Artificial Neural Networks (ANN). The key idea is to make computers learn through examples, as human learn through experience, to recognise patterns that exist within a given data set. This distinguishes ANN from other AI techniques such as the expert systems, which are based on a set of rules extracted from human experts. The main component of an ANN is called node or Processing Element (PE), which is referred to sometimes as neuron after the biological neuron. PEs in a neural network are interconnected by weighted links (synapses). Each PE can receive simultaneously many inputs. These inputs are usually multiplied by the connection weights. The PE sums the weighted inputs and transforms the product into a response, which can be an input to the following PE(s) or may be the final output.

The structure of an ANN model is another important aspect. The most commonly used structure is the Multi-Layer Perceptron (MLP). This type of ANN paradigm consists of an input layer (buffer), hidden layer(s), and one output layer. The PEs in the input buffer only receive the user's inputs and forward them to the first hidden layer. PEs in a neural network are connected fully or partially in a way that the output, i.e. response, of a PE is fed via the weighted connections as inputs to the PE(s) in the subsequent layer. The connection weights of a neural network are modified by learning from examples. The most commonly used learning algorithm is called error back-propagation developed by Rumelhart et al. (1986).

A NEW PARAMETRIC DECISION MAKING TOOL

The way in which construction companies/contractors make their decisions is a highly complex process. In the absence of universal decision tools, these decisions are often based on heuristic techniques, i.e. experience, subjective judgement and intuition of the decision maker. Therefore, practical decision-support tools can yield significant benefits. This section explains the development of a new technique called the Parametric Process and demonstrates its application on the "Bid no Bid" decision making process in the Italian construction industry.

As illustrated in Figure 1, the modelling procedure starts with the identification of the important factors that influence the decision problem under consideration. These factors are then classified into two groups; Encouraging Factors that usually count for a positive recommendation and Discouraging Factors that usually count for a negative recommendation. A parametric profile is developed for each of the considered factors (encouraging and discouraging). A decision situation is assessed by the decision maker by assigning a score between 1 and 5 to each factor. Based on this assessment, each factor will contribute to the final recommendation. Real life examples are then used to test and improve the developed model. These model development and validation steps are explained in the following sub-sections using the Bid no Bid decision making process as an example application.

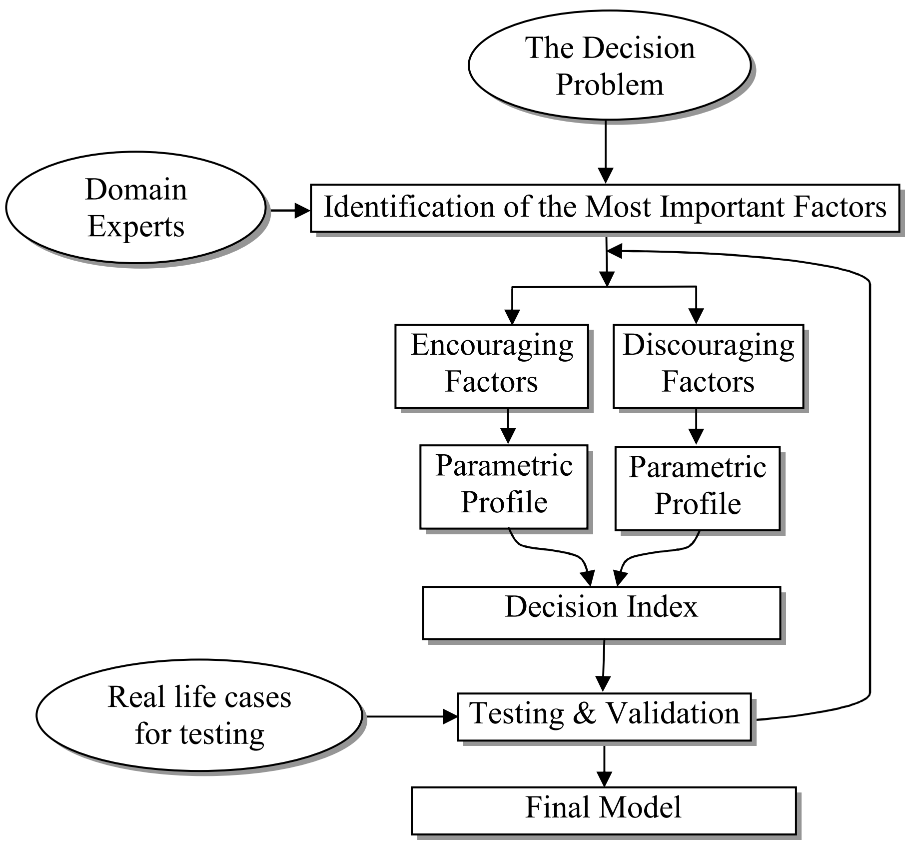


Figure 1: The Development of a Parametric Decision Support Model

Identification of the Most Important Factors

A questionnaire survey was used to uncover the important factors that characterize the "bib/no bid" decisions in the Italia construction industry. The survey also helped to collect expert contractors' opinions about the importance of these factors and their kill scores (when a factor alone can cause a no bid decision) and neutral scores (i.e. the score of no influence).

The formal questionnaire was send to 44 Italian construction companies. Twenty questionnaires were fully completed and returned. This was considered to be adequate in this basic demonstration case study.

The questionnaire uncovered forty two factors that influence the bid no bid decision in Italy. The factors that have an Importance index (I) below 0.60 and/or seemed to be counted for by other factors have been ignored. The remaining 17 factors were classified into to two groups; encouraging and discouraging.

The encouraging factors (F_i) are listed in Table 1 along with their average Importance index (I_i), average Kill Score (KS_i) above which F_i will cause a "no bid" recommendation and the average Neutral Score (NS_i).

The discouraging factors (F_j) are listed in Table 2 along with their average Importance index (I_j), average Kill Score (KS_j) below above which F_j will cause a "no bid" recommendation and the average Neutral Score (NS_j).

Table 1: Parameters of the most influential encouraging "bid/no bid" factors

i Encouraging "bid/no bid" Factors	I_i	KS_i	NS_i
1- Project cash flow	0.76	2.17	3.21
2- Past experience on similar projects	0.73	1.63	1.58
3- Credit & worthiness of owner	0.73	1.14	2.00
4- Potential profit from project	0.72	1.75	2.53
5- Availability of resources	0.65	1.44	1.67
6- Need for work	0.61	1.17	1.81
7- Relations with other contractors and suppliers	0.60	1.13	2.50

Table 2: Parameters of the most influential discouraging "bid/no bid" factors

j Discouraging "bid/no bid" Factors	I_j	KS_j	NS_j

1- Number and type of competitors	0.75	4.13	1.74
2- Size of project	0.73	4.71	2.10
3- Availability of other projects	0.72	4.50	1.74
4- Degree of hazard	0.71	4.86	1.58
5- Current workload	0.69	4.63	1.49
6- Uncertainty in cost estimate	0.67	4.67	1.63
7- Administrative interference	0.66	4.88	2.00
8- Rigidity of specifications & Onerous contract condition	0.65	4.38	2.43
9- Bond requirement	0.63	4.71	2.93
10- Degree of difficulty	0.61	4.57	2.44

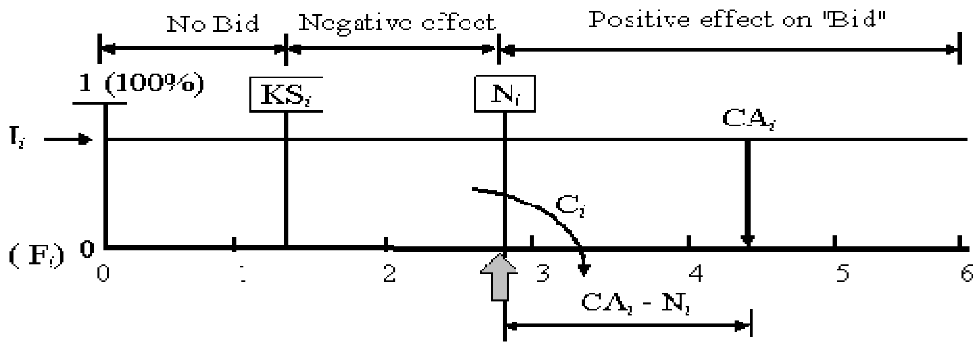
The following section demonstrates the application of the proposed parametric decision making tool on the bid no bid decision making process.

Development of a "Bid no Bid" Index

In this example application, the proposed decision tool will recommend whether to bid on a new project or not based on an index called the "Bidding Index" (BI). A parametric scale is developed for each bidding factor (F_i and F_j in Tables 1 and Table 2).
An encouraging factor F_i is represented in Figure 2 as a beam, with a scale between zero and six. It is supported on the neutral point (B_i), which represents the centre of gravity of this beam. Without applying any force, this beam will stay horizontal (i.e. no contribution to the final decision).
A contractor can assess a new bidding situation in term of factor F_i by subjectively assigning a score CA_i (Contractor's Assessment) between zero and six. The contractor's assessment is presented in Figure 2 as a force applied at the CA_i point. The magnitude of this artificial force represents how important the factor F_i is in making the "bid/no bid" decision, i.e. it is equal to the importance index (I_i). Applying this force will generate a moment, which is the physical representation of the contribution (C_i) of factor F_i in making the "bid" decision.
Based on these assumptions, the following formula is used to compute the contribution (C_i) of a positive factor (F_i):

$$C_i = I_i * (CA_i - N_i) \quad (1)$$

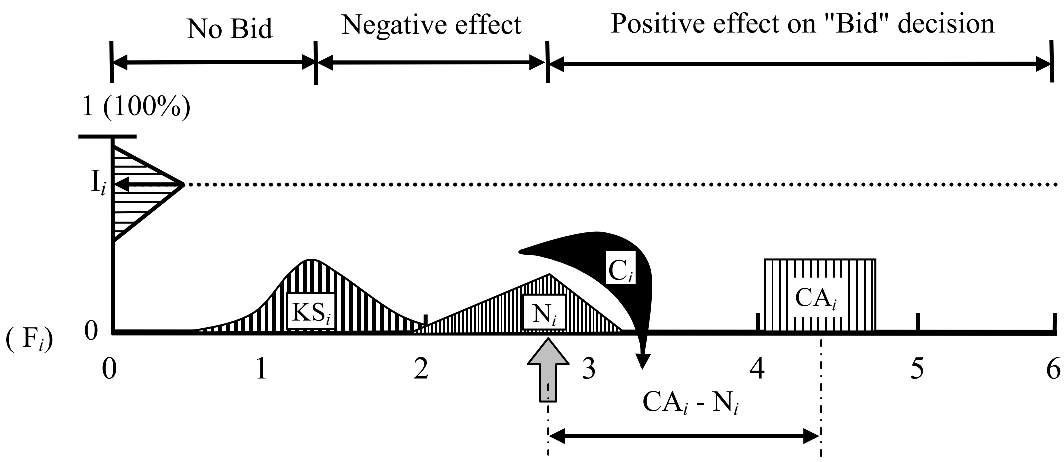
For example, the importance of the "Need for work" factor is ($I_6 = 0.61$) and its neutral score is ($N_6 = 1.81$). If this factor is rated as "very low", i.e. $CA_6 = 1$", in a certain bidding situation, the contribution in the "bid" decision can be found using Formula 1 as follows:
$C_6 = 0.61 * (1-1.81) = - 0.494$
Although it is an encouraging factor, the "Need for work" factor counts against a "bid" decision in this case. If the contractor's assessment was "very high", i.e. $C_6 = 5$, the contribution will be ($C_6 = +1.946$), which contributes towards a "bid" decision.



F$_i$: A positive bidding factor;
I$_i$: Importance in making the "bid/no bid" decision;
KS$_i$: Kill-score of factor F$_i$;
N$_i$: Neutral score for factor F$_i$; and,
CA$_i$: Contractor's assessment of the bidding situation regarding Factor F$_i$.

Figure 2: A basic parametric model for an encouraging factor

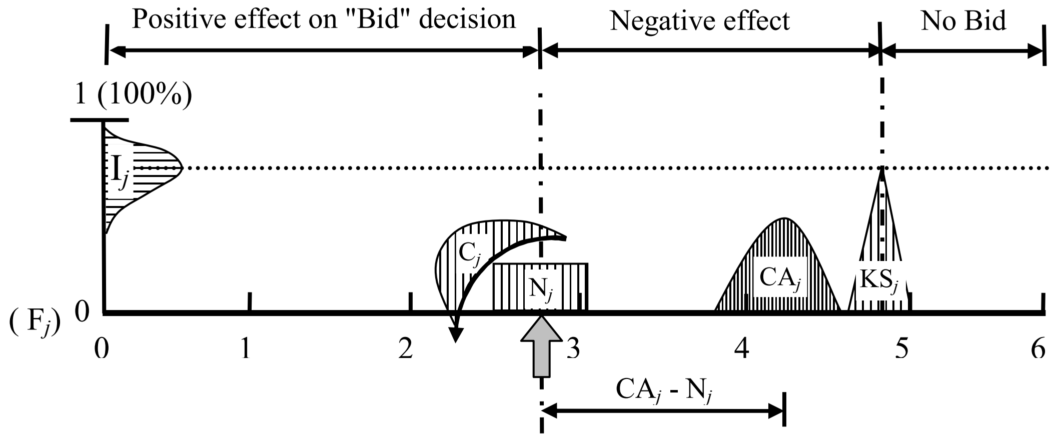
This basic parametric model was first developed by Wanous et al. (2000) and applied on the Bid no bid decision making using data on real life construction projects provided by Syrian contractors. To account for uncertainty, the present paper considers a range of possible values for the model's parameters instead of single values as shown in Figures 3, which illustrates the generic structure of a probabilistic parametric profile of an encouraging factor F$_i$.



F$_i$: A positive bidding factor;
I$_i$: A range of possible importance indices;
KS$_i$: A range of possible Kill Scores of factor F$_i$;
N$_i$: A range of possible Neutral scores for factor F$_i$; and,
CA$_i$: A range of possible Contractor's assessments of the bidding situation considering factor F$_i$.

Figure 3: A probabilistic parametric model for an encouraging factor

Similarly, Figure 4 illustrates the generic structure of a probabilistic parametric profile of a discouraging factor F$_j$.



F_j: A negative bidding factor;
I_j: A range of possible importance indices;
KS_j: A range of possible Kill Scores of factor F_j;
N_j: A range of possible Neutral scores for factor F_i; and,
CA_j: A range of possible Contractor assessments of the bidding situation considering factor F_j.

Figure 4: A parametric model for a discouraging factor

In the case of a discouraging factor F_j, a contractor's assessment (CA_j) that is greater than the neutral score (N_j) will generate a negative contribution (C_j) towards a "bid" decision as represented by the following formula:

$$C_j = - I_j * (CA_j - N_j) \qquad (2)$$

The cumulative contribution of all the considered bidding factors in making the "bid" decision for a project *k* is the bidding index (BI_k) calculated using the following formula:

$$BI_k = \sum_{i=1}^{m} I_i * (CA_i - N_i) - \sum_{j=1}^{n} I_j * (CA_j - N_j) \qquad (3)$$

Where:

m: number of the considered positive factors; and,
n: number of the considered negative factors.

Having all the required inputs, the model produces the Bidding Index (BI_k). If $BI_k \geq 0$ then the "bid" decision is recommended. If $BI_k < 0$ then the "no bid" decision is recommended.

A basic Excel model has been developed based on this method and using Crystal Ball to take uncertainty into account. Crystal Ball can automatically extract the input factors' probability distribution functions, i.e. the all the possible values of the model parameters and their probability from the data set collected on real life projects. It also allows the user to choose his/her assessment of a certain factor as a range of possible values and their probabilities.

As mentioned earlier, thirteen real life projects were used to test the developed demonstration model. The contractors' assessments of the bidding factors in each project of the testing cases were presented to the parametric "bid/no bid" tool. The proposed model produced recommendations that are in line with the actual decisions made by contractors in 85% of the real life testing cases.

CONCLUSION

A simple systematic decision making tool is presented. This model proved to be 85% accurate in simulating the actual decisions in thirteen "bid/no bid" situations collected from the Italian construction industry. Some bidding experience that was provided by expert Italian contractors is embedded in this demonstration model, which could be very beneficial to contractors, who do not have such experience. The proposed bidding model does not require too many inputs or extensive historical data. All is required is some information about the bidding situation and subjectively assessing this situation in terms of predefined criteria. Uncertainty is taken into account by considering all possible values (in the form of probability distribution functions) of the model's parameters. The calculation of all possible values of the decision index (the output) is done automatically by a simple Crystal Ball programme. The proposed model will be explained in more details in a subsequent paper after the collection of a larger set of real life bidding examples. This is expected to contribute to wider practical applications.

REFERENCES

Ahmad, I. A. (1990). Decision-support system for modelling bid/no bid decision problem. Journal of Construction Engineering and Management, ASCE, 116 (4), Pp595-608.

Bryson, N. and Mobolurin, A. (1994). An approach to using the analytical hierarchy process for solving multiple criteria decision making problems. European Journal of Operational Research, Vol. 76, pp 440-454.

Chan, D.W.M. and Kumaraswamy, M.M. (1999). Modelling and predicting construction durations in Hong Kong public housing. Construction Management and Economics. Vol. 17. Pp 351-362.

Denardo, E.V. (1982). Dynamic programming. Prentice Hall.

Fu, L. (1994). Neural networks in computer intelligence. McGraw-Hill. New York.

Jackson, P. (1999). Introduction to expert systems. Addison-Wesley. New York.

Jain, D. (1996). Regression analysis for marketing decisions. In Principles of marketing research. (Edited by Bagozzi, R.P.). Blackwell.

Montgomery, D.C. and Runger, G.C. (1994). Applied statistics and probability for engineers. John Wiley and Sons, Inc. New York.

Nikolopoulos, C. (1997). Expert systems: Introduction to first and second generation a nd hybrid knowledge based systems. Marcel Dekker, INC. New York.

Rummelhart, D.E., Hinton, G.E., and Williams, R.J. (1986). Learning representation by back propagation error. Nature, Vol. 323, pp 533-536.

Saaty, T.L. (1977). A scaling method for priorities in hierarchical structures. Journal mathematical psychology, Vol. 15, No.1, pp 575-590.

Smith, A.A., Hinton, E., and Lewis, R.W. (1983). Civil engineering systems analysis and decision. John Wiley & Sons.

Tempelman, A. (1982). Civil engineering systems. Macmilian Press.

Teo, H.P.(1990). Decision support and risk management system for competitive bidding in refurbishment work. PhD thesis, Heriot- Watt University, Edinburgh, UK.

Wanous, M., Boussabiane, A.H. and Lewis, J. (2000). to bid or not to bid: a parametric solution. Construction Management and Economics, Vol. 18, No. 4, pp. 457-467.

Waterman, D.A. (1986). How do expert systems differ from conventional programs?. Expert Systems, Vol. 3, No. 1, pp. 116-119.

CRITICAL SUCCESS AND FAILURE FACTORS FOR PUBLIC PRIVATE PARTNERSHIP PROJECTS IN THE UAE

Mohamed Alhashemi
The British University in Dubai, Dubai, UAE
mohamed@alsondosdxb.com

Mohammed Dulaimi
The British University in Dubai, Dubai, UAE
mohammed.dulaimi@buid.ac.ae

Florence Ling
The National University of Singapore, Singapore
bdglyy@nus.edu.sg

Mohan Kumaraswamy
The University of Hong Kong, Hong Kong, PPR
mohan@hkucc.hku.hk

There are few Public Private Partnership (PPP) projects in the UAE, but the number is increasing. Recently government and public bodies have increased their interest in PPP to encourage more involvement of the private sector in the country development. This paper reports research into the critical success and failure factors for PPP in the UAE. The research used a case study approach to examine the critical success factors and the failure factors. The results have shown that political support is the most important success factor followed by having a strong private consortium. The most important failure factor is the lack of appropriate skills.

KEYWORDS: PPP, critical success factors, United Arab Emirates.

INTRODUCTION

Public Private Partnership (PPP) is increasingly deployed in many countries to bring in the private sector where only public organisations and government departments used to operate. This concept is new to the United Arab Emirates (UAE) where the government takes the responsibility for procuring all public services. The private sector in the UAE, so far, did not play a major role in providing public services evidenced by the very few partnerships and joint ventures formed between the public sector and the private sector aimed at providing public services. More recently the market witnessed a number of attempts to change this situation.

The aim of this research is to evaluate the experience of the UAE of using PPP so far and identify lessons learned and make recommendations that can guide the public and the private sectors toward improving the effectiveness of their procurement of such projects. The research reports the result of case studies of existing PPP projects which have identified the factors that have helped the partnerships achieve their objectives and the barriers and obstacles they have encountered in the planning, execution, and operation of such projects.

CRITICAL SUCCESS FACTORS FOR PPP

In addition to the factors that may influence the success of projects using more traditional procurement methods PPP projects are affected by other success factors. This research has reviewed previous studies of PPP to identify what researchers have identified to be the critical success factors (CSF) that will be needed to be in place to ensure that the stakeholders realise their objectives. Researchers have identified the following factors of appropriate risk allocation, savings and need for finance, favourable legal framework, political support, strong private consortium, available financial market, stable economy, transparent and competitive procurement process, effective technology transfer, thorough feasibility and assessment study, and opportunities for innovation (Bing Li et al., 2005; Qiao et al., 2001; Hodge, 2004; Pongsiri, 2002; Payne, 1997; Wang, 2006, Flinders, 2005; Jefferies et al., 2006; Hurst and Reeves, 2004). This paper will expand on these factors in the analysis of the case studies. The research also reviewed the literature to identify the factors that are believed to contribute to the failure, Failure Factors (FF), of PPP projects leading to termination or delay. The FF are lack of appropriate skills, high participation cost, high project value, high risk, lack of credibility and contacts, demands on management time, poor communication between private partners, and long procurement and negotiations processes (Bing Li et al., 2005; Papaioannou and Peleka, 2006; Nyachhyon, 2006; Thomson, 2007).

RESEARCH METHOD

The research has adopted a case study research approach to collect the necessary data. The main reason for selecting such approach is that the limited number of projects using PPP and limited exposure of the market to such type of procurement method which would make the research sample small; and that the level of knowledge and experience are limited for a more quantitative approach. The research was not able to find any database of UAE organizations involved in PPP projects. Instead the research approached the main public bodies such as the municipalities and other bodies responsible for providing public services such as water and electricity. This exercise, as well as searching through news reports, has identified a total of eight PPP projects. All eight projects were contacted and five expressed interest and willingness to offer the research an interview. A set of semi structured questions were set to guide the discussion in the interviews. The interviewees did not allow the researcher to tape the interview and hence only notes were taken. The interviews were conducted with a senior figure in every case study. They were a senior consultant to the public client in project A, the operation manager of the private party in project B, and the head of the commercial bank that is a member of the private consortium in project C.

Case Studies

Due to the limitation of space, this paper discusses three of the case studies. The projects are located in three of the seven emirates, Abu Dhabi, Dubai and Sharjah.

Case study A is a project for operating, managing and servicing seven existing water and electricity centres. These are distribution centres that receive water and electricity from the production units and then distribute them through its network to the customers. These centres will also be responsible for dealing with customers direct including revenue collection. The value of the contract is estimated around 50 million AED (US$1=3.67AED). This sum does not cover any additional work such as the construction of new network facilities or upgrading the existing network. Currently, the project is still at tendering stage with ongoing negotiations with four international consortiums. Bidders have expressed concern regarding the difficulties they may face in the collection of revenues from customers and the lack review mechanisms of management fee. The research interviewed a senior consultant who has been involved in the project since the beginning and participated in preparing the feasibility study, tender documents, tender analysis and the negotiations.

Case study B is a project that forms part of a major theme park that the local municipality wanted to develop with the involvement of the private sector. Such a project required experience and major investment which the municipality wanted the private sector to provide. Therefore, the municipality offered the private sector an area of 260,000 square feet in the public park to develop as a PPP project. A local investment company won the contract with a 30 year concession. The project focus is on providing education for visiting school groups, as well as the general public, through entertainment. The idea of having such a theme park was an initiative of a private investor who approached the municipality and presented the idea. The project value is 300 million AED which covers the design and construction and it is due for completion in the summer of 2008. The project was offered to this investor through negotiation. The research interviewed the operation manager of the private company who had significant experience of the project.

Case study C is a project to design, construct, fund and operate of phase 2 of an industrial zone. The concession period is 20 years. The client, a public authority, wanted to attract international companies to invest in the Emirate by relocating their headquarters and factories to the UAE. The client completed phase 1 and the plots were rented out. For phase 2 the client wanted to engage a specific reputable international organization to carry out this phase and use its contact network to attract international companies to relocate to the completed industrial zone. The project’s cost is approximately 1 billion AED, which covers the design and construction costs of the facilities. After completion of the construction phase, the private organization should arrange and approach international companies to rent plots and establish factories or headquarters in the area. The contract was negotiated with the selected private investor. The financial arrangement included the client agreeing to give the rentals received from phase 1 to finance phase 2 (which would cover 75% of the finance needed for the infrastructure) while the consortium will finance the 25% balance. The consortium will then pay annual rent to the client. The research carried out the interview with a senior manager of the commercial bank that has worked with the client in planning and negotiating the contract.

DATA ANALYSIS

Case Study A: Water and Electricity Distribution Centres
Critical Success Factors

The risks in this project were clearly defined for all parties. The private parties that participated in the tender were capable to deal with most types of risks including design, construction, finance and operation risks. However, there are two types of risk that are critical to the success of this project but are not covered by the contract. The first is related to the tariff fee paid to the private party due to the lack of mechanisms for reviewing the tariff fees. The private bidders were concerned about the increase in operation costs and as a consequence to that they would have to request the government for fee review and additional money to cover the cost. Bidders had either to propose some conditions in their offers to minimize this risk or propose higher fee. The second risk is related with the collection of water and electricity bills from the customers where in certain cases it has been a difficult exercise. This has meant that the government objective to cut down on expenditure is difficult to achieve. In effect there will be extra cost that the public sector may have to pass down to the customers by increasing the unit rate of the water and electricity. There was concern that such an increase in customers' bill will hit the low paid users. The Senior Consultant for the project explained that "*many employees have households, and water and electricity bills paid by their companies. So it is the low paid [users] that pay their bills that will be affected*".

There is no legal framework or law to support the procurement of PPP projects in the UAE legal system. Hence, the private party had to include conditions in the contract for unclear issues to avoid disputes. The client requested a contract that is clear to all parties in order to reduce the likelihood of a dispute on interpretation. In addition, the contract provided for the formation of an arbitration committee of 5 members, 2 from the client, 2 from the private party and 1 independent, to resolve disputes.

The concerned Emirate has an independent regulatory authority for water, electricity and sewage responsible for regulating and licensing all companies working in water and electricity supply in the Emirate. This authority can play a critical role in resolving disputes between the parties. However, the role of such authority was not clear to the parties and its decisions are not enforceable or final. This would reinforce the importance of having a clear contract to minimize the risk of irresolvable disputes.

The two companies involved in the consortium are professional and have rich technical experience in such projects. They acted as one unit in the negotiations represented by project team. The consortium has sound financial skills and abilities as well as disciplinary attitude and commitment to the project. The private party was capable of providing innovative solutions in designing and constructing new water and electricity network and sub-stations. The Senior Consultant said, "*They can provide innovative solutions in designing and constructing new network as well as in restructuring the organization to be more effective*". They also have the ability to restructure the organization structure in the distribution centres making them more effective in handling the operation requirements.

The availability of a sympathetic financial market was not so important in this PPP project, as initial investment required by the private party was not so big and could be financed easily by their own funds. The initial investment is mainly consists of payments for the tendering process, advisory requirements, salaries for staff and project team. It was agreed that the government would fund any required construction project. In case additional funds were required, the financial market in

the UAE including banks and financial institutions can provide competitive financial packages with low interest charges.
The economy of the UAE has provided the stability required for the success of such projects. The economy was growing rapidly and the demand for water and electricity is increasing. The materials and products required for the PPP project are available and can be supplied easily to the project; but unfortunately the inflation rate in the country is high, over 9%, and the fluctuation in prices is unpredictable. The private party had the difficult task of providing a fixed rate for fee increment for the period of the PPP when they could not get their suppliers to fix their prices for more than three months, sometimes even for 30 days.

The procurement and tender processes were transparent to all involved parties. The deadlines for each stage were clearly identified and the private parties did not face any problems in communicating with the public party for clarifications and when the bid results were known they were communicated to all bidders. The client commissioned four different advisors to conduct detailed feasibility studies and assessment covering the legal, financial, water and electricity aspects, and describing the potential benefits of this project. However, tender prices were higher than what was estimated due to the fact that the feasibility study was carried out one year earlier during which prices increased more than forecasted.

The political support needed was missing in this PPP project. The government was concerned about the high tenders that could lead to higher water and electricity bills to customers. The problem requires either change to the revenue collection regime or a subsidy from the government to facilitate such project. There is concern of the effect of rise of service charges on the commercial sector where such increases may push up inflation. It was felt that this issue was pivotal to the later decision of the government to withdraw its support to this PPP. The government was also concerned of the possible redundancies of the privatised service where the staff are predominantly UAE nationals when it has set one of its main priorities the creation of more job opportunities for the locals. There was also a concern that the private party would cut jobs to maintain its profit margin in the face of these difficulties. As a result political support was withdrawn and ultimately the project was stopped/ suspended.

Failure Factors
The lack of skills of the private party was not an issue as they have long experience in handling similar projects and if necessary they could recruit staff that can handle the project efficiently from the local market to train them, or from abroad if required.

The cost of participation in the tender was more expensive than traditional procurement methods due to the hiring of the different advisors to support both the public and the private parties. Still the participation cost for the project was not more that would be expected for a PPP project. The project finance was not a problems as the tender covered the cost of management of the centre and construction works are to be funded directly by the government. It was expected that the government would make an advance payment to the private party to cover the set up costs.

The risks involved in the project were high due to the issues highlighted about regarding the tariff fees paid to the private part and lack of review mechanism in the contract. The high risk was also caused by the difficulties in the collection of revenue. Therefore conditional offers were submitted to the public sector to minimize those risks and protect the bidders' interest.

The private parties faced difficulties due to the fact that they were relatively new to the country and lacked the contacts and supplier network. It might have been useful for the private companies to involve local partner with sound reputation to invest in the PPP project in order to avail better facilities from the local market through the local partner's network.

The private party was complaining of the long time the client is taking to reach the final decision. The waiting period and continuous negotiation is very demanding on the management time, as they have to spend time in following up the project and discussing it in the agendas of their meetings. This is extra cost which will need to be covered by the project.

In conclusion it was expected that this project would fail due to the lack of political support. The government does not want to increase the water and electricity charges to the customers as it may lead to extra inflation in the country. The private parties failed to propose an offer that may reduce the cost on the government, but in fact their offers increased the government cost in case it decided to continue to provide free water and electricity to the UAE citizens. The other factor that the private parties could not handle efficiently is the fluctuations in prices in the market; they could not obtain firm prices and commitment from the suppliers involved in the project. They lacked the experience on how the local market works and did not have a good local supply network. So the risks in this PPP project were quite high and the contract did not provide mechanisms to deal with such issues.

Case Study B: Theme Park
Critical Success Factors
The risks in this project are carried fully by the private partner. The Municipality has taken neither the financial nor technical risks of the execution of this project. The private partner will handle design, construction, financial and operation risks. The private partner has sufficient knowledge and experience within its structure to deal with the mentioned risks. The main risk that concerns the private partner is whether the Theme Park will attract enough visitors to make it financially viable. The private partner, hence, developed a detailed marketing plan focusing the attention of the marketing team on how to attract school students to visit the Theme Park due to the learning and educational value the park has. To minimize this risk and limit its liability the private partner formed a Limited Liability Company (LLC) to carry out the project.

Adopting PPP allowed the Municipality to develop such a facility without having to resort to using its own capital at a time when there are serious pressures to provide ever expanding services to society. Using PPP has allowed the Municipality to embark on a venture in which it had no experience in operating such facility.

Again in this Emirate there is no PPP Law therefore the parties had to rely on the contract between them to govern their relationship. The contract is a lease agreement, where the private partner rented the land for a period of time, 30 years, by paying annual rent to the Municipality. The Municipality will carry out regular inspections to make sure that the quality of works is good. A third party may be engaged to carry out inspections on the rides.

The only political support that this project will receive will be in form of the Municipality processing the approvals on urgent bases; the Municipality will support the project with other Government authorities to take approvals, for example for water and electricity connections and approvals. Although the government is not promoting the project the parties have taken advantage of the overall support of the government to the tourism industry and the facilities it provides to support tourism by participating in exhibitions inside and outside the country.

In terms of having a strong consortium in this PPP project the private partner was one company only. The owners of the company set up the management team and selected staff with good experience in entertainment industry. It is their first project and the company was formed specifically to carry out this PPP project. The owners of the company are well known Saudi businessmen with good experience in establishing and investing in new projects.

Despite the availability of good financial market in the UAE, the private partner could not enjoy the available financial offers by the banks because it lacks credit history in the market. It is a new-formed company and the project is a BOT project, so the company does not own the land, and therefore it will not be considered as a security to the banks. The Operation Manager in the private company said *“banks drew back from financing BOT project as it is new and we don’t own the land. They prefer to watch and see what will happen”.* As the government did not provide them with any financial support, the investors had to rely on their own resources.

The market has witnessed a significant rise in the cost of resources, especially materials, over the last 2 years. The fluctuation in construction materials prices had a strong affect on the project leading to 30% increase in the cost. In addition, a recent purge by the government of labourers lacking residency permits had a significant effect on progress with subcontractors facing serious recruitment problems.

There was no tender process for this project; it was an initiative from one of the owners of the private company. Negotiations and discussions were carried out with the Municipality before agreeing on the BOT arrangement. Presentations and ideas were exchanged as well as negotiations on the annual rent. The private party carried out a feasibility study. However, this study had to be revised later. The original study was carried out by staff who had not experience in the entertainment business. The feasibility study had to be revised by experienced staff employed after signing the contract with the Municipality.

The financial pressures have driven and encouraged innovation to make the project commercially viable. The Operation Manager explained *”we had to change the design …. for example the jogging track used to cover 25% of the total area but it contributed with only 1% to the revenue, we had to change this”*. Many changes to the original design were introduced which caused the project to be delayed.

Failure Factors

The Private Partner employed experienced staff to carry out the technical works required for the project. The firm also had the management and business skills but they lacked the experience and knowledge of the local market. This has led to the selection of the construction contract that exposed the firm to the volatile changes in the market. The project needed the support of a local partner that can negotiate better terms for the company and guide them in the selection of the best procurement methods to carry out the project. The project value is quite high and it increased due to the increase in prices of construction materials; and as there is no financial support from the banks, the owners of the company had to rely on their private sources to secure the extra funding. Hence the risks of this project are fully carried by the private partner, so huge responsibilities will be laid on the project team to make the project successful. As the project was negotiated with the Municipality the procurement period was not onerous. The Municipality did not take much time to decide, so the management did not waste so much time in waiting for a decision; this minimised the demands on management time.

In conclusion this project has many of the CSF in place. The speculative nature of the project means that the project team will have to work hard to promote the Theme Park and to take advantage of the booming tourism industry in the UAE. The project has the potential of expanding further, hence, it has to demonstrate its success to be able to win the trust of the financial institution, which is needed to fund future expansion plans.

Case Study C: Industrial Zone
Critical Success Factors
The risks in this PPP project are distributed between the partners where the private partner handles the design, construction and operation risks, while the public party is sharing the financial risk. The public party is contributing approximately 75% of the cost required to carry out the project. Here the public party is minimizing the business risk of the private party by paying the rent of all plots of the project that fail to attract a tenant. Such arrangement represents a significant support and encouragement to the private party to enter into this PPP.

In addition to the saving in the initial capital investment that the public party will enjoy, the main value for money through this PPP is being able to attract a leading international bank, like the foreign bank involved in the PPP project, to invest in the UAE economy. Such an investment will attract other leading banks and international companies to shift their business to the UAE and invest in its economy.

This Emirate did not have any law for leasing lands and even trading in lands was very limited in the Emirate, and it was mainly between UAE nationals in that authorities. However, to make this project successful new Laws and Decrees were issued that allowed leasing lands to non-UAE nationals in certain areas. The Law was developed at later stages to allow Gulf Council Countries' (GCC) nationals to own land in the Emirate and for non-GCC nationals to lease lands for long periods. Other Laws and Decrees were issued to allow foreigners and non-GCC nationals to have trading license in certain locations and areas of the Emirate, which will allow them to start and run their own business in the Emirate. Those Laws and Decrees were a step forward in attracting foreign investors to invest in the Emirate and it had a positive effect in this PPP project because it enabled the private party to attract international companies to set up business within this project. The project enjoys a huge political support. It was the first PPP project in this Emirate and the government wanted to make it successful. The Head of Commercial Banking in the Local Bank said, "*The project had to succeed, the Government was behind it and it was willing to inject money. That was not an issue*".

The PPP consortium was strong having the necessary knowledge and experience. The foreign bank carried out many PPP projects in different countries, and it has sound knowledge and experience in processing PPP projects. It has huge contacts with big companies through its banking network. The local bank did not participate in PPP projects before, but it has good experience and wide contacts in the local market and has been involved in many local development projects. Both banks have sound knowledge and experience in financial market, as it is their core business. As explained above, 75% of the project's cost will be funded by the Government through utilization of Phase 1 revenues, the Consortium will fund the balance 25%, 250 million AED which they should not have a problem to arrange.

The tendering process for this project was direct negotiation between the public and the private parties. Discussions focused on clarifying issues and agreeing on the scope of work. The business model itself was viewed as an innovation that helped the public client achieve its objectives. For that purpose a thorough feasibility study was carried out in association with a famous legal consultant office in the Emirate.

The project did not suffer due to the lack of appropriate experience among the Consortium. Both banks in the consortium complemented each other; the local bank has good experience in the local market, which will help in making decisions like selecting the designers and the contractors; while the foreign bank has good experience in PPP projects. There were no participation fees, but initial payments for advisors were needed, for example for legal advice. In general the participation cost was not high. The project value is one billion AED which is considered high but when the private party only needs to pay 25% of this cost this was found to be reasonable. The credibility of the private party and the significant support from the government support have reduced the risk of failure of this project.

Failure Factors

This project did not have any significant failure factors.

In conclusion the project is considered a great success and it has created an opportunity to start other PPP projects in the Emirate. It had all essential success factors like the huge political support, the sound knowledge and experience within the Consortium as well as the attractive financial arrangement and guarantee agreed with the Government.

CONCLUSION

PPP is still at its infancy in the UAE with fewer than 10 projects that can be identified in the country. This paper aim was to examine the key factors for the success of PPP. The main factor was political support. This is not surprising as in the absence of experience in the public sector and the lack of the legal framework to support a new business arrangement such as PPP the industry and its stakeholders require the intervention of the political leadership and authority to create the confidence and understand the perceived risk of such projects. It is also necessary to develop the knowledge of where PPP can be deployed successfully. It was clear from one of the case studies that if the public client had the deep understanding of what would make PPP successful, much money would have been saved on what looks like an aborted project.

REFERENCES

Bing Li, Akintoye, A., Edwards, P.J. and Hardcastle, C. (2005) Critical success factors for PPP/PFI projects in the UK construction industry, Construction Management and Economics, 23(5), pp. 459-471.

Flinders, M. (2005) The politics of Public-Private Partnerships, Political Studies Association, 7(2), pp. 215-239.

Hodge, G.A. (2004) The risky business of public-private partnerships, Australian Journal of Public Administration, 63(4), pp. 37-49.

Hurst, C. and Reeves, E, (2004) An Economic Analysis of Ireland's First Public Private Partnership. The International Journal of Public Sector Management, 17(5), pp. 379-388.

Jefferies, M., MaGeorge, D., Chen, S.E. and Cadman, K., (2006) Sustainable Procurement: a contemporary view on Australian public private partnerships (PPPs), Proceedings of the Joint International Conference on Culture, Innovation and Management, Editor Mohammed Dulaimi, British University in Dubai.

Nyachhyon, B. L, (2006) Prospects and Constraints of Public Private Partnership for Urban Waste Management. Economic Policy Network. Policy Paper 15, available at: http://www.mof.gov.np/economic_policy/pdf/Prospects_Constraints.pdf.

Papaioannou, P. and Peleka, M. (2006) Recent Practices on Success and Failure Stories from Funding Large Transportation Projects in Greece, 1st International Conference on Funding Transportation Infrastructure, Banff, Alberta, Canada, 2-3 August, pages 1-13.

Payne, Helen. (1997) Key Legal Issues in Projects Procured under the Private Finance Initiative, Engineering, Construction and Architectural Management, 4(1), pp. 195-202.

Pongsiri, N. (2002) Regulations and public-private partnerships, The International Journal of Public Sector Management, 15(6), pp. 487-495.

Qiao, L., Wang, S.Q., Tiong, R.L.K. and Chan, T.S. (2001) Framework for Critical Success Factors of BOT Projects in China. Journal of Project Finance, 7(1), 53-61.

Thomson, D. (2007) Revised Guidance PFI and PPP VFM Assessment, Department of Finance and Personnel, UK, available at http://www.aasdni.gov.uk/pubs/DAOs/dao0207.doc.

Wang, Yin (2006) Keys to Successful Public Private Partnerships (PPP's), University of California SPPD Research. Proceedings of Public Private Partnerships-

Opportunities and Challenges Conference. Arranged by Hong Kong University and Hong Kong Institution of Engineers-Civil Division. Hong Kong Convention and Exhibition Centre, Hong Kong.

CONSTRUCTION PERFORMANCE: CONCLUSIONS FROM A PORTUGUESE SURVEY

Helder Moura
EP – Estradas de Portugal, Almada, Portugal
helder.mmoura@gmail.com

José C. Teixeira
Minho University, Guimarães, Portugal
jct@civil.uminho.pt

Measuring construction performance is essential for benchmarking purposes and for organizations to achieve best practices. The most spread method is the use of Key Performance Indicators (KPI), which are a set of quantitative and qualitative indicators, derived from historical data provided by both clients and contractors. The idea behind Key Performance Indicators (KPI) is to establish a set of national indicators for construction projects, companies and clients whereby the industry could benchmark against the national performance and identify strengths, weaknesses and opportunities for improvement. With the international spread of KPI, comparisons can also be made among different countries and the competitiveness of each country's construction sector may be looked at. Although lack of competitiveness is recognized in Portuguese construction sector, the reasons behind this evidence are poorly known in Portugal. Against this background, a research project has been conducted in order to survey the performance of the main management functions in Portuguese public projects. The conclusions indicate that the main causes for the lack of achievement of management functions are due to client's responsibility, which increased overall litigation and the presentation of claims.

KEYWORDS: KPI's, Portuguese construction, management functions, claims

INTRODUCTION

A common perception of the construction industry is the one in which projects and services are often delivered unsafely, late, over budget and below quality. However, clients want their projects delivered on time, on budget, free from defects, efficiently, right at first time, safely and by profitable companies (KPI Working Group, 2000). Consequently, being the most important stakeholder in the construction, clients play an important role to the project success.

But the success of a project is a somewhat abstract concept and is a complex task to determine to what extent a specific project is a success or a failure (Chan et al, 2002); sometimes, this is only realised during the operation phase of the construction facility.

Moreover, the success of a project may have different meanings for each construction stakeholder, either internal or external (Olander, 2003) and those meanings can even change during the course of the project. For example, the designer may consider the functionality and the aesthetics of a building as the main factor of success, regardless of the cost, while the client may not have the same perspective. The criteria of classifying it a success or a failure may also vary from project to project and be influenced by the type of project, by their size and sophistication, by the participants, the experience of the promoter, and so on.

In the case of public funded projects, its success is also measured by the adhesion of public opinion, and specifically of taxpayers, as we all like to see the best possible application for the money collected through taxes.

On the other hand, construction companies have different levels of responsibility on the overall success of a project, depending on the type of contracting system selected by client. In the traditional system, the company is only contracted to implement the design developed by the client. In this case, factors of success as the location of the facility, its functionality or suitability do not depend on the contractor's performance. Alternatively, if a client selects a design-construction contracting system, the above factors of project's success will take into account the performance of the company in the design phase of the venture.

Thus, it can be concluded that factors of success of a construction project consider the performance of construction companies to the extent of their involvement in the project. And consequently, if success or failure is measured through a suitable set of factors, it will reflect the performance of companies involved in the project and may affect their competitiveness and participation in future projects. In fact, if past performance of competitors is a selection factor, preceding failures of contractor's liability may have negative consequences in further competitive bidding of public projects. Failing new contracts means losing market share and decreasing competitiveness directly or indirectly caused by the failure of projects on which the company was previously involved.

For the above reasons, and in order to provide adequate and comparable information on construction project performance, some measurement criteria have been developed the most widespread of all are Key Performance Indicators (KPI). These are a set of quantitative and qualitative indicators, derived from historical data provided by both clients and contractors, which ought to give information on variables like construction time, construction cost, health and safety, defects, profitability, client satisfaction and users' expectations.

These indicators are clearly adapted to measure project performance and play a crucial role in improving reputation of the construction industry by providing organisations with a simple but effective method for monitoring performance, predominantly in respect to the main project management functions, i.e, cost, time, safety and quality.

Traditionally, the construction industry has relied on reputation as its marketing tool. While this is undoubtedly important, it can be greatly enhanced if combined with hard evidence that KPIs can provide, allowing those within the industry to compare how organisations are performing. In the countries where KPIs have been adopted, they have shown to stimulate a significant number of construction companies to critically assess their performance and of their projects against the industry average, allowing them to take positive action. However, KPIs for themselves do not give sufficient clues on which aspects clients would like to see the performance of projects or companies to be improved, therefore enabling the industry to find the best ways to evolve. This has to be checked through continuous examination to the construction stakeholder's opinion.

Moreover, the performance of projects from the clients' point of view has seldom been addressed in the literature despite the importance of some of them for the national economy.

Poor performance of public projects has otherwise been mentioned in the literature, often revealing poor performance of clients promoting them. Reasons behind this are poorly known in Portugal, despite a number of cost overruns and delays have been registered in some important projects. Against this background, a research project to Portuguese contractors and clients has been conducted in order to survey the performance of the main management functions in public projects. This paper reports the main conclusions of the survey included in the project.

SITUATION IN PORTUGAL

In Portugal there is not enough collected data from past construction projects, that allows benchmarking practices or the use of the suggested indicators to measure performance. On the other hand, the reported efficiency of the use of most KPI's has been criticized, once they are understandable as lagging measures that do not provide the opportunity to change or the improvement of innovation. As a matter of fact, they are being used within the industry as a marketing tool, and not as an integral part of business management (Beatham et al., 2004).

Simultaneously, some practical difficulties apply in gathering data, namely the one related to monetary values (like profitability), still considered confidential and sensitive information. Besides, in public projects, and from the clients' point of view, the objective is to serve citizens and not to have profit. The same occurs in respect to client satisfaction and users' expectations, as normally a public facility is constructed to accomplish a need or a necessity, and in consequence users are supposed to be more satisfied with then without it, even if some kinds of discontent subsist.

So, in order to get available and consistent data, the variables/indicators surveyed were the cost and time overruns, in respect to the beginning of the construction phase, the number of non-mortal and mortal accidents during construction, and the number of defects claimed by clients/users during construction and operation phase of the facility. Considering that not achieving these management functions, frequently leads to construction claims, the construction projects analysed were also surveyed in respect to what type of claims were presented by contractors.

In respect to cost and time overruns, these functions have been thoroughly studied internationally but unfortunately, at national level, research results on these overruns continue to be very rare (Moura et. al, 2007). Recent concerns of construction industry associations about this subject lead to the publication of recommendations for the reduction of cost and time overruns in public construction projects, and the identification of situations that originate cost overruns in past construction projects (OE, 2006).

Another issue reportedly pointed out in the media is the lack of safety in the Portuguese construction sector that continues to lead the number of work-related accidents and fatalities. Although liabilities of all who intervene in the construction process have been reinforced by recent law amendments on risk prevention at work, numerous violations continue to occur with dramatic consequences. Costs related to work accidents as well as health problems related to this profession affect not only injured workers but also the employer, insurance companies and society in general.

According to the General Labour Inspection, 157 fatalities occurred in all the economic activities in Portugal during 2006. The construction industry was accountable for 71 (or 45%) of those fatalities. But more important than statistical data on labour fatalities is the analysis of available information on the causes for these unfortunate events and find solutions for their mitigation. In 2005, the incidence rate of work-related fatalities in the Portuguese construction was 30.5 per 100,000 workers.

A further aspect regarding the need for better quality in the Portuguese construction sector has impelled proposals for the revision of legislation, namely increasing the guarantee period of buildings. Shorter life-cycles of construction materials and components cause unexpected expenses that new end-users have to endure. However, to help mitigate these intolerable costs leaving end-users more satisfied, it is necessary to improve the quality of construction materials and its components.

RESULTS FROM THE SURVEY

Research methodology

To obtain quantitative performance indicators through the evidence of the lack of achievement of cost, time, safety and quality management functions, information from past public construction projects launched between 1998 and 2004 with an initial contract value over 10,000,000 EURO, was gathered. Moreover clients and contractors involved in the projects assessed were asked to point out and graduate in a scale of 1 (less important) to 4 (most important) the possible causes for the lack of fulfilment of each management variable.

In order to measure the importance and the intensity of these causes, an index (I) given by the expression $I = \sum_{i=1}^{4} x_i a_i$ was used, where a_i is the constant that expresses the weight given to the cause (ranging from 1 to 4) and x_i is the frequency of the answers.

Simultaneously, respondents were asked about what kind of the eight possible different types of contractual claims identified in previous studies (Moura, 2003) had been addressed. They were also demanded to fill in the amount of each type of claim requested by contractor and the amount paid by client.

Data analysis

Although approximately 500 public projects had been identified in the database, only 64 individual answers were received, whereas 28 from contractors and 36 from clients. Therefore, analysis will be based on the 64 construction projects distributed by type as follows (Table 1):

Table 1: Types of projects surveyed

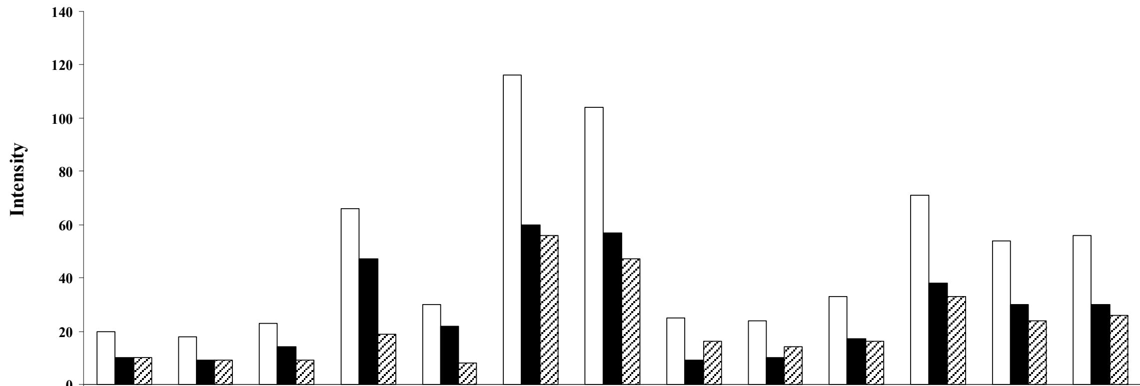
Type of construction	Weight
Civil Works (Buildings, Urban development)	19%

Infrastructure (Water, Gas, Sewer)	17%
Industrial	8%
Dam/Maritime	16%
Roads/Highway/Railway	36%
Environment	5%

Time

The quantitative measure for the time function was the delay in each project, expressed in calendar days, in relation to the initial duration. The average initial contract duration was 512 calendar days and the actual duration was 713 days. Therefore, the average delay was 201 days approximately 40% above the expected duration period.

Reasons for these delays were surveyed and respondents indicated client responsibility (116 points) as the most important, followed by designer responsibility (104 points), either in the clients' perspective and in the contractor's opinions, meaning that clients are actually aware that they contribute significantly to the delays and thus low performance of the project. Overall responses are depicted in Figure 1:



	Material	Equipment	Workforce	Contractor responsabilit y	Financial problems	Client responsibilit y	Designer	Project Manager	Contract	Institutional relations	Project specifics	External factors	Others
□ Total response	20	18	23	66	30	116	104	25	24	33	71	54	56
■ Cliente response	10	9	14	47	22	60	57	9	10	17	38	30	30
▨ Contractor response	10	9	9	19	8	56	47	16	14	16	33	24	26

Main causes for delays

Figure 1: Intensity of delay causes

Construction cost (client perspective)

Analysis of the cost function was done by comparing the final cost of the project with the initial contract value. The average initial cost of the 64 construction projects surveyed was €16,183,327 while the average final cost reached €18,384,341. As a result, the average cost overrun was € 2,201,014 or 14% of the initial average cost.

In the last years cost overruns in main public projects in Portugal had several times reached the maximum permitted by law: 50% for projects launched up to 1999 and 25% afterwards. However, some caution must be taken when analysing these results, as the reasons behind this low average rate of cost overruns are due to scope changes and reduction, which is still permitted by regulations for the procurement of public construction services.

According to Figure 2, aggregate responses indicate three main causes for the lack of achievement of the project's cost management function, which rank approximately the same intensity: design errors (100 points), direct change orders (97 points) and different site conditions (86 points). We can see that all of these causes are deriving from client control:

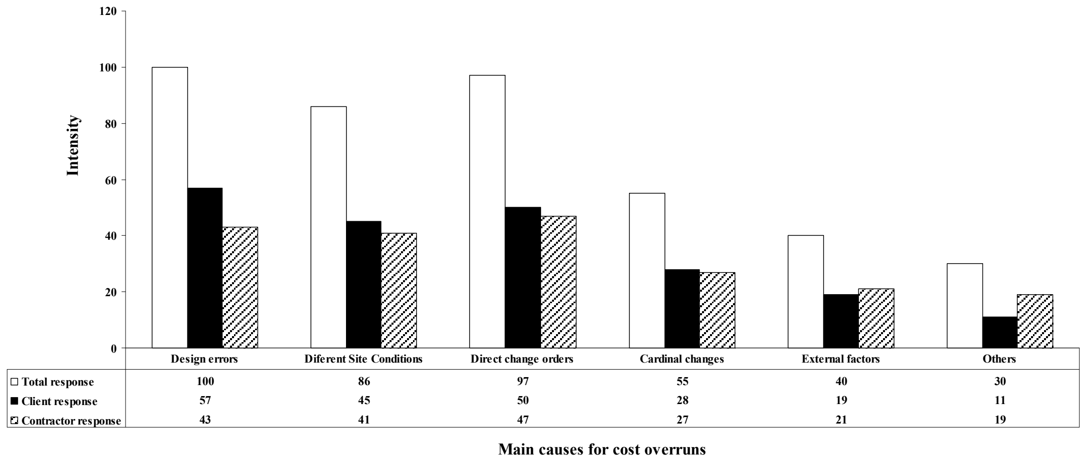


Figure 2: Intensity of cost overrun causes

Reported accidents (including fatalities)

The number of fatal and non-fatal accidents, number of workers involved in the projects, number of work hours and the total working days lost due to accidents occurred was the data surveyed for the safety management function. However, the most reliable and accurate data was the labour accidents reported to the authorities, which reached 3 fatal and 159 non-fatal accidents occurred in the 64 projects surveyed, meaning that the huge accident rate in Portuguese construction industry is due to private and smaller projects, and not so high in bigger public projects, contracted to more organized companies.

The causes for the reported accidents rank first, for contractors, insufficient task preparation. In their opinion, although the high risk of the activity contributes more frequently to the lack of safety, its intensity on the lack of achievement of the project's safety management function, meaning accident rate, is not as significant when compared to insufficient task preparation and the lack of specific training. Thus, this only comes to show that contractors acknowledge their own fault in contributing to the lack of safety in construction. The aggregate answers also attribute insufficient task preparation the most important cause of accidents (44 points), followed by the lack of specific training (40) and the high risk of the activity, this one depending on client/design control. The intensity of the main causes for the lack of achievement of the safety function is represented in Figure 3.

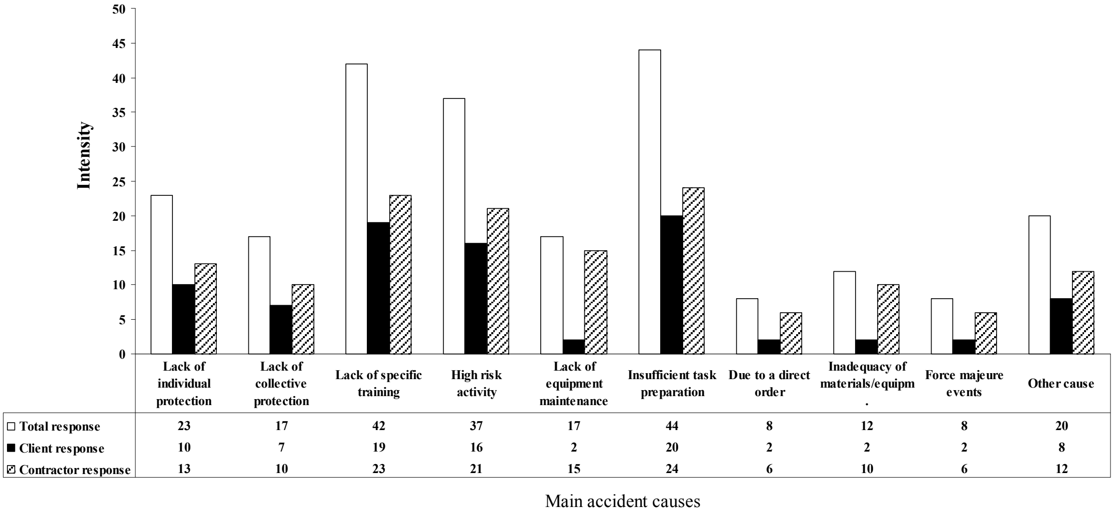


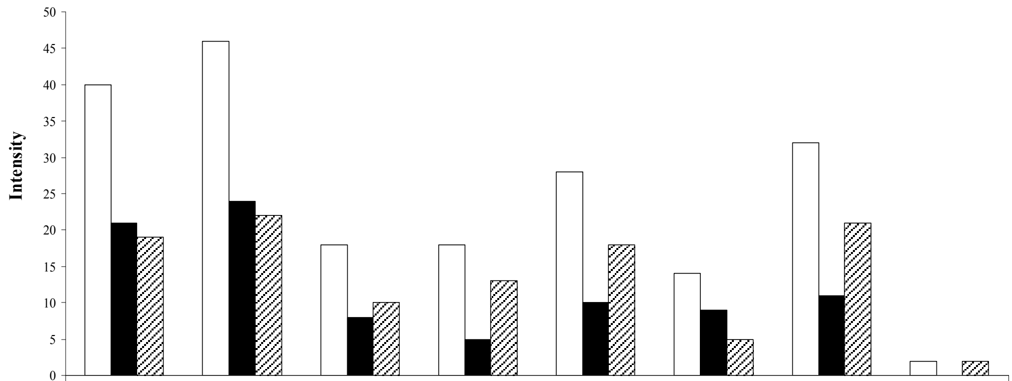
Figure 3: Intensity of accident causes

Defects

The number of defects detected during the construction and operation period of the constructed facility was used to analyse the project's quality function. However it was detected an abnormal frequency distribution of non-compliances that vary from 0 defects, in 26% of the projects, to more than 1,000 in 3% of them, whereas 44% had no available data.

This abnormal frequency distribution must be handled with some care as it might not explain the real situation of the Portuguese construction projects. Instead, it is the consequence and the inexperience in dealing with the recent implementation of Quality Management Systems which is not yet compulsory for the construction companies in Portugal, meaning that the number of defects is still not a reliable indicator to analyse construction performance.

In respect to the projects that indicated construction defects, poor work execution and inadequate design solutions were the most intense causes considered in aggregated answers, with 46 and 40 points, respectively. Clients maintained the preceding rank but with less intensity, while contractors also weighed these causes with approximately the same intensity as clients, along with external factors and inadequacy of construction materials/products (18 points). Figure 4 illustrates these aspects.



	Inadequate design solutions	Deficient work execution	Project manager decisions	Client direct action	Inadequate materials or products	Inadequate site inspections	External factors	Others
□ Total reponse	40	46	18	18	28	14	32	2
■ Client response	21	24	8	5	10	9	11	0
⊠ Contractor response	19	22	10	13	18	5	21	2

Main causes for the lack of quality

Figure 4: Intensity of causes for the lack of quality

Construction claims

In respect to construction claims, data collected indicated that a total amount of € 234,196,145 was claimed by contractors, representing 24 % of the initial contract values of all 64 projects surveyed, while the amount paid by clients summed € 176,963,636, representing 19 % of the initial contract value of all projects, regardless they experienced claims or not (the ratio between projects that suffered claims and those who had not, reached the high value of 0.71).

It is also important to state, that the ratio of success (amounts awarded/amounts requested by contractors) was 0.76. This average rate is significantly high when compared to similar international studies (Zaneldin 2006), supporting the conclusions obtained through KPI's that the majority of the risk of presenting and winning claims is on the side of the clients.

The same conclusion is obtained when comparing the different types of claims presented by contractors, as represented in figure 5, which reveals that direct changes was the most "expensive" type of claim responsible for almost € 100 million of requested amount for compensation, while contractors received about € 88 million, representing a ratio of success of 0.89, considerably above the average of 0.76, relating to all types of claims. Once again this statement reflects the recognition by clients that change orders they issued provoked cost and time overruns, as well as damages to contractors, which gave them the necessary arguments to present well supported claims.

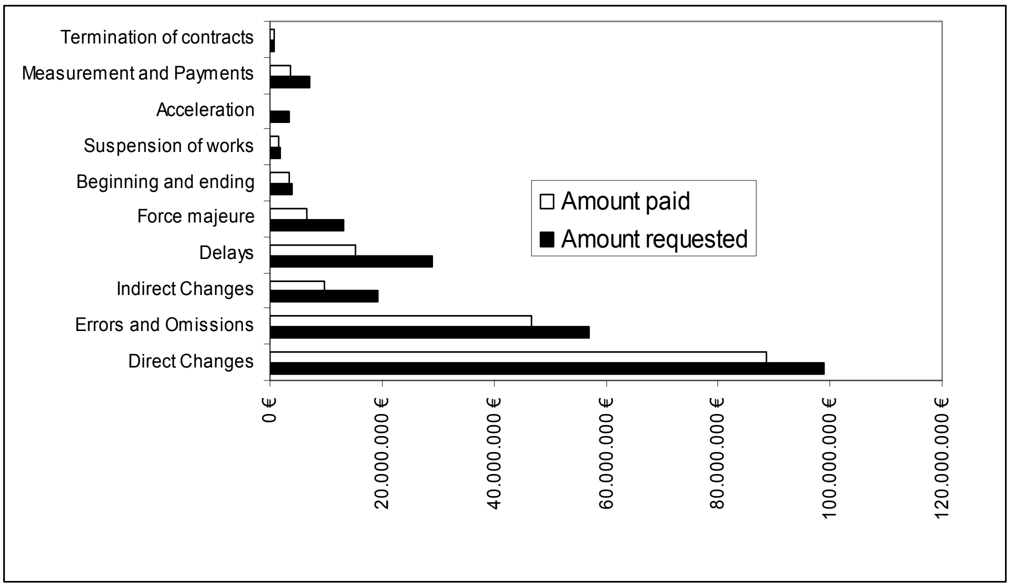


Figure 5: Amount requested versus amount paid by different type of claims

CONCLUSIONS

The results obtained from the construction projects surveyed indicate that future benchmarking, in relation to main management functions, should be done against the indicators presented in Table 2 (considering the average results):

Table 2: KPI's for Portuguese public projects

Indicator	Average score
Project delay	40%
Construction cost overruns	14%
Reported accidents per project	2.4
Fatalities per project	0,03
Construction defects per project	40

The results of the survey indicate that both clients and contractors agree that the reasons behind the above high scores, which are easy to benchmark against, are mostly clients responsibility, either direct when introducing change orders, or indirect due to low quality of contracting documents namely the design. The high amount of construction claims due to direct changes, and the ratio of success, points to the same conclusion, i.e, clients are the main responsible for the failure of the project, in respect to the achievement of the management functions surveyed.

Moreover, if future qualification for public projects ought to be based in past performance, contractors would be compelled to run for them, meaning that concepts like innovation, sustainability or partnering, are subsumed to predetermined quantitative measures and inflexible management objectives at the project level, and the expectation is that overall litigation between parts might begin to increase.

Acknowledgments

Authors want to thank FCT (Fundação para a Ciência e Tecnologia) the support to this research.

REFERENCES

Beatham, S., Anumba, C. and Thorpe, T. (2004) KPI´s a critical appraisal of their use in construction. Benchmarking: An International Journal, 11 (1), 93-117.

Chang, A., Chang, A. (2004) Key performance indicators for measuring construction success. Benchmarking: An International Journal, 11 (2), 203-221.

KPI Working Group (2000) KPI Reporting for the Minister for Construction. Department of the Environment, Transport and the Regions, London.

Moura, H. (2003) As Reclamações nas Empreitadas de Obras Públicas: Alterações e Atrasos (Construction Claims in Public Works: changes and delays, in Portuguese), Unpublished MSc Thesis, Department of Civil Engineering, Minho University, Portugal.

Moura, H., Teixeira, J., Pires, B. (2007) Dealing with cost and time in the Portuguese Construction Industry. In Proceedings of 3º CIB World Conference, pages 1252-1265, ISBN 1-920-01704-6, 14-18 May, Cape Town, South Africa.

OE Ordem dos Engenheiros / Board of Engineers (2006) Recomendações para redução dos desvios de custos e de prazos nas empreitadas de obras públicas (Some recommendations for the reduction of cost ant time overruns in public projects, in Portuguese), Lisbon.

Olander, S. (2003) External stakeholder management in the construction process, Licentiate Dissertation, Department of Building and Architecture, Lund Institute of Technology, Lund, Sweden.

Zaneldin, E. (2006) Construction claims in United Arab Emirates: types, causes and frequency. International Journal of Project Management, 24 (5), 453-459.

AN EFFICIENT MATERIALS MANAGEMENT MODEL TO IMPROVE PRODUCTIVITY

Guomin Zhang
University of Calgary, Calgary, Canada
zhangg@ucalgary.ca

Janaka Ruwanpura
University of Calgary, Calgary, Canada
janaka@ucalgary.ca

Site materials handling has a significant impact on labour productivity. Previous studies showed that 10-18% of labour costs can be saved if an effective materials management system is adopted. Following generic problem-solving steps, a web-based materials management model, aimed at minimizing inefficiencies of site materials handling was developed. Through various means of data collection, ineffective materials handling activities (IMHA) were identified and their impact on tool time was quantified. The root causes of IMHA were analyzed and a new materials management process from materials initiation to installation was established, incorporating databases to address these root causes. Using the Active Server Pages web tool to process information, the model can generate information of materials requirement for specific activities, materials storage, materials delivery schedule, detailed crane schedule, etc. The testing of the model revealed that 20% of productivity improvement was achieved for a scaffolding crew.

KEYWORDS: Materials Management, Productivity, Canada, Tool Time, Active Server Pages.

INTRODUCTION

One of the key areas in which construction industry can improve labour productivity is site materials management. Previous researches showed that applying an effective computer-aided materials management system can yield 10 to 18% savings in labour cost (Bell and Stukhart, 1987) and a benefit/cost ratio for such a system is 5.7(Thomas et al., 1989). Other benefits include reduced materials surplus, reduced materials management labour power and cash flow savings (Thomas et al., 1989).

Although the benefits of a materials management system are evident and clear, relatively fewer studies have been conducted to thoroughly investigate as to what are the reasons causing lower productivity due to materials management issues on site and what is an efficient process that can be followed to improve productivity (Thomas et al., 2005). Most of the past studies focused on specific project situations in construction materials management practices. The activities involved from materials planning, vendor selection, ordering, delivery, site distribution until materials installation have not been treated as a whole process in the past research projects. The potential of computer software and network technology used as automatic process management tool has not been thoroughly explored in construction materials management.

A recent study conducted in Alberta, Canada involving six major general contractors, investigated materials management practices, its impact on labour productivity and finding a best solution that can be adopted in construction industry. Based on this Canadian research project, this paper presents a new approach to quantify materials handling impact on tool time, analyzes root causes that give rise to lower productivity due to materials related issues, and introduces a web-based model developed dealing with the entire materials management process from materials initiation to installation. The model was tested in an ongoing construction jobsite that showed 20% increase of productivity improvement for a scaffolding crew.

SUMMARY OF PAST STUDIES

The subject of construction materials management was first treated as a comprehensive, integrated management activity in the Business Round Table report in 1982(Bell and Stukhart, 1986). The studies in the 1980s focused on identifying factors relating to effectiveness of materials management system (MMS), analyzing cost/benefit of MMS and attributes of MMS(Bell and Stukhart, 1986). It revealed that the single most important factor relating to the effectiveness of any MMS is the support it receives from top management (Bell and Stukhart, 1987). In order to solicit top management support, further research was conducted to demonstrate cost and benefit of MMS. It showed that at least 6% cost savings in craft labour should be achieved by effective MMS as well as reductions in materials surplus, reductions in management power, purchasing improvements, cash flow savings, and reductions in required warehouse space (Bell and Stukhart, 1987). The main cost of the system is computer software, system installation and initialization which far less than the benefits achieved (Bell and Stukhart, 1987).

Thomas et al (1989) quantified the impact of ineffective materials management practice by comparing two steel erection projects. The study showed that work-hour overrun was 18% due to poor materials management and the benefit/cost ratio of 5.7 yielded from an effective MMS. Delivery methods have a big impact on productivity. In this particular case discussed in the paper, double-handling due to improper delivery methods caused a loss of productivity from 9 to 16%(Thomas et al., 1999). O'Brien(1989) advocated that materials handling is the key factor in improving on-site productivity and improvements in materials handling will deserve to be "the point of wedge" that leads to a breakthrough in construction productivity. In his study, mechanical and electrical tradesmen spent 20% of their time in materials handling.

The just-in-time (JIT) philosophy can be applied for logistics management in construction jobsites to increase productivity. JIT philosophy originates from the manufacturing sector. It helps to smoothen the production process by providing the right materials at the right quantity and quality just in time for installation (Low and Choong, 2001). The concept of JIT includes six principles which are Kanban or pull system, top management commitment and employee involvement, elimination of waste, total quality control, uninterrupted work flow and supplier relations. By applying JIT in construction materials management, contractors will accomplish inventory reduction, shorter cycle time and more competitive pricing for the client (Akintoye, 1995).

Since construction materials management involves multiple parties and a variety of materials with different quantities, cost, shapes, functions, delivery tools, etc, it is very necessary to use IT tools to facilitate communication, warehousing and inventory recording. However the benefits of its utilization vary depending on the degree with which those tools are used. Generally, these benefits include increased engineering and support staff productivity, reduced procurement lead times, improved data accuracy, and enhanced materials supplier relationship(Bell and Stukhart, 1987, Bell and Back, 1995). The benefit in terms of craftsman's productivity has not been adequately explored in the past research project.

RESEARCH OBJECTIVES

The overall objective of the research presented in the paper is to develop an efficient materials management model that can minimize inefficiencies of materials handling activities to improve site labour productivity. This was achieved by three phases:

1. Investigate current site materials management practices to identify ineffective materials handling activities (IMHA) and quantify their impact on productivity.

2. Conduct root cause analysis to track down causal factors of IMHA.

3. Based on step 2, develop a computer-based materials management model that addresses these root causes.

By directing the treatment of the root causes through the model application, it is believed that the symptomatic IMHA can be minimized and the productivity will increase as a result. This paper discusses the objectives of 1 and 2 given above.

DATA COLLECTION METHODOLOGY

In this study, three methods of data collection were adopted: interview, direct observation, and questionnaire survey. This is to ensure that the data collected reflect the evaluation of construction practices from three different perspectives: the researcher, site craftsmen and management personnel.

Interviews

At the beginning of the data collection stage, twelve interviews were conducted with management staff on six different construction sites with each interview lasting from 40 to 80 minutes. The subjects of the interview consisted of project managers, project coordinators, site superintendents and foremen. The aim of these interviews was to gain information about current construction materials management practices and to compare and contrast the different practices adopted by different contractors in Alberta. It was also aimed at testing the hypothesis that there is a need to improve current site materials management practices from site management perspective. Issues were investigated are: (1) the process of materials management from determining materials needs to their installations; (2) the entities in charge of the whole process as well as every stage within the process; (3) the process of monitoring and tracking the flow of materials; and (4) the problems/challenges in materials management and their impact on productivity.

Direct Observations

Direct site observations was the main source of data collection, which was performed in a 15-storey office building in downtown Calgary during its structural construction stage. The aim of the observation was to achieve: (1) identify ineffective or inefficient materials handling activities and events, (2) quantify the impact on productivity due to these activities or events. The ineffective materials handling activities (IMHA) were identified as seven categories which will be discussed in the next section. The quantification of the impact on productivity was calculated by analyzing a large amount of samples which recorded the time periods an individual worker spent on each materials handling activity during a five minute observation period. The observation was conducted in two stages for a total period of six months (Table 1).

Table 1. Site Observation Stages

Observation Stage	Time Period	Observation Tasks	Construction Stage
Stage 1	May 1, 2006 to July 31, 2006	Identify IMHA	2nd floor to 6th floor(structure)
Stage 2	August 1, 2006 to October 31, 2006	Quantify IMHA	7th floor to 12th floor (structure)

Questionnaire Survey

Because of the limitation of time the direct observation was conducted in one jobsite, more data was needed to re-justify the problems found from the observations. Questionnaire surveys were used to collect data from eight sites in Calgary. It is also necessary to compare and contrast the results of the observation with that of the survey. The major aspects of questions included in the survey are: (1) identification of ineffective materials handling activities (IMHA) on sites, (2) prioritization of these IMHA, (3) estimation of the magnitude of the impact on worker's tool time, and (4) the reasons behind these IMHA. Through analyzing data collected from these sites, more common materials handling problems can be found.

DATA ANALYSIS

Current Materials Management Practices

Among all the contractors investigated, it revealed that the purchase of field materials constitutes a major part of the procurement of bulk materials plus consumables (lumber, nails, gravel, welding wire, etc.) for a project, ranging from 60% to 95%. However, there was no formally defined materials management system or model in place for site construction. Most contractors have in-house materials management systems, built on Microsoft Excel and communicated via intranet. But these systems were only used for accounting or generating documents, such as purchase orders. The impact of the different stages in the materials management process upon materials handling efficiency was almost neglected. Materials delivery was not incorporated into activity schedule, resulting in the frequent occurrences of early or late delivery. Most of materials handling relied on tower cranes, but crane schedule was loose and not in proper detailed level. Conflict in the usage of crane was attributed as a major factor for ineffective materials handling. The existence of these materials management issues in the current practices necessitates re-establishing a materials management model simulating the entire process from materials initiation to installation.

Identify Ineffective Materials Handling Activities (IMHA)

The first step of the direct observation is to identify ineffective materials handling activities (IMHA) or events which cause lower productivity. Three major categories, waiting for materials, searching for materials, and inefficient carrying materials were observed and generalized. These IMHA are classified into eight categories listed in Table 1.

Table 2. Identify IMHA

Category	Description
Waiting for Materials/Tools	Crew members wait for materials delivered to the installation area.
Searching Materials/Tools	Crew members search materials/tools for installation
Excessive Carrying	Crew members carry materials from another area to installation area
Double Handling	Crew members or handling machine move materials from one area to another area not for installation purpose
Improper Storage	Materials are improperly stored which makes difficult to identify, retrieval or move.
Workface Materials Congestion	Too many materials are placed in small area where installation is going on
Improper Equipment/Tool Box Positioning	Equipment, tool boxes are positioned at inconvenient areas

Quantify IMHA Impact on Tool Time

To quantify IMHA impact on productivity, this study adopts work sampling techniques-5 minutes continuous observation to measure workers' tool time by collecting large amount of samples through direct observation and recording. Previous research indicated that a liner relationship between tool time gained from work sampling data and productivity which means tool time can reflect and predict productivity (Liou and Borcherding, 1986). For example, if "Searching Materials" activity accounts for 10% of the workers' time, it indicates this activity has around 10% negative impact on productivity. Table 2 lists the IMHA time rate from 838 five-minute samples gained from the observation of a high-rise office building construction in downtown Calgary. It should be noted that the listed quantifiable IMHA categorization does not include "improper storage", "work face materials congestion" and "improper equipment/tool box positioning", because the impacts of these issues are fairly difficult to quantify using work sampling technique. Therefore, the total impact on labour productivity due to IMHA is greater then these figures.

Table 3. Quantified IMHA impact on tool time

Category	Average-Formwork Crew	Average-Scaffolding Crew
Waiting for Materials	2.68%	3.56%
Waiting for Tools	0.47%	0.385
Searching Materials	1.96%	2.46%
Searching Tools	2.30%	1.05%
Carrying Materials	5.08%	6.63%
Double Handling	1.60%	2.40%
House Keeping	2.75%	2.35%
Total	18.05%	19.10%

Summary of the Survey Results

Through analysis of the survey results, major IMHA were further identified, confirming the findings from direct observation. The impact of IMHA on productivity loss from the craftsmen's estimation was 16.7% (average), which is close to the researcher's observation at one site (18.6%). The factors causing IMHA were prioritized based on tradesmen's experience. Improper materials storage and the lack of a detailed crane schedule were the highest concerns among all the factors. Both of the results from observation and survey favour the great potential of improving productivity through minimizing the wasted time spent on IMHA.

Root Cause Analysis for IMHA

Root cause analysis (RCA) is a class of problem solving methods aimed at identifying the root causes of problems or events. The practice of RCA is predicated on the belief that problems are best solved by attempting to correct or eliminate root causes, as opposed to merely addressing the immediately obvious symptoms (Wikipedia, 2007). As the IMHA are obviously phenomenal factors causing lower productivity and materials management is a complicated issue in construction sites, the method of root cause analysis is selected to find out the "root causes" of IMHA.

Figure 1 provides a holistic map of the root causes of IMHA and their tracking process. By examining every root cause of IMHA, three main root causes are identified, namely schedule issues (including activity schedule and crane schedule), materials storage/positioning issues and contractor-supplier coordination issues. Further analysis indicates that these three factors not only individually contribute to IMHA, but also interactively impact each other (Figure 2). When the schedule changes frequently, coordination between sites and suppliers is likely to be weakened. As a result, materials are delivered at the wrong time and might be stored or staged in the places that are not close to the installation areas. Inefficient handling then occurs, and productivity drops or becomes unpredictable, which directly affects the schedule.

The intrinsic relation of these root causes requires that site material handling management focus on controlling work flow stability to maintain activity schedule, intensifying coordination with suppliers to ensure on-time materials delivery and clarifying activity sequence to optimize mapping materials site positioning (Fig 3).

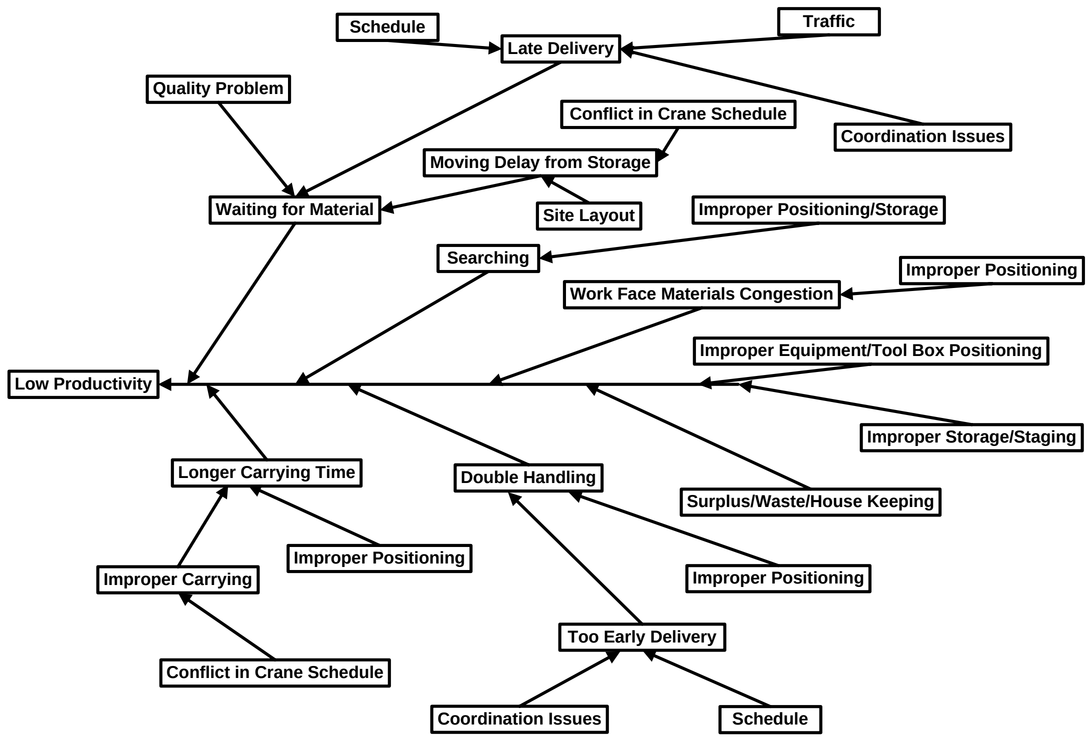


Fig 1. IMHA root causes analysis

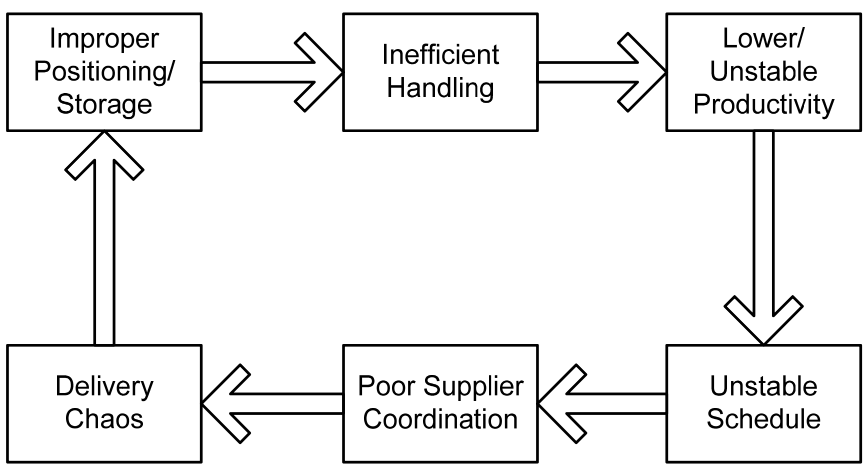


Fig 2. Relationship of the three root causes

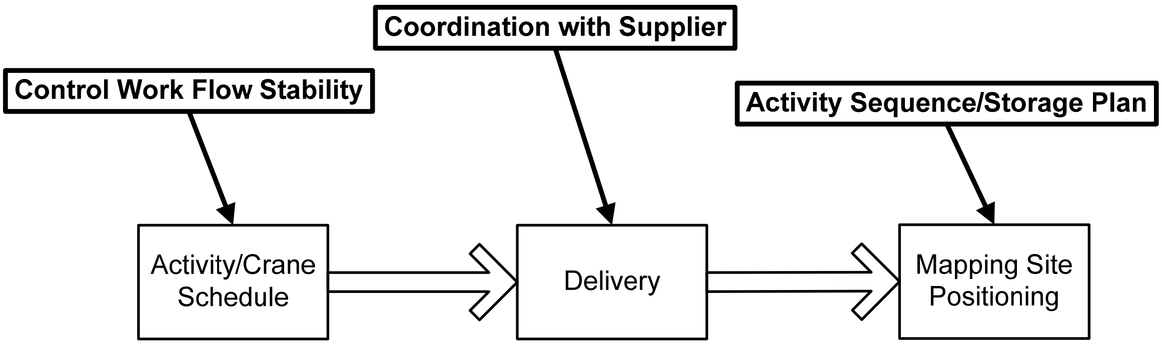


Fig 3. Focusing areas of the material management model

MODEL DEVELOPMENT AND ON-SITE VALIDATION

The result of root cause analysis requires the materials management model addresses these areas: schedule based materials requirement, up-to-date materials storage information, relevant supplier information, materials delivery schedule, detailed crane schedule and on-going workface information. The development of the materials management model follows three steps:

1. Developing a preliminary flow chart model including all the steps in materials management process.

2. Establishing a database that contains activity schedule, storage and inventory information, supplier information, and on-going workface information which can be incorporated into the process.

3. Developing a web-based interactive computer program using Active Server Pages to process the flow of information.

The model has the functionality of listing materials needs for a specific activity, providing inventory and storage area, generating purchase order, scheduling delivery, and establishing detailed crane schedule. It can also provide real time visual site information to assist storage arrangement when it connects to a wireless site camera.

The model was partially implemented on a construction site. Scaffolding materials were selected for the testing subject. Using the detailed crane schedule generated through the model, time spent on “waiting for materials”, “searching materials” and “carrying materials” were significantly reduced. Compared with the scaffolding installation before the model implementation, time was reduced from 2.5 days to 2 days by the same crew to install the same amount of scaffolds, resulting in the productivity improvement by 20%. Because of the limitation of paper length, detailed description of model development and validation are not included in the paper.

CONCLUSIONS

This paper presents a new approach in developing a materials management model from productivity improvement perspective. Ineffective materials handling activities were identified and their impact on productivity was quantified using direct site observation. By performing a root cause analysis, the causal factors of IMHA were further identified which provide focusing areas for model development. Future work of model development includes integrating existing technologies into the model, e.g. applying GPS for remote monitoring of materials delivery, using wireless handheld computer to record and retrieve data, and migrating data from activity schedule created by MS Project or Primavera.

ACKNOWLEDGEMENTS

The researchers wish to acknowledge the support and funding for this research project by Cana, PCL, Ellis Don, Graham, Ledcor, Stuart Olson, Revay & Associates, Canadian Construction Research Board, and Calgary Construction Association, and the Natural Sciences Engineering Research Council under their Collaborative Research and Development Grant # CRDPJ 299392 – 03 and CRDPJ 341047 – 06.

REFERENCES

Akintoye, A. (1995) Just-in-Time Application and Implementation for Building Material Management. *Construction Management and Economics*, 1995**,** 105-113.

Bell, L. C. & Back, W. E. (1995) Quantifying Process Benefits of Electronic Data Management Technologies. *Journal of Construction Engineering and Management,* 121**,** 415-421.

Bell, L. C. & Stukhart, G. (1986) Attributes of Materials Management Systems. *Journal of Construction Engineering and Management,* 112**,** 14-21.

Bell, L. C. & Stukhart, G. (1987) Cost and Benefits of Materials Management Systems. *Journal of Construction Engineering and Management,* 113**,** 222-234.

Liou, F.-S. & Borcherding, J. D. (1986) Work Sampling Can Predict Unit Rate Productivity. *Journal of Construction Engineering and Management,* 112**,** 90-103.

Low, S. P. & Choong, J. C. (2001) Just-in-Time Management of Precast Concrete Components *Journal of Construction Engineering and Management,* 127**,** 494-501.

O'brien, K. E. (1989) Improvement of On-Site Productivity. Toronto, K.E. O'Brien & Associates, Inc.

Thomas, H. R., Riley, D. R. & Messner, J. I. (2005) Fundamental Principles of Site Material Management. *Journal of Construction Engineering and Management,* 131**,** 808-815.

Thomas, H. R., Riley, D. R. & Sanvido, E. (1999) Loss of Labor Productivity due to Delivery Method and Weather. *Journal of Construction Engineering and Management,* 125**,** 39-46.

Thomas, H. R., Sanvido, V. E. & Sanders, S. R. (1989) Impact of Materials Management on Productivity- A Case Study. *Journal of Construction Engineering and Management,* 115**,** 370-384.

Wikipedia (2007) Root Cause Analysis. Wikipedia.

TOWARDS A CO-PRODUCTION RESEARCH AGENDA FOR CONSTRUCTION COMPETITIVENESS

Stuart D. Green
School of Construction Management and Engineering, University of Reading, UK
s.d.green@reading.ac.uk

Chris Harty
School of Construction Management and Engineering, University of Reading, UK
c.f.harty@reading.ac.uk

Recent years have seen considerable debate about the role of research in supporting construction competitiveness. Academics rightly focus on the need for theoretical contributions, but the quest for a unified theory of construction competitiveness is neither plausible nor desirable. Instead, a more pluralistic and contextualised perspective is advocated. Drawing from a three-year collaborative research project, emphasis is given to the research *process* which best supports construction sector competitiveness in the long-term. The advocated approach is positioned within current thinking on co-production research, i.e. research where academics and practitioners co-operate in the joint production of knowledge with a particular focus on the process of moving knowledge into practice. Thereafter we seek to summarise what we have learned about the way in which competitiveness is enacted by regional construction firms. Attention is given to the unbounded contexts within which innovations must be implemented. We further argue that the shaping effects of the past are too often ignored by policy makers and researchers. Finally, consideration is given to substantive topics for further research.

Keywords: competitiveness, construction sector, knowledge, research, embeddedness

INTRODUCTION

‘Sustained Competitiveness in the UK Construction Sector: A Fresh Perspective’, or the *Big Ideas* for short, is a collaborative research project involving Reading, Loughborough and Salford universities which began in April 2005. One of the commitments that we made at the outset of the *Big Ideas* project was to develop a ten-year research agenda addressing the theme of construction competitiveness. We also made a commitment to offer a ‘fresh perspective’; of particular importance was to avoid replicating the tired research agendas of the past and to attempt to offer something a little more radical and even, dare we say it, a little more theoretically informed. The purpose of this paper is to outline the scope and content that such a research agenda might entail. It must also be recognised that the research agenda needs to address the requirements of different constituents, namely (i) the research community, (ii) industry practitioners and (iii) policy makers. Different versions of the research agenda may need to be articulated to cater for the needs of these different audiences. However, the temptation to go too far down this road at the outset has been avoided. Indeed, the continuous tendency to dichotomise ‘knowledge-producers’ from ‘knowledge-users’ we find to be outdated and unhelpful. Notwithstanding this comment, there are clearly issues about the appropriateness of different forms of language for different audiences. But in the first instance it is important to formulate an overall message which is coherent, theoretically informed and yet also grounded in the empirical research that we have done over the last three years.

The paper is structured as follows. Firstly, we address the extent to which the *Big Ideas* project has contributed to a unified theory of construction competitiveness; but more importantly we rehearse the main arguments in support of our view that this is neither achievable nor desirable. We then present some of our core findings in terms of the research *process* best able to support the competitiveness of the UK construction sector in the long-term. These findings are positioned within current thinking on co-production research, i.e. research where academics and practitioners co-operate in the joint production of knowledge with a particular emphasis on the process of moving knowledge into practice. Thereafter we seek to summarise what we have learned about the way in which competitiveness is enacted by regional construction firms. Attention is also given to the unbounded contexts within which innovations are invariably implemented. We further argue that the shaping effects of the past are too often ignored by policy makers and researchers. Finally, attention is given to substantive topics for further research.

CAN WE DEVELOP A UNIFIED THEORY OF CONSTRUCTION COMPETITIVENESS?

Construction management research is frequently challenged in terms of its theoretical underpinnings and criticised for its lack of any underlying ‘unified theory’. The various literature reviews which underpinned the empirical work conducted on the *Big Ideas* project have demonstrated beyond any shadow of doubt that there is no unified theory of competitiveness *per se*, and neither is there any single theory which can be adopted to guide future work. Indeed, the empirical work has reinforced the contention that any quest for a unified theory would be misdirected. Proposals to develop unified theories invariably build on the ‘standard model’ of theorizing informed by the popularisation of Popper's (1963) philosophy of science. From this perspective, theory is seen to play a crucial role in scientific development and is crucially judged in terms of the extent to which it aids explanation and prediction. Such a world view rests on an idealized model of physics from the 1950s and 60s in which a coherent community of scientists, guided by an internally generated agenda, worked to develop a unified theory. However, it is erroneous to suggest that this model prevails across the natural sciences *per se*. Kuhn (1962) was especially influential in arguing that it is the dominant paradigm which shapes scientific production rather than any unified theory.

Within the domain of the built environment, a further problem is caused by the fact that the world does not stand still while ‘scientists’ seek to converge upon an accepted theory. Even if there were a coherent community of built environment researchers striving in this direction, their efforts would be continuously disrupted by the need to take on board externally generated ideas and policy initiatives. Examples include the continuous development of the sustainability debate and the progressive evolution of PFP/PPP and other procurement approaches. Rabeneck (2008) argues that the construction sector is perennially characterised by uncertainties about product (what to build?) and process (how to build?). Such uncertainties are seen to arise from conflicts between two conceptual frameworks that are inseparable from the construction context. The first relates to the institutionalised recipes that are inherited from the past; these govern how the process of building is organised. The second relates to the constantly evolving framework of thought that shapes what we think about buildings and the objectives that we set for the building process. This idea of conflicts arising from these two alternative conceptual frameworks coincides with the challenge throughout the *Big Ideas* project of co-ordinating between Work Package 1 (exploring the future) and Work Package 2 (how the present is shaped by the past). Significant progress has been made in populating these two frameworks with empirical data; although in both cases coverage has been incomplete and partial. Hence there is considerable further scope for populating an ongoing research agenda with the endless conflicts that arise from these two frameworks.

The rejection of any possibility of a unified theory of construction competitiveness has significant implications for the adopted research approach. From the outset, the *Big Ideas* project sought to explore the complementary use of different research approaches. At times this has been extremely challenging leading to exchanges which can best be characterised as the 'dialogue of the deaf'. Such 'paradigm wars' have of course occurred previously within the discipline of construction management (CM) (Seymour *et al* 1997; Runeson, 1997) along similar lines to those which have characterised other disciplines (cf. Rosenhead and Mingers, 2002). There is no need here to re-visit these previous debates, other than to note an emerging consensus in favour of multi-paradigmatic pluralism. Cairns (2008) summarises current thinking by advocating an 'ambivalent' approach to theorising; ambivalence in this context is not meant to imply apathy, but rather to emphasise the coexistence of seemingly incompatible states. Such ideas are increasingly recognised and debated within CM. Certainly the emphasis on multi-paradigmatic pluralism, embracing a broad variety of ontological and epistemological stances, is much more appealing that trying to adhere to any goal of 'unified theory'. What is clear is that researchers working on the *Big Ideas* project have gained valuable experience of multi-paradigmatic research, while at the same time striving to provide meaningful outputs to industry. To a certain extent, the lessons of this experience are still being absorbed, but there is little doubt that the research team is uniquely placed to comment on how methodological pluralism should be enacted within the context of the construction sector. Cairns' (2008) theoretical exposition is useful in providing a framework against which we can position our accumulated experience. Here at last is a commentary that promotes a meaningful alternative to the instrumental rationality of the Egan (1998) agenda and its subsequent imposition by powerful clients. Indeed, there is much comfort here for those of us who have long since expressed discomfort at the instrumental rationality which consistently underpins industry improvement recipes such as lean thinking (cf. Green and May, 2003). The proposed alternative is based on Flyvbjerg's (2001) notion of 'value-rationality' which seeks to question the purpose and motivations of decision-makers, ascertain the desirability of projected outcomes to different stakeholder groups and, where appropriate, to future generations of affected stakeholders. As summarised by Cairns (2008), the emphasis lies on 'interrogating the ethics of different stakeholders and making often difficult choices between competing rationalities'. This alternative position is particularly appropriate for construction because it resonates with the heterogeneity of the sector. We learned very quickly (if we did not already know) that there is no such thing as the 'construction sector'. Any responsible research agenda must clearly seek to reflect the heterogeneity of the sector and to understand the different perspectives of the multiplicity of stakeholders of which the industry comprises.

CO-PRODUCTION RESEARCH

None of the above distracts from the necessity for research which is useful to industry. The issue of industry impact has always been high on the agenda of construction academics and the *Big Ideas* project is no exception. However, in recent years the linear model of research-innovation-impact has become discredited in favour of other models which emphasise the non-linear, iterative and multi-agent character of the innovative process (Perkman and Walsh, 2007). In consequence, attention has increasingly focused on 'co-production' research whereby practitioners and academics cooperate to develop new knowledge and technologies together. More specifically, the term is used to signify the dynamic interaction between researchers and practitioners which unfolds over time. The emphasis lies on the industrial benefits derived through participating in the research *process*. It is therefore suggested that a research agenda for the future needs to be explicitly structured around the co-production of knowledge which serves the needs of two audiences: researchers and practitioners. Both must receive equal recognition.

The idea of co-production research builds on the 'Mode 2' theory of knowledge production, (or rather its 'co-production') put forth by Gibbons et al (1994). In essence, Gibbons *et al* argue that a new form of knowledge production started to emerge in the mid 20th century which they characterised as context-driven, problem-focused and interdisciplinary. Mode 2 is seen to involve multidisciplinary teams being brought together for short periods of time to work on specific problems in the real world. This is distinguished from traditional research, which Gibbons *et al* labelled 'mode 1', which they saw as academic, investigator-initiated and discipline-based knowledge production. The notion of Mode 2 research was subsequently adopted by the Royal Academy of Engineering (2000), who emphasised the need for the development of new quality assessment mechanisms to take into account the 'efficiency or usefulness' of the research as judged by a community of practitioners. They further emphasised that the results of engineering research are often heavily contextualised:

> *"…successful engineering research will produce outputs and processes that are relatively difficult to separate from the context of application in industry, government or any other section of society"*.

The point of interest here is that the CM research community, especially within the leading research centres, is increasingly cited as being an exemplar of co-production research. There are now embedded learned behaviours relating to co-production research and its enactment. Certainly, on the *Big Ideas* project we have enjoyed extensive interaction with industry and have every justification in aligning ourselves with the idea of 'context-driven' research. Traditionalists of course frequently dismiss co-production research as 'mere consultancy'. But we are not at all embarrassed if industry partners were able to derive short-term benefit from our research. Indeed, we would see this as a positive benefit. Overall, we would emphasise the importance of acknowledging the need to deliver to two audiences from the outset. Furthermore, we would concur with Maclean and Macintosh's (2002) observation that such projects are likely to be more rewarding than those which only cater for the needs of one audience.

Of particular importance to co-production research is an ongoing commitment to the feedback of emerging insights to industry partners on a variety of levels. Each request for an interview, or access to data, should be combined with a commitment to feedback the resultant findings and interpretations. The empirical research on the *Big Ideas* has been strongly characterised by this commitment, with feedback events ranging from open half-day seminars to personalised briefing for CEOs. In our experience, social-scientists and colleagues from within business schools are frequently amazed by the depth and longevity of our links with industry. A useful metaphor to describe the more established *modus operandi* within these other research communities is that of 'smash-and grab' research. Once they have the data, industry partners never hear from the researchers again as they concentrate all their energies on the production of the journal publications upon which their careers depend. Such an approach is the antithesis of co-production research.

LOCALISED LEARNING AND EMBEDDEDNESS

Empirical work on the *Big Ideas* project into the way in which regional contractors continuously respond to dynamic environments has moved forward the research agenda in this area. Existing popular theories relating to competitive advantage (Porter, 1980), the resource-based view (RBV) of competitiveness (Barney, 1991) and dynamic capabilities (Teece *et al*, 1997) have been found to be of limited use in making sense of enacted processes (Green *et al* 2008). In contrast, our case studies of regional contractors have revealed the complexities and emergent nature of how firms enact strategy in practice. This is highly dependent on the ways these firms operate within specific and local contexts, whether these are grounded in geographical regions, or particular market niches. For these firms, strategy is performed through the ways that they embed themselves within these various domains, and how this enables them to leverage specific opportunities. We believe this reaffirms the need to rethink competitiveness and competitiveness research, in terms of engagement with localised contexts, beyond generic solutions, instrumentalism and goal-orientation.

Our argument resonates strongly with the concept of *embeddedness* as articulated in the discipline of economic geography. This is derived from empirical observations that entrepreneurial and economic activity tends to be concentrated within certain locations, leading to particular configurations both regionally and by specialisation or market. The concept stresses the importance of local contexts and the social networks which constitute them. Activities such as developing the ability to recognise and act upon opportunities specific to these localised contexts (Jack and Anderson, 2002) together with gaining reputation and credibility within these contexts are central to being competitive. As Maskell *et al.* (1998) contend, competitiveness is rooted in a firm's ability to mobilise capabilities within specific domains, 'which are difficult to imitate for outsiders, and which are partly based on intense interaction between a limited number of actors within a regional or national industrial system'. This is significant for how 'unique capabilities' are developed; they are not bounded within a specific firm, but are constituted across networks. This extends firm-centric accounts of competitiveness in emphasising the ways that tacit skills, resources and capabilities are developed across organisations and, more importantly, across local and social networks.

This process of developing capabilities is one of *localised learning*; it is through on-going processes of localised learning that becoming and remaining embedded depend. It represents interactive engagement between organisations and other local stakeholders, rooted in specific contexts, which give rise to unique capabilities and opportunities. But this approach is not, intended to be presented as a panacea. There are potential problems of becoming over-embedded, which can result in over-reliance on a limited number of relational ties and key individuals and risks strategic visions becoming too entrenched and resistant to change. However, positioned as a process, rather than outcome, embeddedness and the localised learning processes which constitute it offers a new and important perspective on how competitiveness in construction is enacted.

RELATIVE BOUNDEDNESS AND CONSTRUCTION CONTEXTS

An important aspect of the notion of embeddedness is that it is not firm-centred; becoming embedded requires engagement across local contexts, and the development of relations and networks between firms. A firm cannot become embedded in isolation from wider contexts. This is a key insight developed from our studies of regional contractors within the *Big Ideas* project, and has particular resonance more generally within construction contexts, where project-based work is carried out by temporary constellations of inter-organisation actors. But this characteristic also brings challenges, especially when attempting to shift or shape current practices.

Many approaches to enacting change place a strong coordinating ‘champion’ at the centre of the process. Where such a systems integrator is present, centralised mediation can effectively steer and manage change processes. Such efforts can be seen as relatively bounded; there is a coherent centre which aligns the various parties and entities involved. But what happens if the innovation’s effects or repercussions extend beyond the control or sphere of influence of the implementer? In other words, what happens if the innovation is relatively unbounded? There is at present little research which charts how the implementation of change plays out in such circumstances. The significance of this for future research is a shift in focus from the unit of the firm to the wider networks in which particular actors and organisations are situated. Research would need to be directed at exploring the ways that relations are developed across these inter-organisational networks, and examining the interactions and negotiations mobilised over time. Such a research agenda would involve ascertaining who, or what, is being drawn into the negotiations that take place around such change processes, and who and what is being excluded.

The notion of relative boundedness accounts for the contexts in which change is enacted. This means that implementation of the same processes or techniques may be more or less bounded in one location rather than in another and hence generates different challenges and different outcomes. Considering relative boundedness avoids common assumptions that change is uncontested, always taking place within coherent and unilateral landscapes. It also brings more clearly into focus the range of context-specific pre-existing conditions and practices at which change is directed.

Within construction, the appreciation of boundedness is highly significant in terms of attempts to reconfigure sequences and practices of inter-organisational project work. Construction work shows seemingly indelible and intractable patterns such as the partial exchange of information leading to reworking, recourse to litigation, and inflexible sequences in which different actors are mobilised on a project. In such contexts the effects of implementation cannot always be tightly controlled and constrained, and extend beyond the influence of a single organisation or individual. In order to successfully innovate in such a relatively unbounded context, the cooperation or alignment of multiple actors and spheres of influence from across different organisations would be required. Considering the relative boundedness of attempts at transformation and change makes this explicit, and can thereby contribute to bridging the gaps between calls for reconfiguring construction work and detailed exploration of how change plays out in specific contexts.

CONTEXTUALIST RESEARCH

A further important touchstone for a future research agenda is provided by the tradition of 'contextualist research', which emphasises the importance of studying 'reality in flight' and of locating present behaviour in the context of its historical antecedents (Pettigrew, 2003). Few current CM researchers give significant attention to time, with the result that much of their work is an 'exercise in comparative statics'. In contrast, our research agenda would recommend that researchers follow the approach of historians to 'reconstruct past contexts, processes, and decisions' in order to discover patterns, find underlying mechanisms and triggers, and combine inductive search with deductive reason (after Pettigrew, 2003).

Such an approach has already produced alternative accounts of competitiveness as part of the *Big Ideas* project. Rather than view competitiveness as if it were a tangible, acontextual and generic entity that can be measured, benchmarked, transported and improved, it is better positioned as an emerging and evolving set of discourses and material manifestations, situated within specific contexts and historical trajectories. These temporalities are both contingent and complex. The circulation and development of policy initiatives, the legitimization and popularization of generic improvement recipes are directly implicated in shaping over time the contexts, both broad and local, within which competitiveness is constituted and performed.

The re-conceptualisation of competitiveness as an emerging discourse rather than an intrinsic characteristic of organisations has significant implications for research. It certainly questions the relevance of narrowly-construed positivist research methodologies and points towards the need to understand the unfolding complex processes through which competitiveness is enacted and legitimised. The important point for future research is that the context within which strategic decisions are made must be conceptualised as an active part of any analysis. But context is not only *shaping*, it is also *shaped* by action (Pettigrew, 1997). Issues of consideration include unpacking how contexts have been shaped over time, the relationship between language and action and the way that human agency relates to structural aspects of society. Such a research agenda would require a significant shift in theoretical orientation, together with a multitude of research skills beyond those normally mobilised in the cause of construction competitiveness. Of key importance would be the need to shift from a 'being ontology' towards a 'becoming ontology' (cf. Chia, 1995). Such a shift equates directly with a conceptualisation of competitiveness as subject to continuous processes of flux and transformation, rather than an objective characteristic that can be possessed and measured.

POPULATING THE AGENDA WITH SUBSTANTIVE RESEARCH TOPICS

Consistent with the stated commitment to co-production research is the principle of engaging industry in the setting of the research agenda. Furthermore, this is seen to be an ongoing and contextualised process, rather than something which is done at a distance. Nevertheless, on the basis of extensive engagement with a broad cross-section of industry practitioners, colleagues at Loughborough have identified a range of substantive areas which are currently of central importance to industry concerns. These include skills and skill shortages, both in terms of trades and management, issues of recruiting and retaining staff, the need for better collaborating across supply chains, and engaging clients. Similarly, specific markets have been consistently identified as important, such as homes and social housing and hospitals.

In themselves, the above topics do not especially constitute anything which is new or innovative. Furthermore, the current economic downturn is likely to have already changed industry priorities in terms of what they consider to be important. Nevertheless, it is contended that fresh insights could be developed in all these areas by the unfolding application of the research approach advocated above. Staff training becomes an issue of ensuring that individuals have the necessary capabilities to develop and sustain inter-firm social networks. Retention becomes central in keeping those social networks in place. Similarly, leveraging opportunities in specific markets such as hospitals, schools or affordable housing can be positioned as underpinned by becoming embedded into specific local networks and framework arrangements.

The *Big Ideas* project has succeeded in developing exemplar system dynamics models and exploring how they might be used to better inform decision making. There still remains significant scope for interaction with industry in terms of identifying meaningful applications. Nevertheless, several such potential applications have emerged from the workshops done to date with industry. From the outset, the use of system dynamics – and the modelling process especially – was primarily seen as a vehicle for the development of learning and social coordination (de Geus, 1994; Vennix, 1996). As such, the enactment of system dynamics modelling is entirely consistent with the principles of co-production research. However, the communication of the core ideas of system dynamics to construction sector audiences has consistently presented a challenge, and the degree of engagement originally envisaged between modellers and construction practitioners has been difficult to achieve. But the introduction of new ideas, and new ways of thinking is never easy and the models developed to date by colleagues at Salford University have undoubtedly established proof of concept. Future research opportunities lie in the development of models to allow a comparative process analysis between different procurement approaches. Related to this is the exploration of the dynamic effects of the way in which clients decide to package their projects. Further opportunities are provided in terms of better informing contractors' project selection strategies. For example, what are the consequences of targeting a larger number of smaller projects rather than targeting a smaller number of large projects? Such decisions are of central importance to contracting firms, and yet decision support algorithms are few and far between.

The final potential topic for the proposed research agenda relates to the nature and benefits of co-production research itself. Current thinking within policy domains tends to focus on *links* between universities and industry, but the concepts of open, networked and interactive innovation suggests that *relationships* play a more important role (Perkman and Walsh, 2007). In the context of construction-related research, little is known about the nature of such relationships, how they arise, how they are maintained over time and the effects they have on the innovation process. This in itself would constitute a significant research agenda for several years to come.

ACKNOWLEDGEMENTS

This paper is the product of a collaborative project also involving the universities of Loughborough and Salford. Particular mention should be made of Simon Austin & Andy Dainty from Loughborough and Brian Dangerfield & Peter McDermott from Salford. Thanks are also due to Graeme Larsen and Chung-Chin Kao from the University of Reading.

REFERENCES

Barney (1991) Firm resources and sustained competitive advantage. *Journal of Management*, **17**(1), 99-120.

Cairns, G. (2008) Advocating an ambivalent approach to theorizing the built environment. *Building Research and Information*, **36**(3), 280-289.

Chia, R. (1995). From modern to postmodern organisational analysis. *Organization Studies* **16**(4): 579-604.

Egan, J. (1998) *Rethinking Construction*. Report of the Construction Task Force. London: DETR.

Flyvbjerg, B. (2001) *Making Social Science Matters: Why Social Enquiry Fails and how it can Succeed Again.* Cambridge: Cambridge University Press.

Gibbons, M., Limoges, C., Nowotny, H., Schwartzmann, S., Scott, P. and Trow, M. (1994). *The New Production of Knowledge: The Dynamics of Science and Research in Contemporary Society*. London: Sage.

de Geus, A. P. (1994) Modeling to predict or to learn? In Morecroft, J.D.W. and Sterman, J.D. (eds) *Modeling for Learning Organizations*, Portland, OR: Productivity Press.

Green, S. D. and May, S.C. (2003) Re-engineering construction: going against the grain, *Building Research & Information*, **31**(2) pp97-106.

Green, S. D., Larsen, G. D. and Kao, C. C. (2008) Competitive strategy revisited: contested concepts and dynamic capabilities, *Construction Management and Economics*, **26**(1) 63-78.

Jack, S. L. and Anderson, A. R. (2002). The effect of embeddedness on the entrepreneurial process. *Journal of Business Venturing* **17**: 467-487.

Kuhn, T. S. (1962) *The Structure of Scientific Revolutions*. Chicago: University of Chicago Press.

Maclean, D. and Macintosh, R. (2002) One process, two audiences; on the challenges of management research. *European Management Journal*, **20**(4), 383-392.

Maskell, P., Eskelinen, H., Hannibalsson, I., Malmberg, A. and Vatne, E. (1998). *Competitiveness, Localised Learning and Regional development*. London, Routledge.

Perkman, M. and Walsh, K. (2007) University-industry relationships and open innovation: towards a research agenda, *International Journal of Management Reviews*, **9**(4), 259-280.

Pettigrew, A. M. (2003) Strategy as process, power, and change. In Cummings, S. and Wilson, D. (eds) *Images of Strategy*, Blackwell Publishing, pp. 301-330.

Pettigrew, A. M. (1997) What is a processual analysis? *Scandinavian Journal of Management*, **13**(4), 337-348.

Popper, K. (1963) *Conjectures and Refutations: the Growth of Scientific Knowledge*. London: Routledge and Keegan Paul.

Porter, M. E. (1980). *Competitive Strategy - Techniques for Analysing Industries and Competitors*. New York, Free Press.

Rabeneck, A. (2008) A sketch-plan for construction of built environment theory. *Building Research and Information*, **36**(3), 269-279.

Rosenhead, J. and Mingers, J. (eds.) (2001) *Rational Analysis for a Problematic World Revisited*, 2nd edn., Wiley: Chichester.

Royal Academy of Engineering (2000) *Measuring Excellence in Engineering Research*, London: RSA.

Runeson, G. (1997) The role of theory in construction management research. *Construction Management and Economics*, **15**(3), 299-302.

Seymour, D., Crook, D. and Rooke, J. (1997) The role of theory in construction management: a call for debate. *Construction Management and Economics*, **15**, 117-119.

Teece, D. J., Pisano, G. and Shuen, A. (1997). Dynamic capabilities and strategic management. *Strategic Management Journal* **18**(7): 509-533.

Vennix, J. A. M. (1996) *Group Model Building: Facilitating Team Learning using System Dynamics*, Wiley: Chichester.

CONSTRUCTION SITE MANAGEMENT TEAMS AND PROJECT PERFORMANCE MEASUREMENT

Dr. Stuart Tennant
School of Engineering & Science, UWS, Hamilton, UK
stuart.tennant@uws.ac.uk

Prof. David Langford
School of the Built and Natural Environment, Glasgow Caledonian University, Glasgow, UK
David.Langford@gcal.ac.uk

Dr. Michael Murray
Department of Civil Engineering, University of Strathclyde, Glasgow, UK
m.d.murray@strath.ac.uk

The volume of team literature is testimony to the organisational appeal of team working. The notion that team compositions cultivate from group origins is widely respected within team management theory. Within the UK construction industry the team ideal rarely extends beyond a casual interpretation that may be more accurately expressed as group work. Although a definitive definition of a team is elusive, research suggests it may be best articulated in terms of performance outcomes. A performance measurement framework for both site management teams and construction project performance is established within an overarching team-performance management model. Analysis is undertaken to empirically evaluate the correlation between the two variables. The results establish a team performance benchmark for future education and training of site management team compositions. Key threats and opportunities for the attainment of high performance teams and enhanced project performance are identified and a measurement template established that others can use.

KEYWORDS: Teams, Project Performance, Key Performance Indicators, Performance Management.

INTRODUCTION

A fundamental feature of management thinking in recent times has been teams and team working, (McCabe and Black, 1997). This observation has a particularly resonance for the UK construction industry. Firstly, the construction industry is extremely important to the UK's economic well-being, not only in fiscal terms but also on society in general. Industry contribution to Gross Domestic Product (GDP), Gross Value Added (GVA) and employment positions the construction industry as a strategic barometer of economic and domestic well-being, (Dti, 2005). Secondly, "teamwork is an inherent part of construction work and seen as one of the major factors in success," (Raiden et al, 2006). As a consequence it could be argued that the realisation of a sustainable socio-economic environment may be strengthened by improving the performance of the UK construction sector. Over the past decade raising the performance of the construction industry has been the ambition of several government initiatives, (Leiringer et al., 2005). One of the recurring themes to stem from the various reports has been the better utilisation of team working philosophies, (Latham, 1994; Egan, 1998 and Egan, 2002). The reports identified team working as a primary tenet of a successful UK construction industry operating in a highly competitive global market. The formation of high performance team working in an industry closely aligned with socio-economic indicators may have far-reaching benefits that extend beyond organisational and industry boundaries.

The Research Rationale

The research rationale aspires to address an observation made by Katzenbach and Smith (1993) in their seminal team article ‘The Discipline of Teams’; “the difference between teams that perform and other groups that don’t is a subject to which most of us pay far too little attention.” A ‘measured’ investigation of the team – performance relationship may elicit positive virtues that would be beneficial for the management of teams in the workplace. For this particular research, construction site management teams.

TEAM WORKING

Team and team working are familiar expressions. Regardless of their popularity in daily conversation a precise meaning of the term remains elusive. Dictionary definitions only communicate a casual interpretation of the team ideal. Whilst a generic use of team terminology may represent a societal need for expressing collaborative activity, within a business model, laissez-faire team rhetoric may dilute the very essence of team-oriented tasks. Vague team classifications will only support ‘lazy’ management in the creation of ‘name-only’ teams and with it carries the danger that teams and team working will lose all meaning, (Procter and Mueller, 2000). Already corporate language uses the term group and team synonymously, drawing little or no distinction between the two expressions, (Fisher et al., 1997; Belbin, 1997). The notion that team compositions cultivate from group origins is widely respected within team management theory. Published in 1965, Bruce Tuckman’s universal sequential ‘group-to-team’ transition model of ‘forming, storming, norming and performing’ is an important point of reference for the majority of today’s’ contemporary group studies. The model culminates with the group developmental stage ‘performing’. This suggests that the transformation from group to team classification may be judged in terms of performance levels achieved. For some, the link with performance is absolute. In the article, “The Discipline of Teams,” Katzenbach and Smith (1993) state that “teams and good performance are inseparable; you cannot have one without the other.” This declaration suggests that regardless of factors influencing the human, organisational and environmental backdrop; the definitive definition of a team may best be articulated in terms of a performance outcome. As a result, team working can be characterised in terms of working collaborations that demonstrate satisfactory levels of performance achievement. They may be described as ‘true’ teams; collaborative compositions that fail to demonstrate acceptable levels of performance may be more accurately defined by the term ‘group’.

PERFORMANCE MANAGEMENT

Interpretation of organisational performance is contingent upon the contextual constraints of a particular situation. While performance is principally outcome orientated it can signify different things to different people. Historically, organisational performance criterion has focused first and foremost on the financial aspects of business achievement, (Crowther, 1996). Over the years a number of criticisms have been levied at the cost-accounting approach to performance management. Monetary data reflects operational competence "emphasising economy and efficiency and neglecting measures of customer satisfaction and quality," (Open University, 2001). Lagging indicators typified by financial accounting systems are better at measuring the consequences of yesterday's decisions than they are at indicating tomorrow's performance, (Eccles, 1991). This viewpoint is supported by Kaplan and Norton (1993), who have written extensively on the shortcomings of traditional accounting systems. Contemporary management thinking has embraced performance an all-inclusive, holistic concept, amalgamating 'hard' and 'soft' standards of measurement. The "hard measures are those which are quantifiable, such as profit and market share, while soft measures include innovation and flexibility," (Ingram, 1996). These emergent ideologies coupled with continued development in quality management provide construction companies with an opportunity to engage with and measure best practice principles.

Performance Management of Teams

Team working is a long-established practice and in recent times its popularity has grown in direct response to changes in organisational outlook, (Staniforth, 1996). Traditionally corporate conviction in team working was operational, used to secure improvement in both productivity and morale. Today the application of team values has been given a strategic status, endorsed as a business philosophy that has the potential to remodel an array of organisational processes. The paradigm shift in corporate interpretation of team ideals has unquestionably tied the wider business interests to the performance of teams. That said it is surprising to discover that at present there is limited research literature on team performance management, (Armstrong and Baron, 1998; Staniforth, 1996; Telleria et al., 2002). This may suggest that the resurgence in team theory and subsequent utilisation within the workplace has outpaced the traditional performance management support mechanisms. They are now becoming increasingly obsolete. The omnipresent contradiction in management rhetoric, advocating team working on the one hand and appraising only the individual on the other may be indicative of a wider underlying cultural and organisational conflict between the behaviour management desire and the behaviour management reward. Staniford (1996) recognised that many UK organisations have not yet appeared to have broken the shackles of an individualistic approach to work.

METHODOLOGY

The principal aim of the research is to empirically test the presumption that teams and performance are inter-dependent variables. In an effort to promote analytical consistency and confidence in research outcomes it is imperative to clearly identify the research parameters.

Team Variables

A literature review of team theory identified seven recurrent key variables deemed necessary for the accomplishment of a 'true' team ethos. The key success variables are prearranged under three distinctive categories. The first category, Group Compatibility and Diversity refers to the intra-team dynamics of the individual and the group. The variables include 'inter-dependency', 'group diversity', 'team dynamics' and 'trust'. The second category refers to Organisational Context, examining the inter-relationship between the site-based participants and the wider corporation. Team variables include 'corporate intent' and 'policy, procedures and customs'. The third category, Industry Context, with the team variable 'culture' has been included to capture latent facets of established industry conventions and behaviour, functional and dysfunctional that pervade and characterise construction conduct.

Team Metrics

Teams come in many guises and therefore team demarcation was crucial. Team member participation for the research programme was restricted to site-based construction professionals, employed full-time by the sponsor contractor and working under the direct leadership of the construction project manager. The evaluation of perceived team working is best suited to an attitude statement questionnaire. A 'team rating' team member questionnaire was developed. The questionnaire had seven sections, one for each variable identified and five statements per variable. The team member was asked to answer to all thirty-five statements, selecting only one response from a set of five predetermined options. The options were; completely true, mostly true, partly true, slightly true and never true. Although qualitative in its conceptual origins the questionnaire response was later quantified by applying a Likert scale of 1 (never true) to 5 (completely true). Each of the seven team variable scores were collated and calculated as a team variable percentage rating. The percentage ratings are then plotted and illustrated on a radar chart. In addition to the seven team variables, a mean team variable rating was calculated and presented as an overall collaborative appraisal of construction site management team performance.

Performance Metrics

Construction project performance measurement has a more tangible aspect to the quantification of data. It was a key consideration to develop a project performance measurement model that was holistic in nature and compatible with recent developments in the management and measurement of construction activity. One of the most prominent contemporary performance management frameworks is the Kaplan and Norton's Balanced Scorecard. Kaplan and Norton's Balanced Scorecard outlines a performance template that is structured around four different business perspectives, namely; financial, external, internal and innovation and learning. The financial perspective is traditionally viewed as a 'lagging' measure. Providing a snapshot of past results primarily founded on monetary data. The other three perspectives may be considered as 'leading' measures. The function of 'leading measures' is to provide a potential insight of organisational attributes that may significantly influence future performance. For the purpose of the project performance measurement seven Key Performance Indicators, four from the 'Economic - All Construction' KPI's and three from 'Respect for People' KPI's were selected for inclusion within the balanced scorecard framework. The resultant project performance research selection model assimilates current Key Performance Indicators (Constructing Excellence, 2004) with Kaplan and Norton's Balanced Scorecard to produce a customised suite of 'Pan-Project' Performance Indicators. The working definitions of the KPI's selected conform to best practice initiatives advocated and endorsed by Constructing Excellence in the Built Environment. In addition to the seven individual KPI's, a mean project performance score was calculated and presented as an overall measurement of construction project performance. The calculation of a mean project score aligned with the evaluation of a mean team rating creates a unique opportunity to investigate the correlation between construction site management team working and project performance across a number of construction case-studies.

Project Case-Studies

The operational merits of a case-study offer an obvious and pragmatic method to test the assertion that team work and project performance are related. Data from a cross-section of construction site management teams sampled from different UK construction companies facilitate the examination of project, corporate and industry team performance trends. To support the validity and reliability of the case-study results and in an attempt to minimise sources of 'contamination' the focus of assessment is specific, namely team working and project performance. The case-study and data collection phase of the research project was carried out between June 2004 and April 2005. The research data compilation involved the cooperation of three major UK construction contractors, (Company B, C and D) and involved the participation of thirteen individual construction project case-studies. In total eighty two research questionnaires were completed and returned. This included fifty six 'Team Member' questionnaires', thirteen 'Team Member / Team Leader' questionnaires and thirteen 'Client / Client Representative' questionnaires. The response rate for 'Team Member' questionnaires was 96%. The response rate for both 'Team Leader' questionnaires and 'Client / Client Representative' questionnaire was 100%. All KPI scores have been calculated using Constructing Excellence in the Built Environment KPI Pack 2004.

RESULTS

The results of the construction project case-studies have been ranked in order of team rating. In the first instance the highest to lowest team rating corresponds with their associated project performance score, (see Table I). If the team rating is of an equal value the league position is determined using the highest project performance score.

Table I. Project League Table based on Team Rating

Rank	Project Id.	Team Rating (x)	Project Performance (y)
1st.	Project C/1	80% (rank 1st.)	70% (rank 2nd.)
2nd.	Project D/4	79% (rank 2nd.)	74% (rank 1st.)
3rd.	Project C/2	77% (rank 3rd.)	59% (rank 5th.)
4th.	Project D/2	77% (rank 4th.)	42% (rank 10th.)
5th.	Project D/3	76% (rank 5th.)	63% (rank 3rd.)
5th.	Project B/5	74% (rank 6th.)	61% (rank 4th.)
7th.	Project B/1	72% (rank 7th.)	54% (rank 7th.)
8th.	Project D/1	72% (rank 7th.)	40% (rank 11th.)
9th.	Project D/5	70% (rank 9th.)	59% (rank 5th.)
10th.	Project B/4	70% (rank 9th.)	43% (rank 9th.)

11th.	Project C/3	69% (rank 11th.)	39% (rank 12th.)
12th.	Project B/2	68% (rank 12th.)	48% (rank 8th.)
13th.	Project B/3	62% (rank 13th.)	29% (rank 13th.)

To test the core research hypothesis, (H_o: $\mu_1 = \mu_2$) a number of statistical investigations have been undertaken. A Pearson's Correlation Coefficient for the two variables, team and project produced a positive value of +0.8, indicating a strong, marked level of association. A Spearman Rank Correlation Coefficient was calculated at +0.70, although marginally less than the Pearson's value the outcome does support the initial finding. A Kendall tau rank coefficient of concordance also produced a marked level of agreement (+0.60) corroborating with the earlier findings. The team / project league table highlights three exact matches, Project(s) B/1, B/4 and B/3 are ranked 7th., 10th. and 13th. respectively. There are three projects one position out of synchronisation, namely Project(s) C/1, D/4 and C/3 are ranked 1st., 2nd., and 11th. respectively. The top two team ratings align closely with their project performance ranking and two of the bottom three team ratings align in a similar fashion with their associated project performance position. Four of the top five team ratings all align within two places of their corresponding project performance ranking. To better appreciate the correlation between team 'performance' and their corresponding project 'performance' a Team Rating / Project Performance Scattergram (see Figure 1) has been produced.

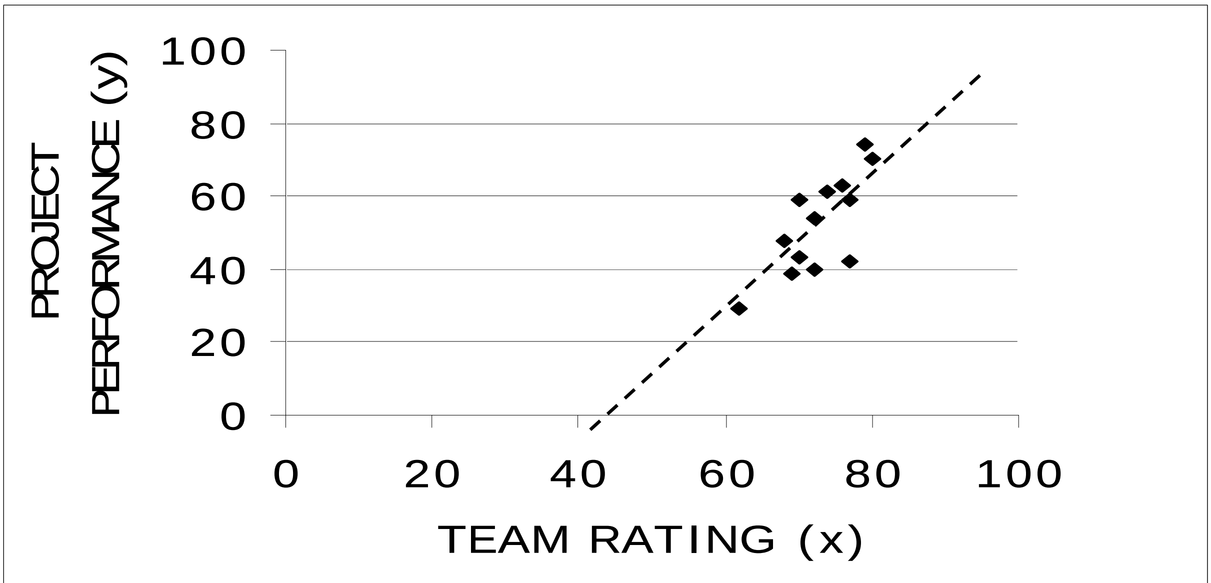


Figure 1. Team Rating / Project Performance Scattergram

From the scattergram it can be seen that in response to an increase in team rating (x) there is a resultant increase in the project performance (y). The Spearman Rank Correlation Coefficient (rs) was used to test the null hypothesis, H_o: x and y are independent variables against H_A: x and y are positively correlated. For a sample size of 13 and $\alpha = 0.05$, H_o would be rejected if the calculation produced a value of $rs \geq 0.480$ (obtained from Spearman Rank-Correlation Coefficient tables). The calculation shows that $rs = 0.692 \geq 0.480$ and therefore the null hypothesis is rejected in favour of H_A. To summarize, team rating (x) and project performance (y) are positively correlated with a 95% level of confidence.

DISCUSSION

The set of results spread across the thirteen construction projects illustrates some interesting findings. Some of which may have been predictable. Key team variables such as interdependency and team dynamic rated highly across the majority of the projects. Functional, hands-on leadership, small team numbers and clearly defined professional responsibilities probably helped contribute to a strong interaction between all site members. At the other end of the spectrum the team variables that consistently recorded below average ratings were ‘corporate intent’ and ‘membership diversity’. Membership diversity may also be considered foreseeable. For an industry driven by unpredictable ‘availability’, the alignment of people and projects would appear to be a continual challenge for construction management. The upshot is that limited consideration appears to be given to the concept of balanced teams in terms of function and personality. Questionnaire responses endorse this observation with an overwhelming majority of team members stating that they have never partaken in any inventory of team member analysis or psychometric profiling. Team member feedback on the influence of corporate intent raises some interesting challenges for team working. Corporate intent recorded the lowest overall mean rating. Combined with a lower than average rating for the team variable ‘policy, procedure and custom’, the organisational relationship between the site management group and the parent organisation is singled out as a potential barrier to the fulfilment of team working practices. Further discussion concentrates on the causes of organisational dissonance and the importance of organisational fit between project-based team structure and corporate strategy.

Human Resource Management

In terms of corporate homogeneity and organisational compatibility a key department of influence is arguably Human Resource Management (HRM). It is widely recognised that HRM policy broadly falls in to two distinct schools of thought, the ‘hard’ school and the ‘soft’ school. The soft model recognises employees as valued assets and a source of competitive advantage. The hard approach adopts an unapologetically commercial perspective of labour as a commodity, (Marchington and Wilkinson, 2002). In this guise a number of criticisms have been levied at HRM policy within the construction sector. Green (2002) in a critical examination of HRM policy observed that “there is an established dichotomy in the HRM literature between the ‘hard’ model, reflecting utilitarian instrumentalism, and the ‘soft’ model reflecting developmental humanism.” The review concluded that within the UK construction industry the ‘hard’ model of HRM policy was in most cases the ‘default’ model adopted by the majority of construction companies. Under these circumstances the introduction of a team management philosophy would appear to contradict some of the core values associated with a ‘hard’ HRM policy. On the one hand there is a potential for enhanced performance output that is likely to satisfy the ideology of greater economic efficiency. On the other hand the majority of current HRM policy is individualistic in nature with relatively few organisations making any specific arrangements for team performance management, (Armstrong, 2004). A collectivism approach to managing people would be central to the successful adaptation of a team performance criterion. To achieve an HRM – organisational fit, construction companies would be required to modify existing HRM doctrine. In practice this may ‘soften’ HRM policy, amalgamating the ‘utilitarian instrumentalism’ currently practiced with a measure of humanistic persuasion. Realigning HRM policies with a more altruistic standpoint, developing team pay initiatives as well as promoting good communication systems all present opportunities for better team management and enhanced team performance in the workplace. Two managerial issues foremost in the research findings were the existence of communication 'gatekeepers' and contradictory reward management practice.

Formal Communication

The problem with corporate intent is communication. During discussions with senior management, responsible in part for disseminating company strategy to site managers and supervisors, it became apparent that senior managers communicated on a one to one basis with the various site project managers. In turn the project managers became the 'gatekeepers' of the information and it was at their discretion, regardless of senior management expectations; when, how or if the information was broadcast. For some project leaders it was apparent that the link between corporate strategy and the site management team contribution to the success of the bigger corporate picture was less significant when prioritised against the short-term demands of project cost, time and specification. For all three companies the organisational structure and the position of the project leader as a 'buffer' between the 'wider' organisation and the site team meant communiqués important in meaning to senior management were filtered and edited for site management team briefings. The corporate intent variable may benefit from more frequent communication with senior management talking directly to the site teams. This would capitalise on the sense of corporate unity, promote a stronger, more visible senior management presence and simultaneously remove an unintentional communication 'gatekeeper'. Improved and frequent formal communication would increase the likelihood for the effective dissemination of corporate intent and help convey the increasingly strategic role played by site management teams.

Reward Management

The assertion is a simple one. Not to reward the behaviour your organisation desires will only compound existing misconceptions of corporate intent. This is reflected in the team member response to the questionnaire. The majority of team members questioned felt that there was little or no explicit policy linking individual pay to the collective efforts of the site team. It was evident that a team reward for enhanced project performance was not common policy. The solution for this type of organisational misfit between collectivism and individualism resides with senior management and HRM. Where reward management of team performance remains the exception rather than the rule a contradiction in terms of strategy (team work) and tactics (the individual) will persist. The disparity between working ethos and remuneration may provide the catalyst for addressing deep-rooted problems of organisational mismatch. Motivating the group unity via a team reward system has the potential to reinforce the need for a common agenda and encourage participation in collaborative working practices. Team rewards "may also be more effective in making the link between the individual team member and the wider concerns of both the team and the organisation as a whole," (Thompson, 1995). In other words the implementation of team rewards will communicate a corporate allegiance to genuine team-based strategies.

CONCLUSION

The debate that better performing teams will consistently produce better performing projects is always going to be contentious. The argument is inherently complex and depends much on the definitions adopted for both the team rating and corresponding performance measurement. Notwithstanding the many imperceptible and elusive facets that interminably infuse the field of behavioural sciences the resultant research programme has produced a compelling series of findings. Statistical evidence validates, with a significant degree of confidence, the widely held belief that the team works, “teams and good performance are inseparable, you cannot have one without the other,” (Katzenbach and Smith, 1993). The resultant team-performance diagnostic toolkit is not another team building programme. On the contrary, it is a management model with the potential to provide an objective measure of site management team performance. Traditional team building initiatives address the question of team performance whereas the innovative team-performance model addresses the question of team management capacity. The results establish a team performance benchmark for the future education and training needs of site management team compositions. The ability to identify, measure and challenge explicit aspects of team synergy provides opportunities for further developments within the team management theme, principally performance management and human resource management. In conclusion two notable contributions have been made to construction management research: first, empirically testing the construction site management team - project performance relationship; and second, creating a methodology and a team - performance template that others can use.

REFERENCES

Armstrong, M. (2004), “Employee Reward”, 3rd. Edition, Chartered Institute of Personnel and Development, London.

Armstrong, M. and Baron, A. (1998), “Performance Management – the new realities”, Institute of Personnel Development, London.

Belbin, M. (1997), “Team Roles at Work”, Butterworth-Heinemann, Oxford.

Constructing Excellence, (2004), “KPI Pack 2004”, Dti, London.

Crowther, D.E.A. (1996), “Corporate performance operates in three dimensions”, Managerial Auditing Journal, Vol. 11/8. pp. 4–13.

Dti, (2005), “Construction Sector Unit Annual Report 2004 / 2005”, HMSO, London.

Eccles, R. G. (1991), “The performance measurement manifesto”, Harvard Business Review, Jan / Feb. pp. 131–137.

Egan. J. (2002), “Accelerating Change”, Strategic Forum for Construction, HMSO, London.

Egan, J. (1998), “Rethinking Construction”, HMSO, London.

Fisher, S.G., Hunter, T.A. and Macrosson, W.D.K. (1997), “Team or group? Managers’ perceptions of the differences”, Journal of Managerial Psychology, Vol. 12. No. 4, pp. 232–242.

Green, S.D. (2002), The Human Resource Management Implications of Lean Construction: Critical Perspectives and Conceptual Chasms, Journal of Construction Research, Vol. 3. No.1, pp. 147–165.

Ingram, H. (1996), "Linking teamwork with performance", Team Performance Management – an international journal, Vol. 2 No. 4. pp. 5–10.

Kaplan, R.S. and Norton, D.P. (1993), "Putting the balanced scorecard to work", Harvard Business Review, Sept / Oct. pp. 134–147.

Katzenbach, J. and Smith, D. (1993), "The Discipline of Teams", Harvard Business Review, March / April, pp. 111–120.

Latham, M. (1994), "Constructing the Team", Final report of the Government / Industry review of procurement and contractual arrangements in the UK construction industry, HMSO, London.

Leiringer, R., Fernie, S. and Ramboll, N.S. (2005), "Adopting Partnering in Sweden: A Critical Perspective", CIB W65 Conference Proceedings, Vol. 7. pp. 42-53.

McCabe, D. and Black, J. (1997), "Something's gotta give: trade unions and the road to team working", Employee Relations, Vol. 19 No. 2, pp. 110–127.

Marchington, M. and Wilkinson, A. (2002), People Management and Development – Human Resource Management at Work, Chartered Institute of Personnel and Development, London.

Open University, (2001), "Best Practice Benchmarking", The Open University, Milton Keynes.

Procter, M. and Mueller, F. (2000), "Teamworking: strategy, structure, systems and culture", in Procter, M. and Mueller, F. (Eds.) Teamworking, MacMillan Press Ltd. London.

Raiden, A.B., Dainty, A.R.J. and Neale, R.H. (2006), "Balancing employee needs, project requirements and organisational priorities in team deployment", Construction Management and Economics, Vol. 24. pp. 883-895.

Staniforth, D. (1996), "Teamworking, or individual working in a team", Team Performance Management: an international journal, Vol. 2. No. 3. pp. 37-41.

Telleria, K.M., Little, D. and MacBryde, J. (2002), "Managing processes through teamwork", Business Process Management, Vol. 8. No. 4. pp. 338–350.

Thompson, M. (1995), "Team Working and Pay", The Institute for Employment Studies, Report 281, IES.

Tuckman, B.W. (1965), "Developmental Sequence in Small Groups", Psychological Bulletin, Vol. 63, pp. 384-399.

VALUE MAPPING FOR URBAN INFRASTRUCTURE PROJECTS: MAPPING PROJECT OUTCOMES TO CORPORATE OBJECTIVES

Judy Kraatz
CRC Construction Innovation, Queensland University of Technology, Australia
j.kraatz@qut.edu.au

Professor Stephen Kajewski and Dr Karen Manley
Faculty of Built Environment and Engineering, Queensland University of Technology, Australia
s.kajewski@qut.edu.au and k.manley@qut.edu.au

Current research, in conjunction with the Cooperative Research Centre for *Construction Innovation* (Australia), is investigating the role of greater corporate responsibility in the provision of urban infrastructure projects. This paper reports on doctoral research which is enabling project teams to better identify and align project objectives with corporate objectives, thus assisting in managing future risk and possible ecological and social harm.
The research methodology in use is based on Checkland's soft system methodology, engaging in action-research with Brisbane City Council (Australia) on three case study projects. Key findings of the collaborative case studies include:

- Linking project objectives to corporate objectives provides greater decision-making transparency; increased rigor in establishing objectives; and greater awareness of project opportunities.
- Using an iterative process to identify the project's stakeholder footprint and accountabilities, at the pre-feasibility phase, can better inform the subsequent project phases.
- Developing project indicators, measureables and targets, linked to corporate objectives can enhance decision-making transparency and communication.

KEYWORDS: corporate responsibility, value mapping, major economic infrastructure projects, construction innovation

INTRODUCTION

The aim of this current doctoral research is to develop a value mapping framework for major economic infrastructure projects for the Australian public sector. This will assist those delivering such projects to better identify and align project objectives with stated corporate objectives, values and outcomes, and to assist in managing medium to long term risk and minimise possible ecological and social harm.

A review of literature relevant to this paper has been previously published (Kraatz, Kajewski and Manley 2008, pp.4-5). Key outcomes of this research include the development of a framework which provides enhanced understanding of project accountabilities and the project's stakeholder footprint; greater decision-making transparency; increased rigor in establishing and tracking project objectives; and increased awareness of project opportunities beyond the traditional scope of the project's budget and contractual arrangements.

THE RESEARCH METHODOLOGY

This academic basis for this research derives from the fields of both corporate responsibility and lean thinking. The value maps which are the outcome of this research integrate tools from both areas, into a single framework appropriate for application in the construction sector. This value-mapping framework addresses issues related to value as expressed by Emmitt et al (2005, p.59). The authors provide a clear distinction between the differing types of value, and how it can be interpreted by different players in different situations. “The distinction between client values as the focus and end goal of our efforts and internal values of the delivery team is made... The external value is separated into (i) process value and (ii) product value. Process value is about giving our customers the best experience during the design and construction of the project. It comprises:

• ‘Soft values’ such as work ethics, communication, conflict solving etc. between the client and the delivery team.

• ‘Hard values’ such as the delivery teams ability to keep agreed time limits, cost estimates, quality of the product and workers safety etc.”

An understanding of this interpretation of value is an important basis for implementing this framework.

The research methodology underpinning this work is based on Checkland’s soft system methodology (SSM) (1984, 2000). The approach adopted involves engaging in an action-research based relationship with an Australian public sector agency on selected major economic infrastructure case study projects. Checkland’s SSM research cycle was used as the basis for identifying a real world problem (i.e. how to track project deliverables back to corporate objectives) and then progressing through a series of structured steps, involving engagement and evaluation in a real world context.

In this context, three practice-based case studies have been undertaken, by way of ‘exploration’, ‘testing’ and ‘implementation’ of the value mapping framework. Dul and Hak (2008, p.23) discuss the distinctive role of practice-based case studies as those which “describe the design, implementation and/or evaluation of some intervention, or illustrate the usefulness of a theory or approach to a specific company or situation. Although such studies might make use of theories or theoretical notions, their aim is not to contribute to the development of those theories. We use the label "practice-oriented" for this category of case studies.”

The ‘exploratory’ case study, the Eleanor Schonell Bridge, Brisbane, Australia (Case 1), was part of the initial action-planning phase, in which the conceptual model for both the process maps and the value mapping framework was developed. The ’test’ case study, the Hale Street Link, Brisbane, Australia (Case 2), was the initial action-taking phase wherein the draft models were applied to a real-life situation to test the framework. The final ‘implementation’ case study, the Northern Link, Brisbane, Australia (Case 3), then enabled the learnings the both these case studies to be applied as part of a second round of action-taking, prior to a final evaluation of the framework wherein key findings and learnings will be considered. Final evaluation will be undertaken based on reflections by the researcher; formal feedback from those involved in the collaboration, and through discussions with other agencies as the applicability of the framework to their program/sector. Figure 1 illustrates how the SSM has been adapted for the purposes of this research.

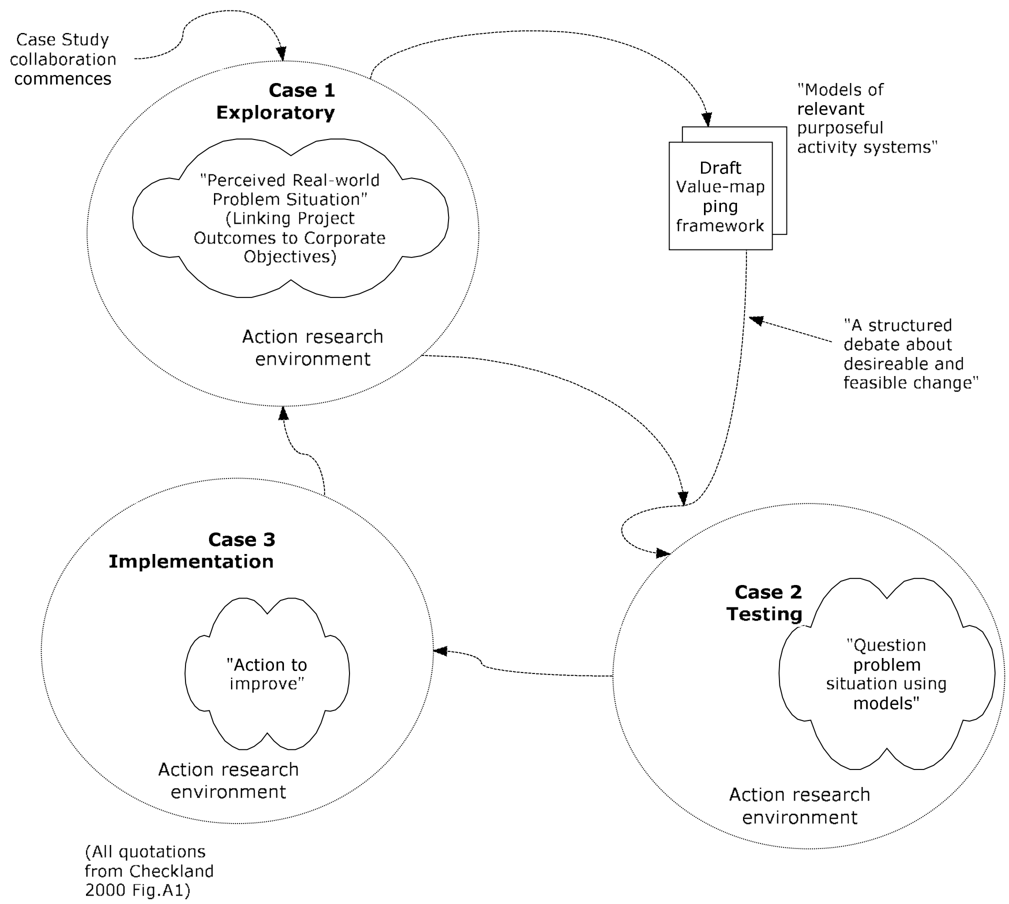


Figure 1 - Value mapping framework development cycle (Adapted from Checkland 2000, p.S16)

Prior to detailed work on the three case studies it was necessary to study the corporate context in which the case study projects were being delivered. This was needed to develop an understanding of the corporate responsibilities and values that guide decision-making, and the linkages between the corporate structure and the sub-agency delivering the infrastructure projects. The project proponent for each of these projects was the Major Infrastructure Projects Office (MIPO) of Brisbane City Council (BCC), Australia. The highest level of corporate objectives within this agency are the eight themes of the Living in Brisbane 2026 (LiB2026) statement. These themes are Accessible City, Active and Healthy City, Sub-tropical City, City of Inclusive communities, Clean and Green City, Creative City, Regional and World City and Smart and Prosperous City. These themes are accompanied by a set of seven Values and Behaviours which form a part of BCC's operational and ethical guidelines, and twenty 'city-wide outcomes' which are used to guide policy and decision-making, and measure performance and outcomes. These three elements, the themes, values and outcomes, are developed through a rigorous process of community and organisational consultation, and form a valid basis upon which to develop and implement the value-mapping framework. MIPO then has a formalised 'work breakdown structure' which provides definition around the actual delivery of projects within this broader corporate context.

The Case Studies

Case 1 was undertaken in November and December 2006. The Eleanor Schonell Bridge is a cable-stay bridge spanning 390 metres, serving bus, pedestrian and cycle traffic. It was completed in January 2007 for a total project cost of AUS$57million, and was delivered via a modified design and construct contract. The research objectives of this case study were three-fold:

1) to test and consolidate the proposed research direction.
2) to understand the delivery of a major project in this public sector agency, and map these processes.
3) to develop the draft project-specific value maps for further testing.

A review of this project enabled the researcher to identify what gaps, if any, existed in the process of linking project and corporate objectives and outcomes. This work included interviews with eighteen project team members and a review of project documentation from the pre-feasibility, detailed feasibility and implementation phases. The case study provided a well documented opportunity to build a series of process maps which represent a high level overview of project decision-making for that project.

A key outcome of this case study was that it revealed little in the way of formal, documented linkages between corporate objectives and project outcomes, throughout the planning and procurement process, and that decision-making in the pre-feasibility phase of the project in this regard, was largely intuitive and informal.

The second case study was undertaken between June and December 2007, once the draft framework and method had been established and verified. The Hale Street Link project will be a 60km/hr, four-lane tolled cross-river bridge and is currently due for completion in 2010. The project budget is AUS $250million and it is being delivered by an alliance contract.

The research objectives of this case study were to test:

1) the applicability of the generic process mapping process developed on the pilot case study.
2) the practicality and applicability of the draft value mapping process on a current project.

Five interviews were conducted with three project team members from mid to late 2007. A workshop engaging with a broader cross-section of team members was scheduled but cancelled due to conflicting project team commitments and uncertainty on behalf of the researcher as to the value to all of such a workshop. Case 2 confirmed the relevance and applicability of the proposed framework, but demonstrated the difficulties in implementing such a framework once the project has progressed to the implementation phase, when the project team was focused on project delivery rather than project strategy. The indicator set being focused on by team members was that negotiated and committed to by the Alliance team. Revisiting past processes (i.e. development of project objectives, accountabilities and stakeholder foot-printing) provided no value add to the project team retrospectively. Despite these difficulties, project team members expressed a high level of satisfaction with the intent of the framework, and an interest in the application of this framework on future projects.

Collaboration on Case 3 also commenced in July 2007 and is continuing. The Northern Link project is currently in detailed feasibility stage with completion scheduled for 2014. It has a project budget of AUS$2billion and options for delivery are still under consideration. The proposed project is an electronically tolled vehicle tunnel extending six kilometers from the inner western suburbs of Brisbane to the inner city providing a missing link in a CBD bypass for both freight and passenger vehicles. The project had just commenced detailed feasibility work when the first interview was held between project staff and the researcher. Senior project team members recognised the value of implementing the framework in terms of current activities, and readily agreed to the collaboration. This enabled the researcher to work in conjunction with fourteen key project team members over an intensive period of two months to refine the framework in an implementation environment.

THE VALUE MAPPING FRAMEWORK

Prior to work on this framework proper, an understanding of the processes involved in delivering projects within the agency was required. This initial mapping required a helicopter view of the key processes involved in the delivery of the project, so that a set of key decision points can be determined for the implementation of the value mapping framework. The value mapping framework itself, is where accountabilities, stakeholders, indicators and measurables are determined so that performance can be monitored on a selected project, and reported on against corporate objectives, throughout the planning and procurement process.

Process Mapping

The methodological foundations for the process mapping are drawn from the lean manufacturing methodology developed in the vehicle manufacturing sector in the early to mid 1990’s (Jones and Womack 2002, Rother and Shook 2003). These principals were later adopted by proponents of ‘lean construction’ such as Bertlesen and Koskela (2004). Klotz et al (2007) have recently developed the ‘lean’ concept into their ‘lean and green’ protocol wherein they track the development of this protocol from the initial lean manufacturing process, through to current day, with a priority on an expanded set of values and the sustainability agenda. This current value mapping research thus adopts this proven strategy to map an overview of the decision-making processes on major economic infrastructure projects, in order to establish the key intervention points for monitoring performance to indicators aligned to established corporate objectives.

Value Mapping

Two key elements of corporate responsibility, as developed by the World Business Council for Sustainable Development (WBCSD) are integral to the value mapping framework under development. These are (i) enhanced accountability and (ii) stakeholder foot-printing. Engen and DiPiazza (2005) discuss the relationship between business, accountability and sustainability, including the need to build awareness of the ‘spheres of influence’ of corporations, and better understanding the nature of corporate accountability. Holme and Watts (2000) introduce their stakeholder foot-printing tool and suggest that corporations need to better recognise and understand their engagement with external stakeholders. Emmitt et al (2005) further highlight the need to better understand these needs and drivers, based on the premise that stakeholders “all have a different set of values and interests in the project. When we know that the perception of value is subjective and individual, and that it changes over time, how do we map the values and satisfy all the stakeholders?” (Emmitt 2005, p.59)

The value mapping framework draws upon this background and proposes a series of activities to capture these elements of corporate responsibility for infrastructure projects. Activities undertaken includes the identification of objectives for the project; the establishment of accountabilities and stakeholders for each objective; using an organisation’s stated corporate objectives and outcomes, to establish a set of project-based indicators; the establishment of measurables and targets for these indicators; and the review, monitoring and reporting on of indicators at key project decision points to assure on-going alignment. This process is outlines in Figure 2.

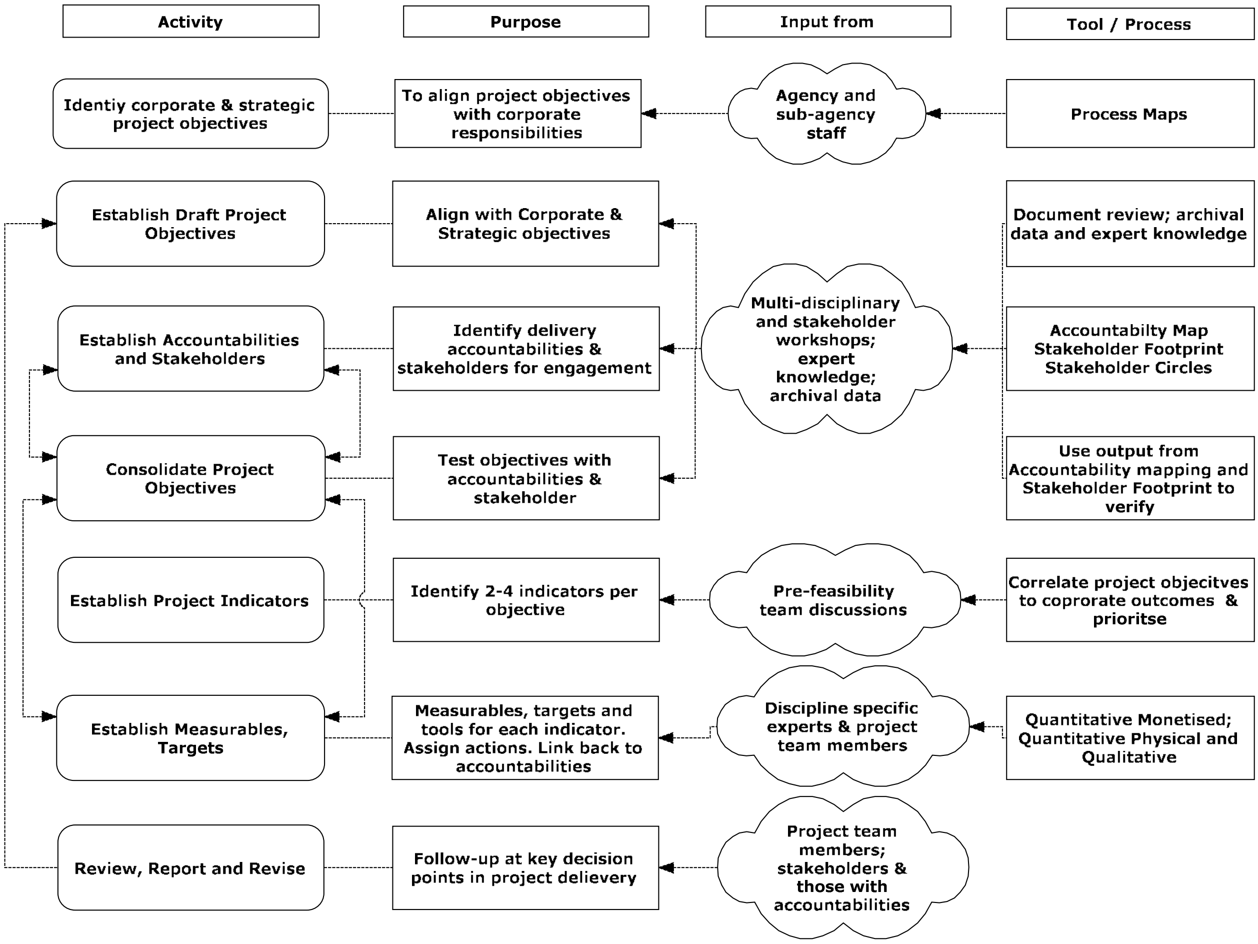


Figure 2 - Value mapping process

Thus, the value mapping framework as developed consists of a series of five spreadsheets, linked to each of the five stages of implementation, including (i) the Project Objectives worksheet; (ii) the Accountability Map; (iii) the Stakeholder Footprint; (iv) the Indicators Matrix and (v) the Value Map.

Case 3 Value Mapping

Knowledge and information relevant to the development of the value maps for the final 'implementation' project (Case 3) was gained from a number of sources including outcomes of the two previous case studies; a review of project documentation by the researcher; semi-structured interviews between the researcher and project team members; a project team workshop including the researcher; direct input by project team members, and from academic and technical literature.

Establishing the draft project objectives

The first step was to establish a set of objectives aligned to the corporate objectives and values, which could be effectively tracked throughout the life of the project. A key issue

identified in Case 1 was the number of differing sets of project objectives discovered, attributable to differing purposes, for differing stages of planning and procurement. Despite this complexity, it was not until detailed feasibility work began that any formal alignment was made between the corporate objectives and project objectives.
For Case 3, strategic project objectives were identified in addition to the corporate objectives previously detailed. These included:

- service level requirements as detailed in the TransApex Pre-feasibility Report (2005)
- five primary project objectives listed in the Initial Advice Statement to the State Government in mid 2007
- three strategic objectives in the Preliminary Assessment Report (2007)
- four strategic project objectives developed in project team workshops in September 2007

All of these were developed with specific intent, and are strategic in nature. The value mapping process however requires a set of objectives, which align with pre-determined corporate objectives, for which specific measurables and targets can be established, and which would remain relevant for subsequent review, measurement and reporting through to project completion. Thus, an initial set of project objectives were developed which recognizes a hierarchy of objectives from corporate to strategic to project. The draft set for value mapping was thus based on the above, along with knowledge and information gained from a variety of other sources (i.e. previous projects, technical experts and academic literature). These were then developed and verified in interviews and a workshop with project team members.

Establishing accountabilities

The accountability mapping methodology used derives from World Business Council for Sustainable Development (WBCSD) tools, including (i) the accountability mapping tool presented by Engen and DiPiazza (2005, p.9); and (ii) the stakeholder foot-printing tool as presented by Holmes and Watt (2000, p.6). The first tool asks the questions:

1. *Who* is accountable?
2. For *what*?
3. To *whom*?
4. Through *what mechanisms*?
5. With *what outcomes*? (Engen and DiPiazza 2005, p.6)

Engen and DiPiazza (2005, p.8) also present the ‘spheres of influence’ proposition, which expands upon the above question of ‘accountable to whom’ through requiring businesses to think outside their traditional mindsets when considering the impacts of their decisions.

For Case 3, accountability data relevant to the project objectives was discussed by the researcher at an early interview with two project team members. Further development of this map was undertaken by the project team members independent of the researcher. In its final form, this map will be cross-referenced to the actions identified against the indicators in the final value map. Additionally, the stakeholder footprint was used to clarify accountabilities and responsibilities by mapping the draft project objectives to a generic set of possible stakeholders. Through this process, project team members are stimulated to consider a broader set of stakeholders than may otherwise be the case; and a transparent and trackable map of stakeholders is developed. The final stakeholder foot-print worksheet can thus become a comprehensive listing of project stakeholders for each of the project specific objectives.

Consolidating the project objectives

The draft project objectives for Case 3 were then reviewed and finalized with the project team members, in light of consideration of accountabilities and stakeholders.

Table 1 - Case 3 Value Mapping Objectives

Accessible City

- Improve cross city and orbital traffic flow
- Improve freight network efficiency
- Improve local traffic accessibility on the local road network.
- Improved opportunities for public transport service
- Maximise tunnel access without negative impacts on local network
- Provide opportunity to improve pedestrians/cycle accessibility

Active & Healthy City

- Improve opportunities for pedestrian/Cycle connectivity

City Designed for Sub-tropical Living

- Maximise beneficial environmental outcomes
- Improve Brisbane's livability
- Provide opportunity to improve surface corridor to enhance sub-tropical local environment

City of Inclusive Communities

- Effectively manage the impact on local community
- Provide a safe project in all project phases
- Provide effective stakeholder and community consultation

Clean & Green City

- Provide best practice environmental outcomes.
- Minimise and manage of impacts of air pollutants
- Assist in the development of sustainable urban environment for inner western suburbs

Creative City

- Provide high quality, innovative design solutions

Regional & World City

- Deliver a legacy project as per project vision statement
- Contribute to the effectively servicing of high density urban development in Toowong and Milton

Smart & Prosperous City

- Provide innovation in delivery
- Project affordability
- Economic growth and employment facilitated

Establishing the project indicators

For Case 3, both the project objectives (as aligned with the BCC corporate objectives or themes) and the twenty city-wide outcomes where then used to develop a set of project specific indicators. A matrix was established between the two, and primary and secondary linkages highlighted in collaboration with project staff. A total of fifty-four primary linkages were identified (i.e.3-4 per objective), with these becoming the key performance indicators. These were then transferred to the final value map from where measurables and targets were established. When operationalised, it is proposed that this process would be undertaken by a team representing both stakeholders and knowledge experts.

Establishing the measurables and targets

These indicators were then used to establish a set of measurables and targets; identify associated tools to assist with their capture; and detail actions associated with their implementation for each of the project objectives established for Case 3. Measurables were formerly segregated into three categories including qualitative, quantitative (physical) and quantitative (monetised). Monetized and physical measurables are typically the most easily managed in the intense decision-making environment in the delivery of major economic infrastructure projects. The least easily managed is the qualitative aspects of projects, and whilst these cannot be conveniently measured, their impacts can be considerable in terms of both medium and long-term environmental and social outcomes. To disregard the latter thus increases the risk of future project failure (e.g. community dissatisfaction, environmental degradation).

Initial input into this map was made by the researcher on the basis of documentation review, and data derived from the previous case studies. Further input was made by project team members. A final overlay of data was subsequently made by the researcher, drawing upon academic literature and industry knowledge on the monetization of some of the environmental and social indicators. Sources included:

- Sinha and Labi (2007): related to the measurement of indicators for visual impacts, energy intensity and impacts, land-use impacts and social/cultural impacts (with specific reference to environmental justice).
- Todd Litman (2007) reviews the costs and benefits of transportation, and how this can be applied in the planning process. The author “provides monetised estimates of twenty costs for eleven travel modes under three travel conditions.”
- Peter Bein (1997) reports on the monetisation of environmental impacts of roads and how this knowledge can be incorporated in the decision-making process.

Against each indicator and measure, a project or corporate target was then identified, along with the option for a potential stretch target, which can be of value in terms of contractual performance. The setting of targets was a task for the project team to determine, based on expert knowledge and corporate intention.

Monitor, review and report

The final step in the framework is the on-going monitoring, reviewing and reporting on performance to these measurables. Key points for this activity will be identified in future research, which will provide input to the overview process map previously discussed.

CONCLUSION

Outcomes to date of this research and the associated collaboration, has been the development of a value-mapping framework which clearly links project objectives (via a set of project-based indicators) to pre-existing corporate objectives, against which performance of Brisbane City Council, as an organization and a community agent is measured. This framework is currently being implemented in an on-going manner on Case 3, with the support of both project team members, and agency executive.

Two areas of future research have been identified. The first is further research on enhancing engagement with non-contractual stakeholders over the long-term course of such projects, and the second is to further investigate the monetisation of qualitative indicators, without diminishing their intangible value.

REFERENCES

Bein, P. (1997). Monetization of Environmental Impacts of Roads.Highway Planning and Policy Branch, Information Management Section, Victoria B.C.

Bertlesen, S. and L. Koskela (2004). Construction Beyond Lean .12th annual conference in the International Group for Lean Construction, Elsinore, Denmark.

Brisbane City Council (2005). TransApex - Strategic Context Report.

Brisbane City Council (2006). Our shared vision - Living in Brisbane 2026. BCC.

Brisbane City Council (2007). Northern Link Preliminary Assessment Report. MIPO, BCC.

Checkland, P. (1984). Systems Thinking, Systems Practice, John Wiley and Sons.

Checkland, P. (2000). "Soft Systems Methodology: A Thirty Year Retrospective." Systems Research and Behavioural Science 17(S1): 11-58.

Dul, J. and T. Hak, Eds. (2008). Case Study Methodology in Business Research, Elsevier.

Emmitt S., D. Sander, et al. (2005). The Value Universe. IGLC - 13, Sydney Australia.

Engen, T. and S. DiPiazza (2005). Beyond Reporting : Creating Business Value and Accountability. Global, World Business Council for Sustainable Development.

Holme, R. and P. Watts (2000). Corporate social responsibility: making good business sense, World Business Council for Sustainable Development.

Jones, D. and J. Womack (2002). Seeing the Whole - Mapping the Extended Value Stream. The Lean Enterprise Institute.

Klotz, L., M. Horman, et al. (2007). "A Lean Modelling Protocol for Evaluating Green Project Delivery." Lean Construction 3(1).

Kraatz, J., Kajewski, S. and K. Manley (2008) Value mapping for major economic infrastructure projects for the Australian public sector. Clients Driving Innovation: Benefiting from Innovation - Third International Conference of the CRC for Construction Innovation.

Litman, T. A. (2007). Transportation Cost and Benefit Analysis. V. T. P. Institute: 275.

Major Infrastructure Projects Office (2007). Northern Link - Initial Advice Statement. MIPO, BCC.

Rother, M. and J. Shook (2003). Learning to See - Value-Stream Mapping to Create Value and Eliminate Muda . The Lean Enterprise Institute.

Sinha, K. C. and S. Labi (2007). Transportation Decision Making - Principals of Project Evaluation and Programming, John Wiley and Sons.

ASSESSING GENDER INEQUALITY IN EUROPEAN CONSTRUCTION RESEARCH

Abigail Powell, Tarek Hassan, Andy Dainty and Chris Carter
Loughborough University, Loughborough, UK
A.Powell@Lboro.ac.uk

Very little is known about the role of women in construction research and the factors hindering the equal presence of men and women. This paper explores initial findings from the 'WOMEN-CORE' project (co-funded by the European Commission's Research Directorate General under the Sixth EU Framework Programme), to demonstrate the extent of women's participation in construction research. This is achieved by analysing existing sources of data, including the Community Labour Force survey, the Education database; the EC CORDIS project database, the European Patent Office database and the ISI Web of Knowledge. Findings indicate that women are under-represented in all aspects of construction research with clear evidence of vertical segregation and some evidence of horizontal segregation across built environment research domains. Women appear to be more successful in 'so-called' softer issues within construction, such as research related to environmental and sustainability issues.

KEYWORDS: women, gender, research, Europe

INTRODUCTION

This paper reports on the development of the WOMEN-CORE (Women in Construction Scientific Research) project, established to address the under-representation of women in construction research. The premise of WOMEN-CORE is to determine whether women are under-represented and how women's experiences may differ from those in other research sectors. Given the nature of both construction sector and scientific research cultures, it may be that construction research represents a 'double hurdle' for women seeking a career in this field. This paper begins by examining the significance of gender in both the construction sector and research more generally, and then uses existing data sources to establish women's representation in construction research and how this compares to other research areas. Specifically it focuses on: the potential supply of construction researchers, using data from the Community Labour Force survey (CLFS) and the Education database; gender in construction scientific publications, using the ISI Web of Knowledge; gender in patenting related to the construction sector, using the European Patent Office database; and, gender in EU-funded construction research, using the EC CORDIS project database.

GENDER IN CONSTRUCTION

The construction industry is one of the most important industry sectors in terms of economic growth and employment. In 2006, construction in the EU27 totalled € 1,196 billion, 10.4% of GDP and employed 15.2 million operatives (FIEC, 2007). This makes it the largest industrial sector in the EU (ENBRI, 2005), accounting for 7.2% of the EU's total employment and 30.4% of industrial employment (FIEC, 2007). However, the construction sector also faces increasing global competition, tends to have low profit margins, is dominated by small firms and has a low level image and a poor safety record (ENBRI, 2005). The industry also suffers from a low R&D intensity and the cost of non-quality as a proportion of total output is also high, estimated at 5-10% (COM, 1997). It is therefore important to embrace R&D in order to develop new structures, processes, and relationships that promote innovation and meet the needs of clients, users and society more effectively (ENBRI, 2005). On a European level this has been supported by the establishment of the European Technological Construction Platform (ECTP) in 2005, to promote and shape R&D in the European Construction Sector.

Gurjao suggests that "construction needs diversity to sustain development and growth" (2006: 2) but the construction sector is one of the most male-dominated industries with women representing 10% of the UK construction workforce (EOC, 2006) and 8% of the EU (EC, 2008a). This is despite women's growing role as decision makers and clients. Watts (2007) suggests the low proportion of women in the sector is a result of the continued dominance of masculine stereotypes based on a male career model and a culture of long hours and presenteeism. Watts also maintains that women are not made welcome by the cultural imagery that continues to construct the profession as technical and dirty, or by the abstract curriculum in education which lacks relevance to the real world and fosters an impersonal learning environment. Clarke et al. (2004) suggest that gender equality issues have been taken up only minimally within the EU construction sector, despite the fact that national partners are key players in the formation of the social and equal opportunities agenda at the national level.

GENDER IN RESEARCH

Alongside the significant role the construction sector plays in society and the under-representation of women within this, wider research has addressed the lack of women in decision-making positions in scientific research (EC, 2008b). Despite Europe's strong tradition in research and innovation, the ETAN report (EC, 2001) found that gender plays a disproportionate role in the likelihood of being able to enter, remain in and succeed within the scientific community. Gender was also found to play an unwarranted role in the allocation of positions and resources in science and technology (EC, 2001). At the same time, a more diverse workforce is needed to release potential, foster innovation, create markets and reach diverse consumers (Rubsamen-Waigmann et al, 2003). However, social, economic and demographic changes in Europe also mean that the potential workforce is shrinking while the need for industrial researchers is growing. Rubsamen-Waigmann et al. (2003) argue that employers across Europe need to become more competitive by investing in staff for R&D, and by using staff more effectively. This means it is vital to retain women at every stage of their careers. Similarly, Mitos (2001) maintains there is a need to recognise the promotion of women in science as crucial to improving the relationship between science and society, in order that science better reflects the diversity of the entire population.

In 1999, the Helsinki Group on Women and Science was established to learn about initiatives occurring in the name of women and science and, to benchmark policies and practices designed to promote gender equality in the culture of scientists and in scientific careers. The Helsinki Group (Rees, 2001) concluded that: there is a lack of harmonised sex-disaggregated statistics on women and science; there is a lack of gender-balance in decision making; there is a 'leaky pipeline', whereby there is a disproportionate leak of women from science careers at every stage of the academic hierarchy and; there is a need to modernise human resource management policies in universities and research institutions.

Numerous studies have addressed the barriers women face in both academic and industrial research and many of these factors may be transferable across disciplines, including the construction sector. Some of the main barriers identified include:

Sexualised cultures: women are often equated with biologically determinist definitions of gender, which mean they are perceived as women first and scientists second (see, Etzkowitz et al, 2000; Faulkner, 2006);

Organisational cultures: despite an increase in policies designed to tackle inequalities in the workplace, there is often an inconsistency between organisational policies and workplace practice and norms (see Etkowitz et al, 2000; Bagilhole, 2006);

Long hours culture: the dominant culture in scientific research is long working hours and the expectation of total availability. This is particularly significant for women given that they usually have more domestic responsibilities than men (see Davis, 2001; Grant et al, 2000; Watts, 2008);

Gender stereotyping: the association between masculinity and technology can mean that women are pushed into 'softer' research areas, deemed more suitable for women, but often with less opportunities for career advancement (see Cockburn, 1985);

Gendered networking: despite the significance of networking for career success, women in science are often excluded from existing social and professional networks (see Davis, 2001; Faulkner, 2006; Etzkowitz et al, 2000).

This complex web of cultural and structural issues are a clear expression of the dominance of masculine cultures and together create problematic career paths for many women (and some men) pursuing scientific careers (Bagilhole et al., 2007; Watts, 2008).

RESEARCH METHODS AND DATA ANALYSIS

Building on the current climate of the construction sector and the situation of women in scientific research, WOMEN-CORE has been established to address the unequal representation of men and women in construction research in Europe by enhancing the knowledge and strengthening women's participation in construction research. The data presented in this paper is particularly focused on enhancing the knowledge on women in construction research. The project examines a number of core disciplines within it's definition of construction research, including: architecture; building physics; building structures; construction and economic management; construction technology; environmental engineering; heating, cooling, ventilation, electricity and networks; geotechnics and underground studies; IT; transport organisation and structures; urban planning; water management and structures; and, mechanics, including fluid mechanics and dynamics.

The project has undertaken a secondary analysis of data sources, compiling relevant statistics from, the CLFS, the education database, the EC CORDIS project database, the ISI Web of Knowledge, and the European Patent Office database in order to build a picture of: gender education segregation; gender segregation in R&D personnel; women's construction scientific research publications and citations; the role of women as patent originators in construction; and, women's participation in EU funded projects in construction research.

As some of the databases used in this analysis do not collect data on gender (ISI Web of Knowledge, European Patent Office database and EC CORDIS project database), a first name database (FNDB) was created using a similar methodology to Naldi and Parenti (2002). The FNDB is a comprehensive collection of European first names, divided by country and gender. It is derived from a combination of government sources, internet searches and language experts and contains a total 46,619 names in 20 European languages. Of these, 25,135 were identified as female, 21,107 were male and 377 were 'double-gendered' in that they could be applied to both genders. First names listed in the databases were then cross-checked against the FNDB to establish gender. The FNDB was successfully used to identify gender of 91% of publishing authors, 76% of patentees and 86% of people involved in EU funded construction research.

POTENTIAL CONSTRUCTION RESEARCHERS

As shown in table 1, women were found to account for 40.7% of bachelor and masters graduates and 33.9% of doctoral graduates in construction-related fields of study (2004). While this is considerably lower than the average across all fields of study, for bachelor and masters graduates, it is higher than the proportion of women graduates in science and engineering. This may be because construction-related study includes architecture which tends to be less male dominated than other science and engineering subjects. The data also indicates that the proportion of women graduating in construction is increasing, albeit at a lower rate than the proportion of women graduates across all fields.

Table 1: Proportion of Women among Graduates in EU27, 2004. Source: Education database, Eurostat.

	Bachelors and Masters Graduates	Doctoral/PhD Graduates
All fields of study	58.8%	43.4%
Science and Engineering	33.9%	33.9%
Construction	40.7%	33.9%

In 2004, countries with the highest proportion of women construction bachelor and masters graduates were Cyprus (66.0%) and Bulgaria (51.1%), while those with the lowest were the Netherlands (21.8%) and Austria (29.8%). Interestingly, while most countries experienced an increase in the proportion of women bachelor and masters construction graduates between 1998-2004, the UK, Denmark, Cyprus, Bulgaria, Malta and Latvia all experienced decreases. Among PhD construction graduates, Latvia (66.7%) and Lithuania (54.5%) had the highest proportion of women and Germany (22.1%) and Estonia (29.4%) had the lowest.

Despite the increase in women among recent graduates, women only account for 21.5% of the highly qualified population (total population holding bachelor, masters and doctorate degrees) in construction, compared to 48.9% across all fields of study in 2005 (see table 2). Figures for the proportion of women among the highly qualified population in employment are slightly lower for all fields of study and construction fields of study.

Table 2: Proportion of Women among Highly Qualified Population in EU27, 2005. Source: Community Labour Force Survey, Eurostat.

	Total	In Employment
All fields of study	48.9%	47.7%
Construction fields of study	21.5%	20.8%

In 2005, the Netherlands (12.5%) and Denmark (12.8%) had the lowest proportion of women among the highly qualified population in construction-related fields of study, compared to the highest proportions of women in Bulgaria (37.8%) and Latvia (36.6%). For construction fields of study this data was only available for 2005, so no historical comparison was possible.

As displayed in table 3, women only account for 19.0% of construction scientists and engineers compared to 34.8% of scientists and engineers in general, although there has been a positive increase between 2000-2005. Scientists and engineers are understood to be employees working in the most R&D oriented occupations. In construction these are scientists and engineers working in occupations most related to construction research (architects, engineers, physicists, chemists and related professionals).

Table 3: Proportion of Women among Scientists and Engineers in EU27, 2000-2005. Source: Community Labour Force Survey, Eurostat.

	2000	2005
Total	33.2%	34.8%
In construction	16.1%	19.0%

By country, in 2005, Bulgaria (38.7%) and Portugal (32.4%) had the highest proportion of women among construction scientists and engineers, while Germany (13.9%) and the UK (14.7%) had the lowest proportion of women.

GENDER IN CONSTRUCTION SCIENTIFIC PUBLICATIONS

In total 918 articles from 20 journals were analysed, 454 in 2000 and 464 in 2003. The 20 most relevant international journals in construction research were identified based on a balanced coverage of scientific disciplines within the construction sector and impact factor. As some of the articles were co-authored, the total number of authors addressed in this analysis was 2052; 962 in 2000 and 1090 in 2003. Of these, on average women represented

18% of authors, increasing from 14.7% in 2000 to 21.7% in 2003. There was also high variation between journals, ranging from 0% in HVAC&R (Heating, Ventilation, Air Conditioning and Refrigeration) Research to 30.3% in Water Research in 2000, and from 5.3% in Journal of Constructional Steel Research to 50.0% in Indoor and Built Environment in 2003 (see figure 1). For most journals there was an increase in the proportion of women authors between 2000 and 2003. Decreases in the proportion of women authors occurred in 3 journals: Cement and Concrete Research, Energy and Buildings, and the European Journal of Operational Research.

These results indicate that women may be more successful in subjects related to 'softer' issues within the construction sector, such as the environment and architecture, rather than the 'harder' engineering based subjects. Women's rate of publication also varied widely by country. In 2003, Romania (83.3%) had the highest proportion of women publishing, while Cyprus, Lithuania and Slovenia had no women authors.

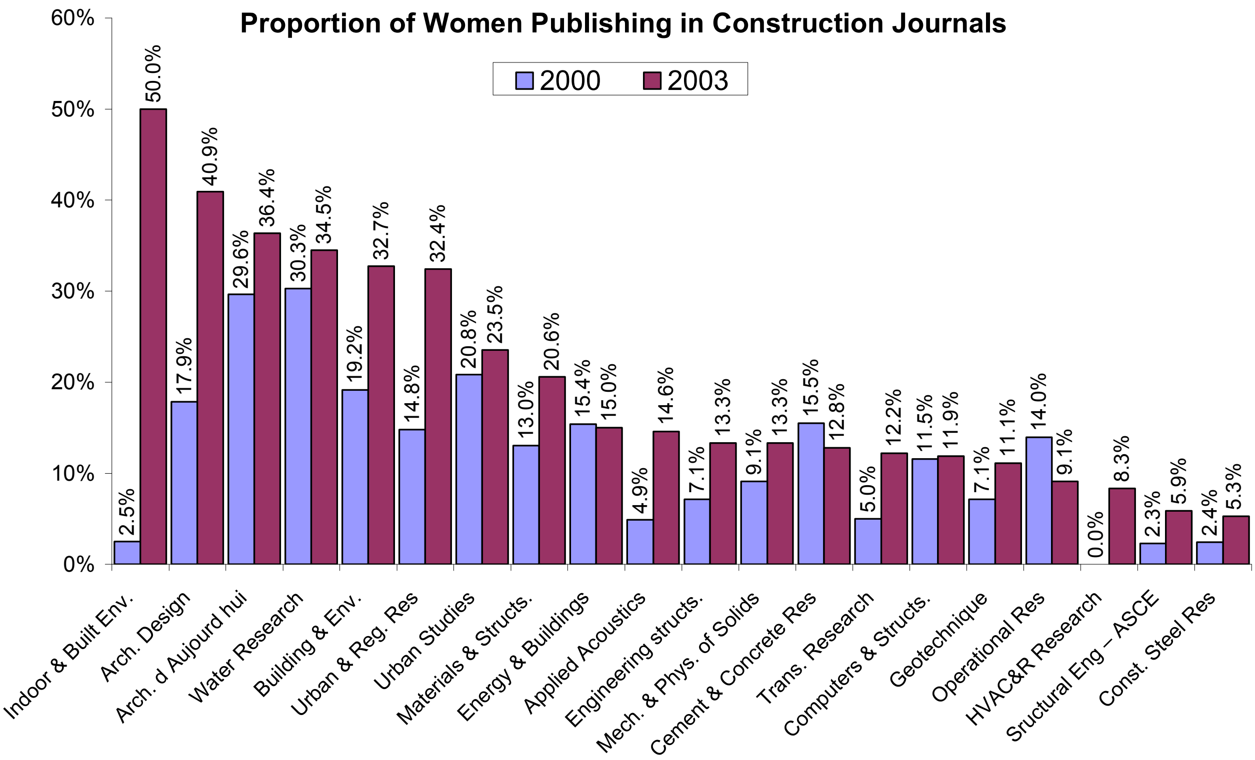


Figure 1: Proportion of Women Authors in Construction-related Journals, 2000 & 2003. Data compiled using ISI Web of Knowledge.

The results also illustrate that citation of articles is high. In 2000, 71.5% of articles were cited and in 2003, 65.6% of articles were cited at least once. In 2000, 75.0% of articles published with women authors were cited, compared to 70.4% of male-only authored articles. In 2003, this difference was even greater with 71.2% of articles with women authors being cited compared to 63.1% of male-only authored articles. This is encouraging and demonstrates that if women are accepted in construction research, their results are highly accepted. However, it may also indicate that women need to provide research findings of a higher quality than men in order to be accepted and successful.

GENDER IN CONSTRUCTION PATENTING

As shown in table 4, while patenting was found to be less common in the construction sector compared to the chemical and pharmaceutical sectors, women patentees were found to be very poorly represented in the construction sector (4.5%) compared to the chemical (10.2%) and pharmaceutical (17.3%) sectors.

Countries with the highest proportion of women patentees were Lithuania (23.0%) and Malta, while Luxembourg (1.4%) and Austria (2.2%) had few women patentees. However, all these countries also had very few actual patents. Germany, for example, has the highest number of construction patents between 1994-2004 (153,677 compared to 113 in Lithuania), but only 4.4% of patentees were women. On average there was an increase in the proportion of women patentees between 1994-2004, again with variation across countries.

Table 4: Proportion of Women Patentees in EU25, 1994-2004. Data compiled using European Patent Office database.

	1994	2004
Construction	3.7%	4.9%
Chemistry	8.0%	11.7%
Pharmaceuticals	13.9%	21.4%

GENDER IN EU-FUNDED CONSTRUCTION RESEARCH

This task identified a total of 497 construction related projects funded by the EU; 308 of which were funded by the Fifth Framework Programme, FP5, (1998-2002) and 189 funded by the Sixth Framework Programme, FP6 (2003-2006). Although fewer projects were funded under FP6 than FP5, the average budget per project was much higher (€5.2 million compared to €2.2 million).

On average (as shown in table 5), women represented 8.7% of all partners in construction related projects, including 10.1% of coordinators and 8.6% of scientific managers (partners named as leading the project within their organisation). Women's participation also increased between FP5 and FP6, with the proportion of women coordinators increasing from 6.2% to 16.4% and the proportion of women scientific managers increasing from 6.7% to 10.8%. The data from FP6 also show that there is a higher proportion of women coordinators than women scientific managers. This may indicate that women are more likely to participate in funded research if they have instigated the research themselves.

Table 5: Proportion of Women Participating in EU funded Construction Research 1998-2006. Data compiled using EC CORDIS database.

	FP5 (1998-2001)	FP6 (2002-2006)
Total Women	6.6%	11.2%

Women coordinators	6.2%	16.4%
Women scientific managers	6.7%	10.8%

Analysing the data by country, in FP5 Slovakia (25.0%) and Greece (16.1%) had the highest proportion of women partners, while Estonia, Latvia, Lithuania, Luxembourg and Malta had no women partners. In FP6, Slovakia (28.6%), Luxembourg (25.0%) and Cyprus (25.0%) had the highest proportion of women partners, compared to no women partners in Bulgaria, Estonia and Latvia. Of the countries with greater participation in construction projects, the proportion of women partners is much lower. For example, Germany is one of the countries with the most involvement in EU construction projects, but the proportion of women partners was only 3.0% in FP5 and 6.6% in FP6.

Analysis of EU funded projects by project budget also indicated that the higher the budget of the project, the less likely it is that women will be participating in the project as either coordinators or scientific managers. While there appears to be a higher proportion of women involved in high budget projects in FP6, this may be due to the fact that the average construction project budget was more than double that in FP5 (€5.2 million, compared to €2.2 million). This finding may indicate that women are less likely to have the more senior roles within organisations that allow them to lead larger scale projects.

CONCLUSIONS AND RECOMMENDATIONS

This paper has focused on exploiting existing sources of information relating to women in construction research. Specifically, this was achieved by analysing women's representation in higher education, the highly qualified population and among scientists and engineers, and women's participation in publication and citation, patenting and EU funded construction research.

Some of the key findings of the research are: in 2005, women accounted for 19% of scientists and engineers in construction research; in FP6 (2003-2006), women represented 11.2% of coordinators and scientific managers of construction research projects funded by the EU; in 2004, women comprised only 4.9% of patentees in the construction sector; in 2003, women accounted for 21.7% of publishing authors in construction scientific journals. The data suggests that vertical segregation may be apparent, with high proportions of women studying construction subjects in higher education (40.7% of bachelor and masters graduates), but much smaller proportions of women in more senior positions such as coordinating European research (16.4%). However, it is also important to consider that any increase in women in more junior positions will take some time to be seen in more senior roles, as they develop these women develop their careers. The difference in the proportion of women involved in publishing (21.7%) compared to patenting (4.9%) may also indicate that women are better represented in construction research in academia rather than industry, as the emphasis on publishing may be higher in academia, while industry has more focus on the commercial impact of research. Generally speaking, the countries with the highest proportions of women's participating across all areas of construction research are countries where the total number of people involved in construction research is very small. For example. Lithuania has the highest proportion of women involved in construction patents (23.0%), but only accounted for 113 patents between 1994-2004, compared to over 150,000 in Germany.

Based on the findings and conclusions of the analysis of existing data, a number of recommendations can be made. Firstly, there is a strong need for the European Commission to improve access to (sex-disaggregated) data and the findings of research previously funded by the EC. This is particularly important if such data can improve the quality of subsequent research and also impacts on the effective use of resources (for example, it is inefficient to collect the same data or complete the same analysis twice, even if it is for different projects). Secondly, given the relatively high proportions of women undertaking construction related degrees (bachelors and masters), but lower proportions of women in scientific and more senior construction research positions, it is important to consider measures for recruiting and retaining women in research-orientated careers in the construction sector. Thirdly, further research is necessary to explain the decrease in women's participation in construction research within particular countries. Additional research may explore whether this pattern is specific to construction research or a pattern reflected more generally within certain countries. Fourthly, with regard to patenting, it is recommended that patent applications collect data on the gender of patentees. This would be a more efficient and effective way of obtaining sex-disaggregated data. Fifthly, analysis of women’s rate of publication indicated that women may have a higher rate of participation in softer areas of construction research such as the environment or architecture. However, further analysis of women's horizontal segregation in construction research is necessary as this was not conclusive in other tasks. Finally, it is also necessary to further explore the significance of publishing and patenting in industrial and academic careers, and whether or not women are better represented in academia than industry. This will be considered further in the data collection stages of the WOMEN-CORE project.

ACKNOWLEDGEMENTS

This research is co-funded by the European Commission’s Research Directorate General under the Sixth EU Framework Programme (FP6) and in collaboration with partners from Labein-Tecnalia, Spain (co-ordinator); Fundacio CIREM, Spain; GESIS-Centre of Excellence Women and Science (CEWS), Germany; Copenhagen Institute for Futures Studies (CIFS), Denmark; Czech Technical University (CVUT), Czech Republic; and, Loughborough University, UK.

REFERENCES

Bagilhole, B. (2006) Family Friendly Policies and Equal Opportunities: A contradiction in terms? *British Journal of Guidance and Counselling,* 34 (3): 327-343.

Bagilhole, B., Powell, A., Barnard, S. and Dainty, A. (2007) *Researching Cultures in Science, Engineering and Technology: An analysis of current and past literature*. A Report for the UK Resource Centre for Women in Science, Engineering and Technology. Available at: http://www.ukrc4setwomen.org.uk/downloads/research/10-_Researching_Cultures_in _SET. pdf

Clarke, L. Frydendal Pederson, E., Michielsens, E., Susman, B. and Wall, C. (2004) (Eds.) *Women in Construction.* Brussels: Reed Business Information.

Cockburn, C. (1985) Caught in the Wheels: the high cost of being a female cog in the male machinery of engineering. In: D. Mackenzie and J. Wajcman (Eds.) *The Social Shaping of Technology.* Milton Keynes: Open University Press.

COM (1997) Communication on the Competitiveness of the Construction Industry, adopted by the Commission of 4 November 1997 (COM 539).

Davis, K.S. (2001) Peripheral and Subversive: Women making connections and challenging the boundaries of the science community, *Science Education,* 85: 368-409.

EOC (2006) *Facts about Women and Men in Great Britain*. Manchester: Equal Opportunities Commission.

Etzkowitz, H., Kemelgor, C. and Uzi, B. (2000) *Athena Unbound: The advancement of women in science and technology.* Cambridge: Cambridge University Press.

European Commission (2001) *Science Policies in the EU: Promoting excellence through mainstreaming gender equality.* A Report from the ETAN Expert Working Group on Women and Science. Luxembourg: Office for Official Publications of the European Communities.

European Commission (2008a) *The Life of Women and Men in Europe: A statistical portrait. Eurostat statistical books*. Luxembourg: Office for Official Publications of the European Communities.

European Commission (2008b) *Mapping the Maze: Getting more women to the top in research.* Luxembourg: Office for Official Publications of the European Communities.

ENBRI (2005) *Future Needs for European Construction RTD.* European Network of Building Research Institutes Position Paper. Available at: enbri.cstb.fr/docs/Aims_Future_ Needs.pdf [Accessed 10 May 2007].

FIEC European Construction Industry Federation (2007) *Annual Report 2007.* Brussels: FIEC. Available at: http://www.fiec.org/Content/Default.asp?PageID=29 [Accessed 21 April 2008].

Grant, L., Kenelly, I. and Ward, K.B. (2000) Revisiting the Gender, Marriage and Parenthood Puzzle in Scientific Careers, *Women's Studies Quarterly,* 28 (1/2): 62-85.

Gurjao, S. (2006) *Inclusivity: The changing role of women in the construction workforce.* Berkshire: CIOB.

Mitos, A. (2001) Introduction. In: L. Maxwell, K. Slavin and K. Young (Eds.) *Gender and Research.* Conference Proceedings, 8-9 November, Brussels, European Commission.

Naldi, F.R. and Parenti, I.V. (2002) *Scientific and Technological Performance by Gender: A Feasibility Study on Patents and Bibliometric Indicators.* Luxembourg: Office for Official Publications of the European Communities.

Rees, T. (2001) First Results from the Helsinki Group on Women and Science: Policy review. In: L. Maxwell, K. Slavin and K. Young (Eds.) *Gender and Research.* Conference Proceedings, 8-9 November, Brussels, European Commission.

Rubsamen-Waigmann, H. et al. (2003) *Women in Industrial Research: A wake-up call for European Industry.* Luxembourg: Office for Official Publications of the European Communities.

Watts, J. (2007) Porn, Pride and Pessimism: Experiences of women working in professional construction roles, *Work, Employment and Society*, 21 (2): 299-316.

ORGANIZING MEGAPROJECTS

Christian Brockmann
University of Applied Sciences Bremen, Germany
christian.brockmann@hs-bremen.de

Megaprojects are very special structures and therefore call for innovative solutions. Resources of one company are usually insufficient to complete the task. With very few exceptions megaprojects are built by international construction joint ventures (ICJVs). Size, untested solutions, and international collaboration are the salient components making up the complexity of megaprojects.
One of the key activities in dealing with this complexity is the project organization that includes not only the structure but also all necessary rules, regulations, and norms. This paper researches appropriate organization structures for megaprojects. Using grounded theory as methodology, it can be stated that the structure of choice for ICJVs is a functional organization with decentralized competencies. Other than the formal and informal structure a third type can be found. Reporting and sense-making follow the line of national languages and cultures within an ICJV, not the formal line of command.

KEYWORDS: megaprojects, organization, decentralization, ethnocentric structure

INTRODUCTION

Literature on the organization of ICJVs for megaprojects does not exist. Research has to draw on the theoretical knowledge of organization science as such. Therefore the question arises whether megaprojects have some specifics that require a special approach to organization. The following two paragraphs lay out the particulars of megaprojects and adapt organization to this framework.

Megaprojects

Megaprojects are invariably described by using superlatives (the prefix “mega” is already one of them). They are called the “giants” among the projects (Grün, 2004) or the “new animal” (Flyvbjerg et al., 2003). While such projects are large, they are not unparalleled in history. Five of the seven wonders of the ancient world have been civil engineering structures (Ogunlana, 1999). Megaprojects are only new as subjects of research.

The label “megaproject” is not used by all authors. Some refer to them as large-scale engineering projects (LSE-Projects, Hassan et al., 1999) and describe them by five attributes: (1) “high” capital cost, (2) “long” duration but program urgency, (3) technologically and logistically demanding, (4) requiring multidisciplinary inputs from many organizations, and (5) leading to a “virtual enterprise” for the execution of the project. Miller / Lessard (2000) have researched 60 LSEs and in their sample the average capital cost is 985 million US$, the average duration is six and a half years with a construction period of four years. This is meant by high capital cost and long duration.

Grün (2004) puts the emphasis on the aspect of the multi-organizational enterprise (MOE) and characterizes these by (1) singularity, (2) complexity, (3) goal-orientation (technical, financial, time) and (4) the nature and number of project owners. Taking these attributes together, megaprojects are indeed daunting tasks especially since cost and time overruns are typical. The list of projects with cost overruns reads like a "who is who" in megaprojects (Flyvbjerg et al., 2003), among them are the Suez Canal (1,900%), the Sydney Opera House (1,600%) or more recently the Boston Artery Tunnel (196%), the Great Belt Rail Tunnel (110 %) and the Channel Tunnel (80%). Reasons given are planning optimism, mistakes, and political lies.

Organization

First, organizations depend on the technology they use. In the construction industry the general technology used is unit production (instead of mass production). This calls for an organic structure with little formalization, little centralization and plenty of communication (Woodward, 1965).

Second, for any type of project it is possible to distinguish between the structure of the client's or the contractor's organization. This research is concerned with how a contractor organizes in design/build contracts. Project complexity for the contractor in such settings is very high and he has to manage a large workforce. For one of the researched projects, the BangNa Expressway, this amounted to 500 employees and 5,000 workers. The client on the contrary manages contracts with a comparatively small workforce.

Third, megaprojects in construction are normally carried out by joint ventures because their size exceeds the resources of one company. This is not necessarily so, but it is the norm. Again, in most cases the joint venture has the form of an international construction joint venture (ICJV).

In sum, the paper is concerned with civil design/build contracts where two or more partners form an international construction joint venture to execute a megaproject for a client. This is the most complex task imaginable within the given limitations.

Research Question

Under these circumstances a question arises begging for an answer: Are there any peculiarities in the way megaprojects are organized and if so, what are they? There is sufficient evidence that the organization of megaprojects cannot follow what is practiced in large corporations because they require a short-term project organization. Neither can they be entirely modeled as normal construction projects, since their much higher complexity does not allow this.

RESEARCH METHODOLOGY

Since there is no existing theory on the research topic, we employed grounded theory as research methodology (Strauss and Corbin, 1998). 35 interviews have been conducted using a semi-structured interview guideline. The technique was adopted from ethnographic interviews (Spradley, 1979). The interviews represent eight case studies (i.e. different ICJVs) and allow for literal and theoretical replication (Yin, 2003). The selection of the cases was guided by the ideas of theoretical sampling to allow for the use of replication logic and to create the situation of a quasi-experiment (Campbell and Stanley, 1963). Six of the eight cases are taken from the Taiwan High Speed Railway (Anonymous, 2002). There were two Korean/Taiwanese ICJVs, two Japanese/Taiwanese ICJVs and two German/Taiwanese ICJVs. This allows for replication. In addition, the type of work, the client, the contract, the economical, social, and judicial environment were for all ICJVs the same. This is the quasi-experimental setting.

Two other cases were from Thailand, one a subway and the other an expressway project. These serve to verify any claims with regard to a different type of work and a different micro- and macro-environment. With this arrangement it was possible to double check all statements.

Data evaluation followed the ideas of grounded theory by employing first a micro-analysis of all interviews. Then open coding helped to classify events, things and actions into categories, axial coding to develop subcategories, selective coding for connecting the categories with each other and finally process coding to detect dynamic developments (Strauss and Corbin, 1998).

RESULTS

Results are discussed in the following four paragraphs. First the environment of ICJVs in charge of megaprojects is described, followed by an analysis ofthe different organizational tasks. Then the type of formal organization is laid out and finally attention will be drawn to a special variety of an informal organization: the ethnocentric structure.

Environment

The task of the ICJV is to design and build an innovative structure by combining very high quantities of resources in a very short time, often using an untested technology and combining the ideas and wishes of a multitude of stakeholders. Specifically they have to fulfill the goals set by the different partners to the ICJV and by the one or more clients. In the words of a project manager this sounds as follows: "*But what happens at the beginning of a project in most joint ventures is, a joint venture has won a project, where we'll limit this to a large project. They have won a large project which will have a turnover and a staff that will be equivalent to most medium sized companies. Medium sized companies develop in most cases from small companies, their procedures develop as the company develops, their staff develops as the company develops and so it's a long process that is controlled. What happens in the start of these projects is that you suddenly have to throw a medium to large company together with no procedures, no processes, no understanding, no trust and you throw it into being an operational organization on day one. And so you have a situation where nobody really knows what the other person is doing, why they are doing it, how they are doing it and even if they should be doing it. And that is the big difficulty in managing these joint ventures because you are suddenly creating a large company on day one and expecting it to operate with the efficiencies of a large company without having any of the benefits of the development time. You can't even, or very rarely are you in a position where you can say, we will adopt the procedures and the policies of one of the joint venture partners and run the joint venture on that because the other partner won't accept that. They believe that their procedures and their processes are what's needed. So you have to blend this organization out of the beliefs of the* *two parent companies, into something that they are both happy with and that is also efficient*."

Organizational task

The organizational task of ICJVs for megaprojects is so demanding that it becomes one of the pillars on which the success of the project depends. It achieves the same importance as design, work preparation, site installation and construction itself. While for a normal sized project organizational set-up and development are side tasks, this is not true for megaprojects. Prominent on the to-do list are: Organizational structure and organization chart, distribution of competencies, job descriptions, contract management, quality management, safety management, personnel management, purchasing, financial accounting, communication, correspondence and filing. More abstract is the creation of an organizational culture. As mentioned in the quote above, each partner has his own ideas about all the tasks and the ICJV has to find some common and efficient solution to those demands.

Formal Organization

The organization of choice in megaprojects is functional. This is due to the fact that they are designing and manufacturing just one product. Therefore a divisional design is not an option. While there might be matrix elements on lower levels of the structure, the second level of the organization is clearly functional and this level normally characterizes the whole organization (Steinmann and Schreyögg, 2005). The organization of a megaproject with its typical functions is shown in fig. 1.

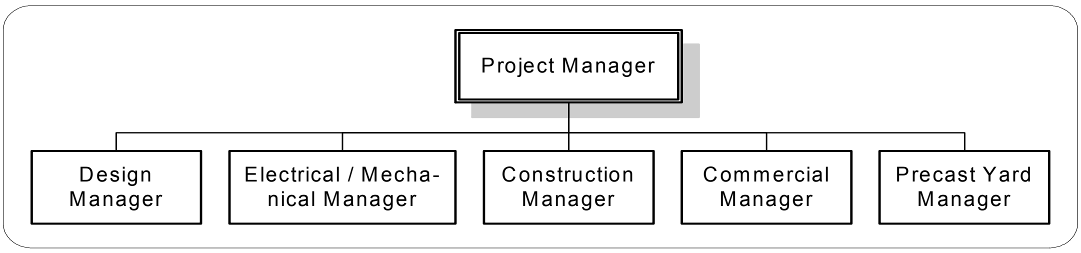


Fig. 1: Functional Organization of a Megaproject

While the functions of design, E/M, construction and commercial management are found in all ICJVs, precast yard management is instituted in most since precasting helps to fulfill tight schedules.

According to theory, functional designs allow for a tight control but little flexibility (Hatch and Cuncliffe, 2006). Coordination across the different departments is also seen as a major problem (Bateman and Snell, 2002). These problems are of greatest importance in a dynamic environment such as described for the start of an ICJV and even later most ICJVs are subjected to sudden changes to their environment. The answer of all ICJVs in the sample (except one) was to delegate authority. They all tried to strike a balance between the emphasis on the functional hierarchy for coordination and delegation of authority for flexibility through decentralization of the structure. In the words of a project manager this sounds as follows: „*It's a delegation because of the size of the project you have no chance to follow up each and every* *detail. So you have to delegate certain issues and also tasks. This is very important and of course the implementation has to be followed up*."

Ethnocentric Organization

What has been said up to now concerned the formal structure of an ICJV. Since the Hawthorne studies in the 1930s everybody in organizational science is also aware of the informal structure within an organization (Roethlisberger and Dickson, 1939). Little if anything has been published on the organizational behavior that follows neither a formal nor an informal (buddy) structure but rather the path of a national language and culture. In all ICJVs such a behavior could be detected. If possible subordinates addressed compatriots in the hierarchy with their problems: "*You know, it doesn't matter if you are the project manager, the local staff will be more dependent on the local senior manager of whatever position he is and they'll be more inclined to report to him then they will be to report to the Western manager. And the information that they are expected to provide is different*."

Most joint ventures facilitate the flow of information along the lines of language and culture by always installing a person from each of the two partners of the ICJV in one position. The doubling of positions is also recommended in theory, although for the reason of finding a balance between the different perspectives of the partners (Yoshino and Rangan, 1995).

ANALYSIS

The amount of organizational work to be done is rather challenging in quantity but it is not difficult to deal with. If at least one of the partners to the ICJV has sufficient knowledge of the required processes, it is a question of early action with the necessary resources. While this sounds simple enough, there are manifold examples where the know-how was not available or the resources were insufficient.

Delegating authority is a more difficult problem. According to Hofstede (2005) and Mintzberg (1983), all national cultures tend to prefer one of five different basic organizational structures. The preferred type of structure depends on the power distance (degree to which differences between superiors and subordinates are accepted) and uncertainty avoidance (way in which uncertainty is handled). In our sample Japan (92) and South Korea (85) score considerably higher on uncertainty avoidance than Taiwan (69), Germany (65), and Thailand (64). Thailand (64), South Korea (60), Taiwan (58), and Japan (54) in turn score considerably higher on power distance than Germany (35). Thus, we would have to expect different organizational structures. The groups with high uncertainty avoidance and high power distance should choose a simple hierarchy without delegation of power. This was not observed. In just one of the eight cases, a Korean/ Taiwanese ICJV, the project manager considered himself to be a general commanding his troops. All the others preferred guerilla tactics (to stay in the picture). The one example of a simple hierarchy produced the worst economical results and everybody – regardless of the national background – commented on the impossibility to organize a megaproject in this way. The conclusion is that the influence of megaproject complexity outweighs national preferences for different organizations.

Reporting and coordinating along the lines of national language and culture was also prevalent. This is a fact that has not been given attention in the literature. The ICJVs are aware of it without specifically setting up their organization with regard to this fact. A possibility to deal with the problem could be by using the idea of Likert's linking pins (1964). This means information is gathered in specified positions and distributed by key persons that can link the different cultures together (fig. 2). It can be arranged either between peers (horizontal link) or between different levels of the hierarchy (vertical link).

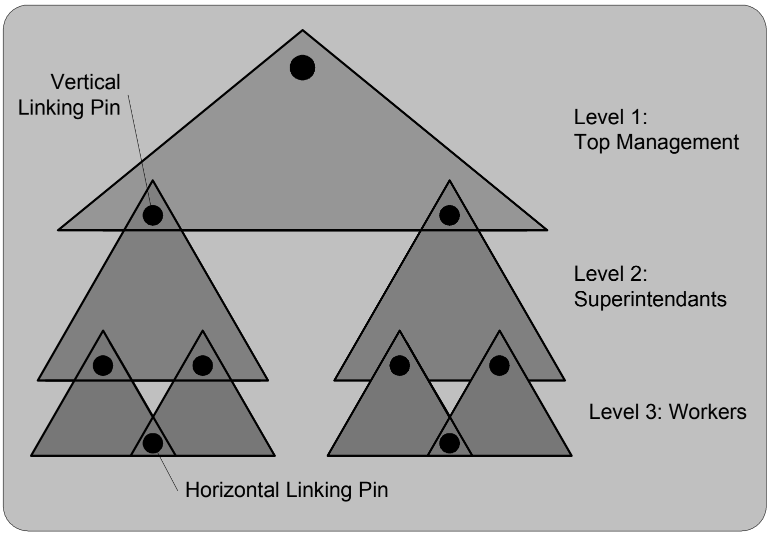


Fig. 2: Linking different National Cultures in ICJVs

CONCLUSION

The results and analysis of the research on organizational behavior in ICJVs are summarized in fig. 3.

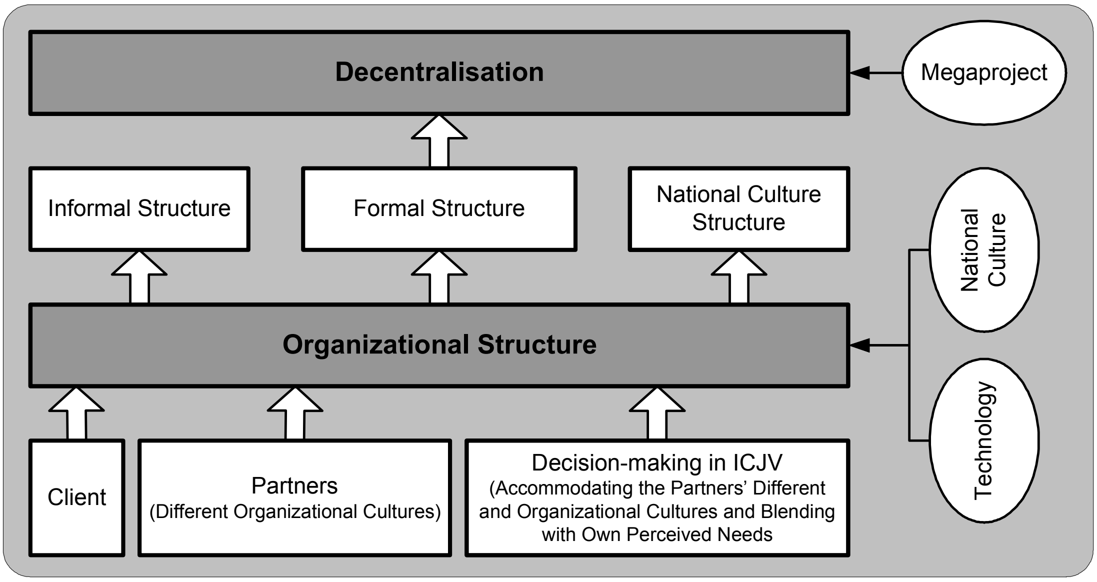


Fig. 3: Influences on the Organizational Structure of ICJVs

The client always has (a small) influence on the set-up of the organization through stipulations in the contract. The partners have an interest to see as much as possible of their own organizational culture incorporated in the ICJV. This is not only founded on the belief that one's own cultural practices are superior, but also on practical considerations. If the ICJV for example adopts the accounting system of one partner, he can easily consolidate the data in his balance sheet while the other partners have to rearrange their financial accounts. These stipulations and interests need to be taken into consideration by the decision makers in the ICJV. In addition, it is their task to find the structure best fitted to fulfill the contract with regard to time, budget (resources), and quality.

The preferred organizational structure is also dependent on the national culture of the actors and the technology used. The result of the planning process is the formal structure. The overwhelming complexity of megaprojects exerts a very strong influence on the type of formal structure: The choice of decentralization and delegation of authority is a condition sine qua non. The result of the organizational behavior is an informal and ethnocentric structure. These two can be predicted, taken into account and to a certain degree molded, yet they escape the complete control of the management of the ICJV.

REFERENCES

Anonymous (2002). "Economic Lifeline." Bridge Engineering and Design, 2002, p. 14.

Bateman, T.; Snell, S. (2002). Management : Competing in the New Era. Boston, USA: McGraw-Hill Irwin

Campbell, D. and Stanley, J. (1963). Experimental and Quasi-experimental Designs for Research. Boston, USA: Houghton Mifflin

Flyvbjerg, B., Bruzelius, N. and Rothengatter, W. (2003). Megaprojects and Risks: an Anatomy of Ambition. Cambridge, UK: Cambridge University Press

Grün, O. (2004). Taming Giant Projects: Management of Multi-Organization Enterprises. Berlin, Germany: Springer

Hassan S., McCaffer, R. and Thorpe, T. (1999). "Emerging Clients' Needs for Large Scale Engineering Projects." Engineering, Construction and Architectural Management, 6(1), 21 – 29.

Hofstede, G. and Hofstede, G. (2005). Cultures and Organizations: Software of the Mind. New York, USA: McGraw-Hill

Hatch, M. and Cunliffe, A. (2006) Organization Theory: Modern, Symbolic, and Postmodern Perspectives. Oxford, UK: Oxford University Press

Likert, R. (1964). New Patterns of Management. New York, USA: McGraw-Hill

Miller, R. and Lessard, D. (2000): Strategic Management of Large Engineering Projects: Shaping Institutions, Risks, and Governance. Harvard, USA: MIT-Press

Mintzberg, H. (1983). Structures in Fives: Designing Effective Organizations. Englewood Cliffs, USA: Prentice-Hall

Ogunlana, S. (ed.) (1999). Profitable Partnering in Construction Procurement. London, UK: E & FN Spon

Roethlisberger, F. and Dickson, W. (1939). Management and the Worker. Cambridge, USA: Harvard University Press

Spradley, J. (1979). The Ethnographic Interview. Belmont, USA: Wadsworth

Steinmann, H. and Schreyögg, G. (2005). Management: Grundlagen der Unternehmensführung. Wiesbaden, Germany: Gabler

Strauss, A. and Corbin, J. (1998). Basics of Qualitative Research: Techniques and Procedures for Developing Grounded Theory. Thousand Oaks, USA: Sage

Woodward, J. (1965). Industrial Organization. London, UK: Oxford University Press

Yin, R. (2003). Case Study Research: Design and Methods. Thousand Oaks, USA: Sage

Yoshino, M. and Rangan, U. (1995). Strategic Alliances: An Entrepreneurial Approach to Globalization. Boston, USA: Harvard Business School Press

THE DISCURSIVE CONSTRUCTION OF A GREEN ORGANIZATIONAL IDENTITY

Ann-Charlotte Stenberg
Chalmers University of Technology, Göteborg, Sweden
ann-charlotte.stenberg@chalmers.se

Christine Räisänen
Chalmers University of Technology, Göteborg, Sweden
christine.raisanen@chalmers.se

Contributing to the development of a sustainable society is currently on the agenda of most organizations and has become an important feature of their internal identity and their external image. The everyday life of these organizations are highly influenced and constrained by the wider context and discourses in which the organizations are embedded and the power structures that prevail. This paper examines how multiple and conflicting notions of 'green' compete and are made sense of within organizational processes and discourses, shaping that organization's identity and image. Based on empirical data from a longitudinal, qualitative case study, we show how, over time, the environmental discourse in the organization has been technologized. Through this process, alliances are created, subordinate groups are mobilized and a common representation of sustainability as well as a consensual green praxis is generated in talk.

KEYWORDS: identity construction, sensemaking, green, environmental discourse

INTRODUCTION

In the last few decades, environmental commitment has become a powerful discursive means of mobilizing actors, of competing for points on the good-will barometer and of creating organizational identity. However, the concept of 'green' carries widely differing values depending on the context of culture (institutions, social structures and ideologies) and the context of situation (place, time and participants) of the actors. For example, members of an organization may operationalise 'green' in ways that make sense to them within the specific ontology, epistemology and ideology of their local work contexts rather than in accordance with the management's interpretation of 'green' (e.g., Weick 1995; 2001; Guy and Farmer, 2001; Starkey and Crane, 2003; Stenberg and Räisänen, 2006). Thus when dealing with specific events or issues, "people engage in double identity-building and sensemaking acts" that is, "they need to make sense of the question at hand both in terms of its implications for the organization and for themselves" (Vaara and Magakian, 2005).

Socially shared meanings facilitate the transfer of different ideological elements from one person to another, and from one setting to the next. From a social constructivist perspective, notions like 'green,' 'sustainable development,' and 'ecological sustainability' are viewed as empty signifiers (Füssel, 2005). According to Füssel, these signifiers are contested terrain where actors make claims and try to influence the discourse. That is, the sensemaking of the ambiguities and contradictions on different organizational levels result in different sets of identities that the actors or groups may enact. As emphasized by Alvesson (1998) the way people within the same organization, or working context, make sense of tasks, for example environmental tasks, is crucial for collective action. Drawing on the organizational identity and the management literature, this paper recounts the story of how the members of a Swedish municipal housing company (Alpha), in interaction with its social environment, made sense of environmental issues over time, and thus created a corporate 'green' identity.

SENSE-MAKING AND IDENTITY CONSTRUCTION

In the frequently used quote "How can I know what I think until I see what I say?" Weick (1995, p.18) views identity construction as a property of sensemaking. So, the link between sensemaking processes and identity construction is that the construction of organizational identity is a precondition for sensemaking while, at the same time, organizational identity is constructed through the process of sensemaking. Sensemaking of ambiguities and contradictions on different organizational levels may result in different sets of identities that the actors may enact. Organizational identity formation is a complex process influenced by both internally and externally informed views (Hatch and Schultz, 2000).

Czarniawska-Joerges (1994) describes identity construction as a two-way process where not only actors perform actions, but also the actions create the actors, or rather, their identities. Applying a post-modern view, identity is viewed as illusions created and maintained by processes of social construction (Hatch and Schulz, 2000). The identity concept is understood as relational and constructed and re-constructed in an on-going negotiation with others, hence opening up for change and multiplicity (e.g., Czarniawska-Joerges, 1994; Sahlin-Andersson, 1996). The fact that "identities are constructed out of the process of interaction" is also stressed by Weick (1995, p.20), who further argues that "to shift among interactions is to shift among definitions of self". Consequently, interpersonal interaction, along with the interplay between an organization and its social environment are crucial factors in organizational identity construction.

Primarily, the identity concept has been applied to individuals (Sahlin-Andersson, 1996); the transfer of the concept to groups or organizations follows from the notion that not only individuals in our modern society, but also collectives, such as organizations, are perceived and presented as actors. Organizations are shaped by heterogeneous and dynamic groupings of people with varied backgrounds, education, beliefs and ambitions. These groups are bound together by organizational activities and processes governed by organizational discourses through which goals, strategies and day-to-day tensions are negotiated in the creation of a sense of self in the organization. Thus, organizations may metaphorically be treated as actors who think, reason and behave, and are able to conceive of themselves and others as having identities (Brunsson, 1989; Sevón, 1996). Identity construction is a discursive process of identification, which involves naming, labeling, classifying and associating of both artifacts and social actors, and it takes place both on organizational and individual levels. These two levels of identities are closely dependent on each other.

Marziliano (1998) makes a distinction between internal identity construction and external image creation, reputation and profile. Identity refers to how actors make sense of previous experiences and create internal personality. Image, reputation and profile, on the other hand, refer to the organization and its enacted environment, that is, they focus on the outsiders and what *they think about us*. Identity and ensuing actions are not solely shaped by the internal activities and discursive practices of an organization; they are also strongly influenced and constrained by the wider context in which the organization is embedded (e.g., DiMaggio and Powell, 1983; Scott, 1995). Thus, the interplay between an organization and its social environment has an important role to play in the organization's identity construction, which in turn may have implications for how different issues, e.g., environmental issues, are framed and acted upon individually and collectively. Furthermore, organizational identity has implications for corporate branding. Therefore, for the organizational members it is important to follow through on the images that are communicated to the outside, which means that the behavior "needs deep roots, it needs to rest in the organization's identity" (Hatch and Schultz, 2004).

METHODOLOGICAL APPROACH

The story of how Alpha is based on a longitudinal qualitative study from 2001-2004 using a three-phase iterative multi-mode method consisting of (1) an exploratory phase consisting of document analysis and 6 initial in-depth interviews, (2) a focused phase consisting of 10 in-depth interviews lasting one to two hours each, and (3) a feedback phase where all participants were invited to a seminar where we presented and discussed preliminary results and our inferences.

The following is the story of Alpha's quest for an green identity interspersed with our theoretical interpretations of what is going on. We believe that Alpha's story will shed light on the complexity of employees' attitudes, beliefs and assumptions in an organization's process of creating an green profile.

THE STORY OF ALPHA

Alpha is a commercially run subsidiary housing company to a Mother Company, which is owned by the City. Alpha had full responsibility over its own operational activities. The Mother Company had managerial responsibility for strategic development, financing, quality analyses, reporting systems, and accounting rules.

The strongest voice in this story is that of the Coordinator (CO), who perceived himself metaphorically as the 'spider in the web.' The CO is a member of the Environmental Unit (EU) and the Business Management (BM), and had been involved in the company's environmental change process from the beginning.

Environmental issues enter the scene

In 1996, as a result of society's increased attention on environmental issues and a re-organization in the company, the BM raised the status of 'the environment' to strategic level. Consequently, the EU, a collective protagonist consisting of representatives from different levels in the company, was founded. By bracketing environmental concerns as a strategic issue and forming an EU, rather than appointing a Manager, the BM signaled that the environment was henceforth an issue that involved everyone in the company, not only environmental specialists.

When Alpha initiated their environmental change process, management worked at mobilizing a collective sensemaking process to rally all the employees. Since environmental concerns for some time had been in the political and media limelight, and since it was by its very nature a concern with which everyman could identify, it already functioned as an ideological space or boundary object in the organization (Bowker and Leigh Star, 1999). Such boundary objects, according to Bloomfield and Vurdubakis (1997, p.95), are parts of the “rhetoric of specialist language games.” It is these ideologically loaded spaces that make it difficult for employees to question the visions and goals to which they are asked to commit themselves (Gee et al., 1996). For the employees at Alpha it was thus difficult to question the management’s new visions concerning the environment. The next step for Alpha’s management was to forge their particular environmental meanings and actions.

As a way of further legitimizing the new strategic turn, a two-day off-site meeting was organized for all the managers in order to collectively discuss visions and goals for the handling of environmental concerns. For example, it was decided to introduce a new function at district level in the company, the Environmental Coach. The role of these Coaches is comparable to that of knowledge brokers (Wenger, 2003); they were expected to be driving forces and local experts ensuring that environmental information was translated and filtered down to their colleagues in the districts. In addition, the first Coordinator of Environmental Work (CEW), an internal expert on environmental issues, was employed as a result of this meeting. Moreover, at the meeting, a strategically important decision was made to strive toward earning an Environmental Diploma by the end of the same year. This Diploma, issued by the City’s Environmental Administration, was agreed upon as a feasible first step to integrate environmental issues in the everyday life of the company.

To generate commitment to the environmental endeavor, Alpha gathered all employees in round-table discussions to collectively ‘make sense of the environment’ and identify success factors that related to their cultural and situational contexts. There was a focus on the individual level and how each single employee might contribute to ‘improve the natural environment.’ Alpha adopted a bottom-up approach in their work of formulating environmental goals, starting with local goals formulated by the employees in local units and districts. Not until one year later did they finalize their Environmental Policy. Thus, the management at Alpha did not practice sensegiving (e.g., Gioia and Chittipeddi, 1991) by coercing employees into acceptance, but rather taped into individual environmental knowledge, using it as a base for creating new collective knowledge to which the employees would be committed. These meetings and ensuing collective discussions were crucial in creating an Alpha-specific environmental discourse.

Seen in retrospect, several respondents considered Alpha’s initial approach to environmental issues as very successful, facilitating the understanding and engagement in the environmental work. Also, bringing together all categories of actors created an arena in which green ideas could be translated and made concrete. Winning the Environmental Diploma reinforced the vision and became a first milestone. Several years later, many respondents witnessed that green issues had become a natural part of work, and a frequently used metaphor by the respondents was that environmental commitment was “bred into their backbone.” As Fairclough (2003, p. 160) describes it, Alpha, through this process, became an organization “whose members have learnt to inculcate within their own way of being the ‘new’ discourse of the organization, especially as a vision (mission) of the organization.”

Grappling with the environment on a day-to-day basis

Alpha's efforts in 1996 resulted in spin-offs, both internally and externally. The company started to make an inventory of their use of chemicals, and in 1998 their Chemical List (List) became official. Thus, from the ongoing 'background noise' consisting of several 'latent objects' (Ericson, 1998), Alpha picked up on the use of chemicals and staked it out as its territory of environmental concern. In contrast to being part of the background noise, as soon as the object had been singled out, it was possible to give it meaning. Subsequently, the use of chemicals, and more specifically, the List, took on symbolic value for Alpha, gaining currency outside the company as well. Respondents at Alpha talked about the List as a living document which for them seemed to embody the company's environmental commitment. Thus, this non-human document had become an actor in its own right in the environmental work.

Generally speaking, sensemaking is about giving structure and meaning to a confused reality. One way of doing this is to implement a system, e.g., EU Eco-Management and Audit Scheme (EMAS), to create a uniform practice and common language for the management of environmental work that would minimize the interpretative flexibility of meanings of green. In 1997, the BM decided to initiate a process aiming at registration according to EMAS in three pilot districts. Together with selected employees from each district, the CO and Alpha's formerly CEW carried out internal environmental audits, formulated environmental plans, instructions and routines. The path toward EMAS registration was paved with much confusion and frustration until the goal was finally reached in 1999.

With mainly positive experiences from the pilot runs for EMAS registration, Alpha decided to continue the registration process for the whole company. To develop a broad-based commitment among the employees, a new role, EMAS-engines, was created. These engines focused on starting up and facilitating the EMAS-registration process and as such may be compared to Fairclough's (1992; 2001) discourse technologists, whose role it is to redesign organizational discourses and work processes turning them into representations of consensual praxis (see also Räisänen and Linde, 2004). Implementing an environmental management system is one method used by discourse technologists to create a uniform language and practice for the company's day-to-day work with environmental issues. They must also ensure that staff is committed to the use of the system. Also, by the EMAS registration, Alpha made sure that the focus on environmental work was maintained over time.

However, some critical voices explicitly expressed the opinion that there might have been too much focus on environmental issues during the late 90s. For example, as one District Manager stated, not all employees were actually paying attention to environmental issues on a daily basis. The environmental management system, EMAS, was also considered to be too labor-intensive. Interestingly, two of the most critical voices belonged to employees within the same geographical district, which gives an indication of how important it is for notions and ideas to be coincident in an organization. When they are not, the tension caused by differences in interpretations can prove destructive for the whole idea (Gray et al., 1985). Contesting voices, if sufficiently powerful, may quickly mobilize counter-action or non-action. These differences could be traced to the individual's history at Alpha, and also to sub-identities within the organization. The following section will therefore offer an example of how a sub-identity was developed in one of Alpha's geographical districts.

Internal organizational boundaries

The boundary concept often refers to specific organizational units that are well-defined, conveying limitations and lack of access (Wenger, 2003). Boundaries are therefore usually seen as constraining. Boundaries may also be more fluid, held together by boundary objects that may be used to mobilize actors to pool together in the fulfillment of organizational visions or goals. At Alpha, one geographical district, Epsilon, held a prominent position regarding environmental work and functioned as an internal example of best practice on the one hand and as a competitor on the other.

District Epsilon was part of the Swedish ‘mass housing areas’ of the 60s and 70s, often referred to as The Million Program. In order to raise the status or Epsilon, which was grappling with the problem of vacant apartments, and also to strengthen the districts position inside the company Alpha formulated a vision for the district: “District Epsilon: With the Environment as a Vision.” The BM expected Epsilon to become a ‘green’ role model within the company. In order to live up to expectations the employees had to learn more about environmental issues. Thus, a green community of practice was formed and nurtured by the district. The Gardening Manager (GM) described how environmental issues subsequently had become an integrated part of the staff’s and the district’s identity. Several ‘green’ projects have contributed to put Epsilon in top position with regard to environmental work at Alpha. For example, together with the City’s Environmental Administration, the district took the initiative to develop the Environmental Diploma to be adapted to the business of property owners. It also developed its own Chemical List, which allowed the use of fewer products than did Alpha’s corresponding list. Due to all the green initiatives and support from the BM, the staff had experienced some enviousness from other districts within the company. As environmental work became prevalent in the company, this difference evened out.

We could discern a change over time regarding the environmental engagement at Epsilon. In 2004 the key enthusiast had left his post and respondents mentioned a backlash in the focus on environmental issues. Small, but not insignificant changes were also noted. For example, as expressed by one Building Supervisor, during the pioneer time when the GM was still placed at the district, the CEW came more often on personal visits, and she even joined their parties.

Expanding organizational boundaries

Drawing on DiMaggio and Powell (1983) and Scott (1985), the interplay between an organization and its social environment has an important role to play in the organization’s identity construction. Marziliano (1998) makes a distinction between internal identity construction and external image creation, reputation and profile. Identity refers to how actors make sense of previous experiences and create internal personality. The identity defines the ‘self,’ that is, a shared and collective sense of ‘who we are’ (Albert and Whetten, 1985). Image, reputation and profile, on the other hand, all refer to the organization and its enacted environment, that is, they focus on the outsiders and what they ‘think about us.’

Concerning Alpha’s quest for a new green profile, the BM were aware of the importance of communicating their mission, both internally to the employees and externally to, for example, the tenants, the Mother and Sister companies, and to municipal politicians. Already in 1997, only one year after the initiation of their environmental strategic program, Alpha availed themselves of the media to inform the public about their environmental approach. As the CO expressed it, media coverage was an external acknowledgement of their internal work. “We can emphasize the importance of environmental commitment to the staff over and over again. But if they can read about it in the newspaper, even if we have written the text ourselves, it becomes important. It is a confirmation” (Coordinator). The CO makes an important point here concerning the power of the media to reinforce organizational or political decisions and actions, or, as the case may be, sow suspicion and cause disruption. Another important point he makes concerns the social effects of texts. Texts, of which a news item in the press is an example, have causal effects on people that may contribute to a change in their beliefs, attitudes and their actions (e.g., Fairclough, 2003; Räisänen and Linde, 2004; Gluch and Stenberg, 2006). By extension texts contribute to changes in social relations and the material world. In the case of Alpha, the internal spoken or written texts (meetings, informal talk, memos, directives, mission statements, items in the company newsletters) have all been mediating tools to effectuate changes in the employees, their social relations to each other and to the material world of the company. Observe that these changes are not the effects of one text or type of text, but of an aggregate of texts reinforcing the message. However, over time, these internal texts become formulaic; they lose their meaning, timeliness and power to engage. At this point, an outside text, with a different focus and perspective seen through the eyes of a different agent can be viewed as a mediating tool to give the endeavor new strength, or confirmation as the CO put it. The outside text mediates subtle changes in employees attitudes and actions in that it turns their attention outwards, to view the company in the light of other companies and society at large. In this respect the media itself is an important mediating tool for the company, not only to project a positive image outward, but also to reinforce the image inwards.

Quite recently, the Marketing and Information Manager was co-opted into the EU as a means of strengthening Alpha’s external communication. He stated that previously, there had been too little focus on external stakeholders. Furthermore, the CO described the environmental work as a balancing act between factual matters and image building. That is, besides the focus on minimizing the environmental impacts, it was also important that Alpha’s tenants appreciated the company for its environmental efforts. Consequently, the tenants needed to be informed about Alpha’s environmental work. Still, much work remained before Alpha’s environmental approach had influenced the individual behavior of the tenants. Also, it would probably be unrealistic to embrace all tenants by the expanded boundary since not all tenants were receptive to this influence.

GENERAL DISCUSSION AND CONCLUDING REMARKS

Riding on the wave of the growing environmental consciousness of the late 80s and early 90s, Alpha re-created itself as a ‘greening’ organization by initiating a change project to transform the organization into a green workspace with environmental care as a salient theme. The management’s most important role during a change process is to influence sensemaking in the organization (Weick, 1995; 2001) by defining organizational reality and ensuring that there is consensual acceptance of the meanings it shapes. Alpha’s management adopted a bottom-up approach in their work to formulate new environmental policies, starting with local goals generated by the employees in local units and districts. The management tapped into the individual’s personal environmental knowledge and beliefs, using these as a basis for creating new collective knowledge and practices to which the employees could commit.

Moreover, the collective brainstorming meetings generated an Alpha-specific environmental discourse, which the employees could easily appropriate.

Being a subsidiary implies that Alpha had to relate to at least two different organizational boundaries. First, by defining the ‘self,’ Alpha automatically constructed its organizational boundary. Second, Alpha was also embraced by the organizational boundary of the Mother. Another complicating factor was that Alpha’s environmental impacts to a high degree were dependent on the behavior of their tenants. Therefore, when addressing some particular issues, Alpha expanded its boundary to include the tenants. However, in these cases the boundary was more vaguely defined. Therefore, to form a shared and collective sense of ‘us’ became difficult. Not only were there different boundaries to relate to, there were also multiple environmental identities to consider. As the perspective changes, depending on what level of the organization is in focus, both individual and collective identities may become objects for negotiation. Obviously, even if the company strove to create a collective sense of ‘who we are’ (Albert and Whetten, 1985), still there were discrepancies in how the employees perceived their internal environmental identity. Moreover, which is important to emphasize, the green identity in focus here was just part of the company identity. For example, neither the business concept nor the business vision statements mentioned any environmental issues. Instead Alpha’s focus was on being “...the leading housing company in the city, developing the housing for the future and modernizing the public housing sector in Sweden” (quote from Alpha’s Business Vision).

We have seen how Alpha developed a distinctive green profile by defining their preferred environmental area of key concern. Alpha’s environmental profile was constructed through a sensemaking process where ‘green’ was constituted through interaction in the organization, and in turn, the interaction constituted the meaning of green (for the organization). Alpha’s concrete area of environmental endeavor, which became a symbol of the company’s environmental identity, can be seen as an instrument by which the organization successively develops a rationale for its environmental activities, e.g., the organization makes sense of its relationship to ‘the environment.’ This sensemaking (Weick, 2001) was clearly manifested in the language used by the respondents (Stenberg, 2007). The areas of specialization provided employees with a collective rationale that they could rally around and simultaneously gave the organization an edge that differentiated it from the other organizations.

It could be argued that the story presented here is just a single example of how a housing company created an green profile for itself as a competitive edge. More, in the light of the sensemaking story of Alpha, it should be emphasized that, as researchers, we may very well interpret the respondents’ different actions and stories. However, it is not possible to reflect any genuine empirical representation, the only thing researchers may achieve is a comprehension of other people’s understandings. For that reason, this paper does not claim to tell ‘the true story’ of how Alpha made sense of the environment, if there even exist such a thing, but to tell the story as we made sense of it.

REFERENCES

Albert, S. and D. A. Whetten (1985) Organizational Identity. In L. L. Cummings and B. M. Staw (eds.) Research in Organizational Behaviour. Vol. 7:263-295.

Alvesson, M. (1998) The Business Concept as a Symbol. International Studies of Management & Organization. 28(3):86-108.

Bloomfield, B. P. and T. Vurdubakis (1997) Paper traces: Inscribing organizations and information technology. In Bloomfield, B. P., Coombs, R., Knights, D. and D. Little (eds.) Information technology and Organization. Oxford University Press: Oxford.

Bowker, G. and S. Leigh Star (1999) Sorting things out. MIT Press: Cambridge, Massachusetts.

Brunsson, N. (1989) The organization of hypocrisy: Talk, decisions and actions in organizations. Wiley: Chichester.

Czarniawska-Joerges, B. (1994) Narratives of individual and organizational identities. In Deetz, S. A. (ed.) Communication Yearbook (p. 193-221). Sage: CA.

DiMaggio, P. J. and W. W. Powell. (1983) The Iron Cage Revisted, The New Institutionalism in Organizational Analysis. American Sociological Review. Vol. 48(April):147-160.

Ericson, T. (1998) Förändringsidéer och meningsskapande: En studie av strategiskt förändringsarbete. Dissertation. Studies in Management and Economics. Linköpings Universitet: Linköping.

Fairclough, N. (2001) 'The discourse of new labour: Critical discourse analysis,' in M. Wetherell, S. Taylor and S. J. Yates (eds) Discourse as data: A guide for analysis. SAGE: London.

Fairclough, N. (2003) Analysing Discourse. Routledge: London.

Fairclough, N. (1992) Discourse and social change. Polity Press: Cambridge.

Füssel, L. (2005) Corporate environmental governance: perspectives on organizing and communication. Studentlitteratur: Lund.

Gee, J. P., Hull, G. and C. Lankshear (1996) The new work order behind the language of the new capitalism. Westview Press: Boulder, Colo.

Gioia, D. A. and K. Chittipeddi. (1991) Sensemaking and sensegiving in strategic change initiation. Strategic Management Journal. 12(6):433-488.

Gluch, P. and A.-C. Stenberg. (2006) How do Trade Media Influence Green Building Practice? Building Research and Information. 34(2):104-117.

Gray, B., Bougon, M. G. and A. Donnellon. (1985) Organizations as Constructions and Deconstructions of Meaning. Journal of Management. 11(2):83-98.

Guy S. and G. Farmer. (2001) Reinterpreting Sustainable Architecture: The Place of Technology. Journal of Architectural Education. 54(3):140-148.

Hatch, M. J. and M. Schulz (2000) Scaling the Tower of Babel: Relational Differences between Identity, Image, and Culture in Organizations. In Schultz, M., Hatch, M. J. and M. G. Larsen (eds.) The expressive organization: linking identity, reputation, and the corporate brand (p.11-35). Oxford University Press: Oxford.

Hatch, M. J. and M. Schulz (2004) Instroduction. In Hatch, M. J. and M. Schulz (eds.) Organizational Identity. A Reader. (p. 1-15). Oxford University Press: Oxford.

Marziliano, N. (1998) Managing the Corporate Image and Identity: A Borderline Between Fiction and Reality. International Studies of Management & Organization. 28(3): 3-11.

Räisänen, C. and A. Linde. (2004) Technologizing discourse to standardize projects in multi-project organizations: Hegemony by consensus? Organization. 11(1):101-121.

Sahlin-Andersson, K. (1996) Imitating by Editing Success: The Construction of Organization Fields. In Czarniawska, B. and G. Sevón (eds.) Translating Organizational Change (p. 69-92). Walter de Gruyter: Berlin.

Scott, W. R. (1985) Institutions and Organizations. Thousand Oaks, CA: Sage Publications.

Sevón, G. (1996) Organizational Imitation in Identity Transformation. In Czarniawska, B. and G. Sevón (eds.) Translating Organizational Change (p. 49-67). Walter de Gruyter: Berlin.

Starkey K. and A. Crane. (2003) Toward Green Narrative: Management and the Evolutionary Epic. Academy of Management Review. 28(2):220-237.

Stenberg, A-C. (2007) Green ideas travelling across organizational boundaries. Building Research & Information, 35(5):501-513

Stenberg, A.-C. and C. Räisänen. (2006) The Interpretative Flexibility of “Green” in the Building Sector: Diachronic and Synchronic Perspectives. International Studies of Management & Organization. 36(2):32-54.

Vaara, E. and J. L. Magakian. (2005) On the role of language in organizational sensemaking. Paper presented at The 21st EGOS Colloquium, Berlin.

Weick, K. E. (1995) Sensemaking in Organizations. Thousand Oaks, CA: Sage.

Weick, K. E. (2001) Making sense of the Organization. Blackwell Publ.: Oxford.

Wenger, E. (2003) Communities of Practice and Social Learning Systems. In Nicolini, D., Gherardi, S. and D. Yanow. (eds.) Knowing in organizations: a practice-based approach. M. E. Sharp: New York.

DEVELOPMENT OF A PERFORMANCE MODEL FOR INTERNATIONAL CONSTRUCTION JOINT VENTURE: A SYSTEM DYNAMICS APPROACH

Muhammad Nateque Mahmood
The University of Tokyo, Tokyo, Japan
nateque@ken-mgt.t.u-tokyo.ac.jp

B.H.W. Hadikusumo
Asian Institute of Technology, Pathumthani, Thailand
kusumo@ait.ac.th

Stephen O. Ogunlana
Heriot Watt University, Edinburgh, UK
S.O. Ogunlana@hw.ac.uk

Azmeri Rahman
Stamford University Bangladesh, Dhaka, Bangladesh
azmeri14@yahoo.com

The uncertain and dynamic nature of International Construction Joint Venture (ICJV) performance is evolved with many critical factors which lead to make partner relationships more complex in respect of making decisions to maintain a cohesive environment. Addressing to the fact, a generic system dynamics performance model for ICJV is developed by integrating a number variables as to get an overall impact on performance of ICJV and to make effective decisions based on that. In order to formulate and validate the model both structurally and behaviourally, both qualitative and quantitative data are gathered by conducting intensive interviews from two ICJVs in Thailand. After conducting intensive simulations of model, three major problems are identified related to negative value gap, low productivity in construction and high rate of ineffective information sharing of both ICJVs. Several policies are suggested and integrated application of these policies provides a maximum improvement to performance of the ICJV.

KEYWORDS: international construction joint venture, system dynamics performance model, joint ventures- Thailand.

INTRODUCTION

Global construction business has moved towards more competitive environment over the past two decades. As local markets erode due to competition, firms need to change their business strategy and expand their traditional markets. According to Yoshino and Rangan (1995), joint ventures (JVs) have emerged as a popular strategy in an environment in which fast access to up-to-date technology and emerging markets is more critical than ever before. The complex and diversified nature of construction industry makes JVs as a vehicle of seeking new opportunities to increase organizational strengths and reduce weaknesses.

Although there is a significant growth of ICJVs, the success rate is not satisfactory (Adler et al., 1992). This success is measured in terms of performance level of joint venture. The performance of ICJVs depends on many factors which affect performance at different stages (selection, formation, operation and dismantle stage) of joint venture. The factors are changing with time and have a dynamic effect on performance of joint venture. ICJVs have become increasingly prevalent in the business environment and the need to understand the dynamics of these emerging organizational forms increase, as managers and researchers struggle to find patterns and indications of how to effectively manage these complex collaborative arrangements. Hence, a better understanding of performance of ICJVs and their dynamic development over time is needed. Modelling relationship dynamics in joint ventures makes interactions visible and thus understandable. Once understandable, managers are positioned to make judgments about the observed patterns and intervene, as appropriate, to increase the likelihood of partnership success. Considering to the dynamic and uncertain nature of the performance of ICJV, the primary objective of this paper is to develop a generic system dynamics model in order to explain how the factors affect the performance of ICJVs and then develop adopted system dynamics models for different cases of ICJVs.

The structure of the paper is as follows. The second section provides a brief review of performance measurement of ICJV. Then in the third section development of system dynamics modelling process is described. Based on a discussion presented in the third section, the final part provides a conclusion and direction on the future research.

PERFORMANCE MEASUREMENT OF ICJV

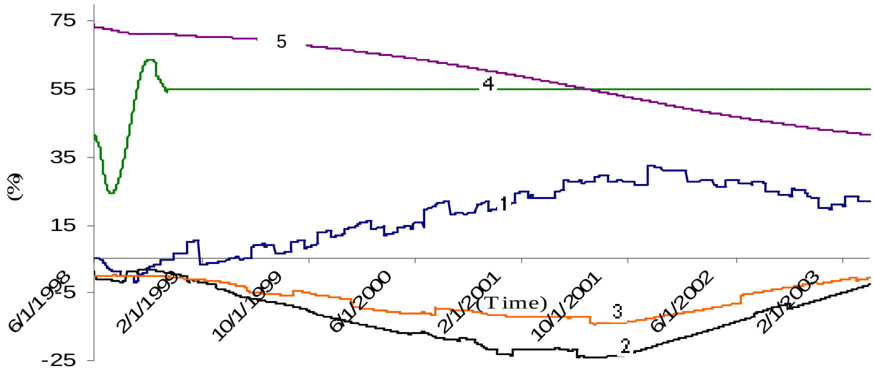
If one considers inter-partner harmony as a long-term objective of parent firms, a financial or objective measure in itself is unlikely to capture accurately an IJV's relative performance against objectives (Chowdhury, 1992). Moreover, there is also the problem of not reporting financial data concerning joint venture performance (Geringer and Hebert, 1991). Thus, instead of measuring financial performance of the ICJV, project output (time, cost and quality) can be considered as objective measure. The ICJV's performance can be reasonably judged in terms of subjective measure and objective measure. According to Mohamed (2003), the subjective and objective measures representing performance, is measured by three items, namely; (1) *Value* (reflecting the overall business benefit including tangible and intangible gains derived), (2) *Project output* (reflecting project-based tangible gains), and (3) *Satisfaction* (reflecting the organization's willingness, given the opportunity, to have a continued relationship beyond the project under investigation).

SYSTEM DYNAMICS MODELLING PROCESS

Sterman (2002) proposed a modelling process which has been adopted in this study. First step is to articulate problem to be addressed. Second step is to formulate of dynamic hypothesis or key feedback loops. Third step is to construct a formal model which is incorporating the dynamic hypothesis along with other structural details of the system related to the problem being addressed. Fourth step is to test the model until it satisfies the purpose, and fifth step is to design and evaluate policy for improvement. Powersim® software has been used for the task of system dynamics modelling as building causal loop diagrams, stock and flow maps, an elaborate model, testing, simulation, and policy analysis. In order to develop firstly, reference modes and some key feedback loops, secondly, formulate and validate the model both structurally and behaviourally and lastly policy formulations both qualitative and quantitative data are gathered by conducting four phases' intensive interviews of 12 key personnel from two ICJVs in Thailand.

One is related to double track railway project. Local company had been at the forefront of this effort, undertaking civil works of approximately 193.5 km starting from June, 1998 to April, 2003 and foreign partner supporting technical part, which is considered as Project A in this paper. Another one is related to instalment of fibre optic cables in the same trench as the product pipe for oil and gas, which is considered as Project B. Foreign joint venture partner joined in this telecommunication project in order to transfer latest technology to the local partner. Local company installed 11,000 km of fibre and around two hundreds of control stations across the country starting from January, 1999 to December, 2002.

The historical data for satisfaction and value from the interview have been developed by the interviewees and then combined as a cumulative average value and develop points for the reference mode for each ICJV in a scale of 0-100% with a range from very low to very high. However, the reference data of project output (time, cost and quality) have been gathered in terms of tabular form. In order to have better understanding of the project output, cost is referred by project cost discrepancy, time is by schedule pressure and quality is by quality discrepancy. The discrepancy is the difference of the actual to the desired one. Due to the space constraint, only the reference modes of Project A are shown in Figure 1.



Legends: 1-project cost discrepancy; 2-schedule pressure; 3-quality discrepancy; 4-value; 5-satisfaction

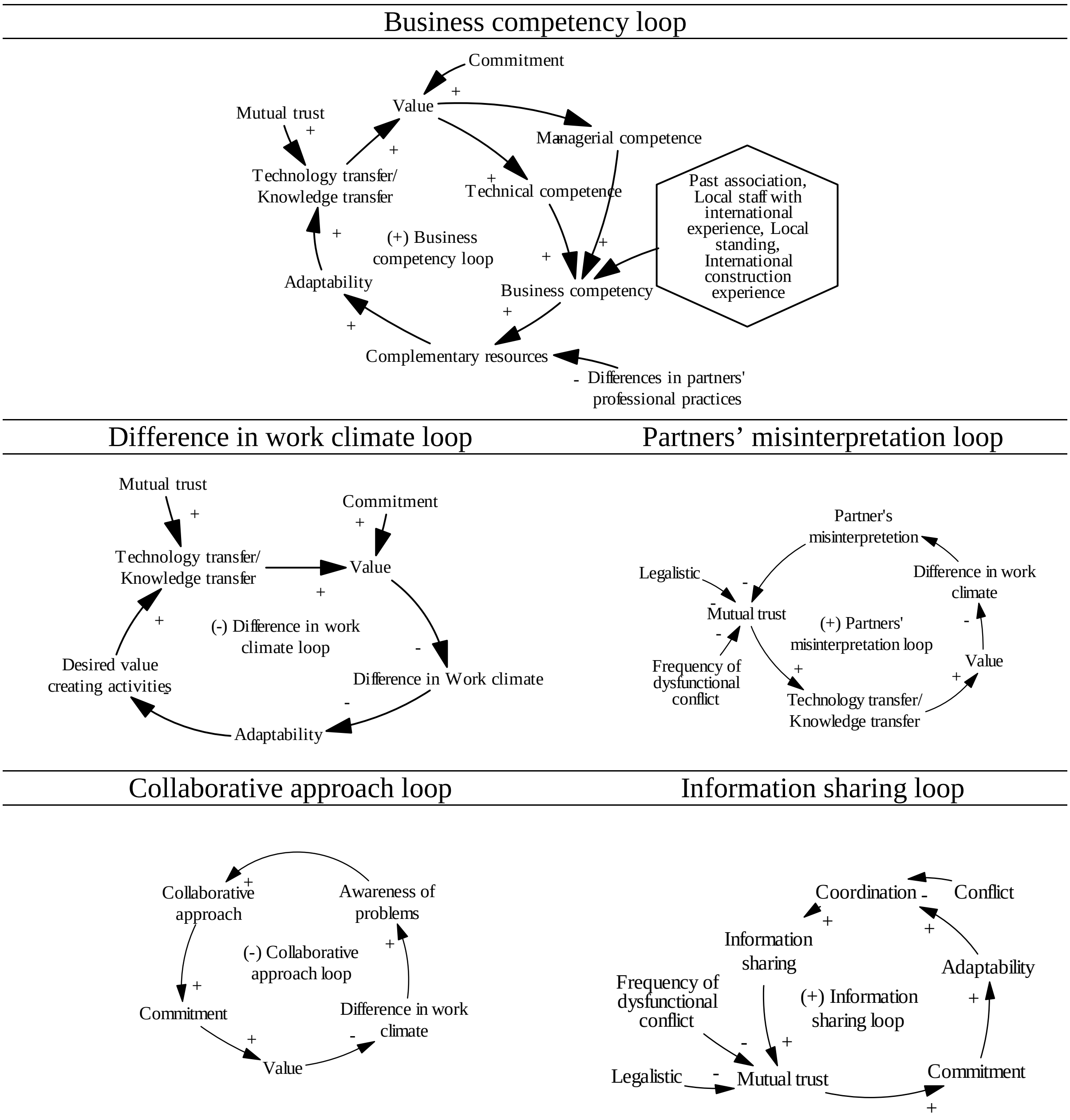
Figure 1: Feedback loops concerning value

Key Feedback Loops

A set of dynamic hypotheses have been developed in order to investigate the effect of variables on performance of ICJV. The feedback loops have been developed by using the knowledge gained from literature review and interviews conducted with the concerned personnel in the case study joint ventures. The whole causal-effect relationships or feedback loops have been broken down into feedback loops concerning value (Figure 2), feedback loops concerning project output (Figure 3a) and feedback loops concerning satisfaction (Figure 3b).

Feedback loops concerning value

Business competency loop: Shenkar and Li (1999) found that partners tend to see that IJVs are the preferred way to gain tacit or embedded knowledge, particularly management skills or intangibles. More explicit knowledge such as marketing and technological may be equally learned by other forms of alliances as by IJVs (Pucik, 1988). The technical and managerial knowledge transfer can be described as 'value'. The 'value' increases managerial as well as technical competency which in turn increase business competency.



Legend: ⟶ A causal relationship; + (-) signs at the arrowheads indicate that the effect is positively (negatively) related to the cause

Figure 2: Feedback loops concerning value

Business competency is also positively affected by local staff of international experience, past association, local standing and international construction experience. However, differences in partners' professional practices induce negative impact on complementary resources as there are differences of using functional practices such as dissimilarity in using technical specifications, codes and different management system (i.e., accounting system, cost control system, quality control system, human resource management system etc.). Higher business competency enhances the chance to share resources as a part of complementary and which positively affects adaptability. The ‘value’ can be extended to include the cases in which the knowledge in question is itself a set of learning skills constituting of firm’s adaptability or absorptive capacity. This capacity increases as a function of previous experiences through sharing of complementary resources, its learning processes, and the need for information that the partners consider lacking in order to attain its strategic objectives (Huber, 1991). The partner’s ability to monitor, process, integrate and deploy new flows of knowledge will depend, among other things, on its ability to link this knowledge to its existing knowledge base. Furthermore, Huber (1991) also found that partners are more likely to search for partners with complementary knowledge, e.g., a managerial skill base complemented by a technological or marketing skill base. However, the level of expertise that a firm may actually gain through a technology transfer will vary. Leonard and Barton (1992) suggested that a higher adaptability will increase the technology and knowledge transfer and which lead more value added to the IJV.

Difference in work climate loop: The deep level of technological and managerial knowledge transfer (higher value) enhances the adaptability and competitiveness of the firm in a changing environment by reducing the difference in work climate. The higher ‘value’ of IJV means that the partners have adopted similar measurement and functional control systems and so the partners reduce desired ‘value’ creating activities. As the desired ‘value’ creating activities decreases, the level of ‘value’ of the IJV will be static or decrease. The decrement of ‘value’ level may be due to the adopted systems do not serve as efficient system and in addition to that changes in project scope may require more technical and managerial knowledge transfer.

Partners’ misinterpretation loop: Higher difference in work climate increases misinterpretation between partners and consequently decreases mutual trust. The lower is the mutual trust; the lesser will be the technology/knowledge transfer. However, lower technology and knowledge transfer decreases ‘value’, problem solving as the partners are not willing to share knowledge due to lower trust level. So, lower value can not minimize the difference in work climate.

Collaborative approach loop: If companies are not aware of (the extent of) differences between partners, functional management tasks may not be carried out efficiently and tasks may be duplicated or tackled in incompatible ways. If differences become apparent through misunderstandings and conflicts, partners need to evaluate different approaches, which take longer the more dissimilar the approaches are. Sometimes, difference in work climate leads to increase awareness regarding the negative impact between the partners and try to minimize the difference by introducing collaborative approach. This collaborative approach will increase the commitment for long term relationships. As commitment increases, ‘value’ is also stimulated and in turn reduces the difference in work climate of the joint venture

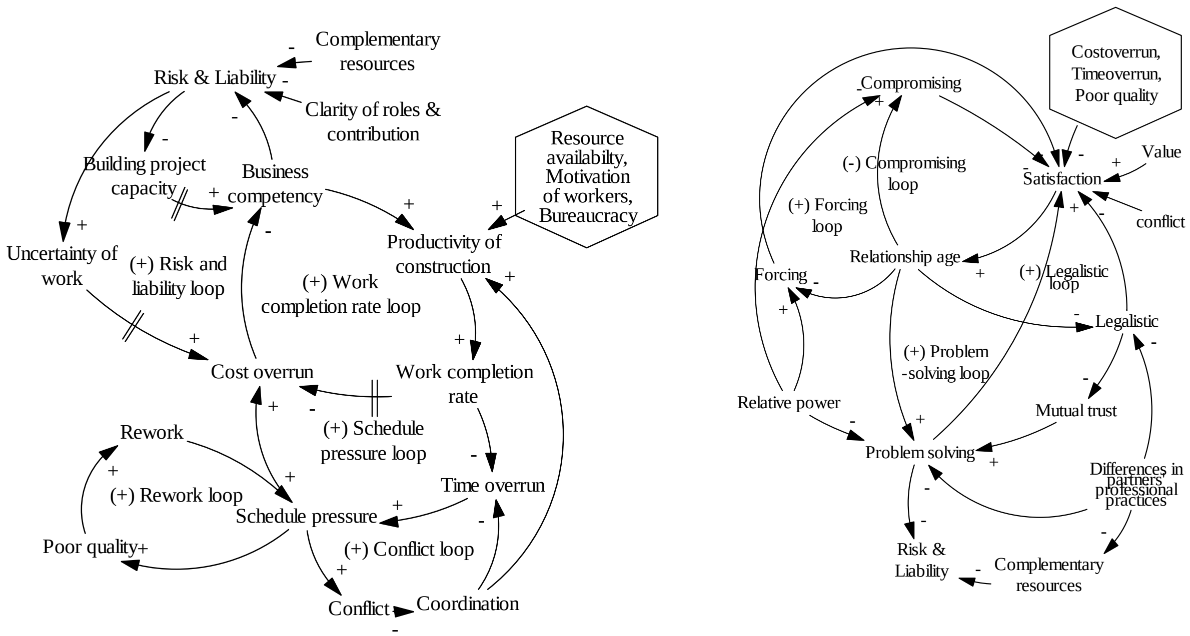
Information sharing loop: If the adaptability is higher, there will be more coordination among the different functional units due to less learning gap. Coordination induces an environment of openness which leads to increases information sharing among the project participants. Effective information sharing stimulates mutual trust as it reduces operation process delay.

Commitment for long term relationship is affected by the mutual trust between the partners. If the mutual trust is high, commitment will be high.

Feedback loops concerning project output

Work completion rate loop: If the business competency is high, then productivity of construction will be high due to intervention of new technology, and higher efficiency in operational control. Productivity of construction is also positively influenced resource availability, motivation of workers, coordination and negatively influenced by government bureaucracy for getting permit. Higher productivity increases work completion rate and higher work completion rate decreases cost overrun. As there is less chance of cost overrun, the business competency will be increased due to higher profitability.

Schedule pressure loop: On the other hand, if the work completion rate is lower, the probability of time overrun of the project will be more likely. Schedule pressure is affected by time overrun and it affects cost overrun due to overhead cost. Sometimes cost overrun creates financial instability which in turn negatively effect business competency.



(a) (b)

Legend: ⟶ A causal relationship; + (-) signs at the arrowheads indicate that the effect is positively (negatively) related to the cause; ⟶ Delay sign

Figure 3: (a) Feedback loops concerning project output; (b) Feedback loops concerning satisfaction

Rework loop: When the schedule pressure continues to increase as a result of an increase in aggressive scheduling it can bring about other negative effects on the work site. First, the higher the schedule pressure the greater will be the amount of work performed out of sequence. Second, workers may intentionally try to cope with schedule pressure by cutting corners. Third, an increase in schedule pressure may increase the number of work defects through the selective use of information, which, unlike the previous effect, can occur unintentionally. This situation is due to the fact that under high-pressure conditions, site staff and workers are likely to engage in activities that make progress even though not all the prerequisite information is available. All these phenomena—working out of sequence, cutting corners, and work defects—are responsible for increasing the amount of rework. The increase in rework on construction sites is arguably a quality problem.

Conflict loop: Conflict may arise due to increase in schedule pressure and which leads to decrease in coordination of work in the project. As the coordination decreases, the process time will increase which in turn increase schedule pressure.

Risk and liability loops: If the company has higher business competency, then the probability of managing risk will be higher. The company increases their project capacity as there is less risk involved by investing more on similar type of project. On the other hand, if the risk is more, the uncertainty of work will be more. Uncertainty of work increases cost overrun due to more time is required to response the unexpected situation.

Feedback loops concerning satisfaction

Problem-solving loop: As a conflict resolution strategy, problem-solving approach tends to make a relationship more satisfying, since it aims at achieving positive outcomes for both partners (Campbell et al., 1988). So, the relationship age would be last long. As a relationship endures, shared experience may facilitate an open problem-solving approach to resolve conflicts. An ICJV partner can use its relative power as a mechanism to coordinate and integrate the activities of the two ICJV partners. But unbalanced power relations provide an incentive to less integrative behaviour when conflicts need to be resolved. The more powerful an ICJV partner, the more likely it is that a lengthy problem-solving process can be avoided, especially during the formative stage of an International Joint Venture (Friedmann and Beguin, 1971) that means higher difference in relative power reduce the probability of using problem-solving as a negotiation strategy.

Compromising loop: Compromise approach tends to make a relationship less satisfying and is likely to be observed in short term relationships, since long term partner often understand better that short-term asymmetries in bargaining outcomes are likely to balance out in the long run (Dwyer et al., 1987). The more powerful an ICJV partner, the more likely it is for the partners not to seek compromise, since their powers offer them leverage with which they can make their preferences prevail.

Forcing loop: In general, power asymmetries induce more chance for partner to engage in more demanding coercive behaviour (i.e., forcing). The tendency to be forceful during a conflict may decline with IJV age, since partners are more likely to become concerned with the other party's interests.

Legalistic loop: A party's reliance on legal mechanisms may decline as an IJV ages, since uncertainties regarding the other party's competence, reliability, and other qualities tend to decrease over time. When IJV partners view one another regarding difference in professional practices, the feeling of a lack of common ground may result in higher degree of perceived behavioural uncertainty. As a consequence, the parties may be more likely to place their trust in legal and written documents and hence to rely upon legal mechanism for resolving conflicts which tend to make a negative impact on satisfaction when more legal changes are occurred.

Model Formulation

The structure of the generic model has been developed based on the aggregated views and opinions of the interviewees. The generic model is preliminarily divided into three subsystems (value, project output and satisfaction). Also, each subsystem can be divided into sectors. While implementing in real case studies, the generic model has been modified into two different models for two different ICJV projects. In the modified models only the input values are different but the structures are same as generic model. The modified model's scope and focus are reflected in the model boundary as shown in Table 1. The modified model consists of various variables. The interrelationships among the variables have been translated in terms of equations and graphical representations. The details of the model formulation and output of the simulations are somewhat large in volume. The whole set of representations related to model formulation can be provided upon request.

Table 1: Model boundary chart

Endogenous	Exogenous	Excluded
Mutual trust, Partner's commitment, Difference in work climate, Conflict resolution procedure, Communication and information exchange, Legalistic, Managerial competence, Technical competence, Financial status, Business competency, Complementary resources, Productivity in construction, Project scope, Coordination, Frequency of negotiation, Conflict, Project scope, Project output	Local standing, Past association, Prior ICJVs experience, Local staff with international experience, Fluctuations in exchange rate, Change in material price, Difference in partners' professional practices, Bureaucracy, Resource availability, Relationship age, Relative power, Clarity of roles and contribution	Changes in policies, Inconsistencies in laws and regulations Corruption and bribery**,** Cash flow problems**,** Incompetent suppliers or subcontractors**,** Local business environment**,** Market contacts and knowledge

Model Behaviour, Validation and Sensitivity Analysis

The model has been validated in terms of structurally and behaviourally. Structural validation includes structural assessment test and dimensional consistency check. Structural assessment test is related to check interrelationship among variables. In the second phase interviews, all the equations and graphical relationships have been checked thoroughly by the interviewees and rectified any corrections at the same time. Dimensionally consistency check is automatically tested by the inherent function of Powersim®. Behavioural validation can be done by comparing base run with reference mode and also by parameter sensitivity analysis. While comparing base run (Figure 4a) with historical data (Figure 1), the output of the model replicates historic data well. Parameter sensitivity is usually performed as series of tests in which the modeller sets different parameter values to see how a change in the parameter causes a change in the dynamic behaviour of the model. The sensitivity analysis has been done for the model and it has been found that the model is numerically, behaviourally or policy sensitive.

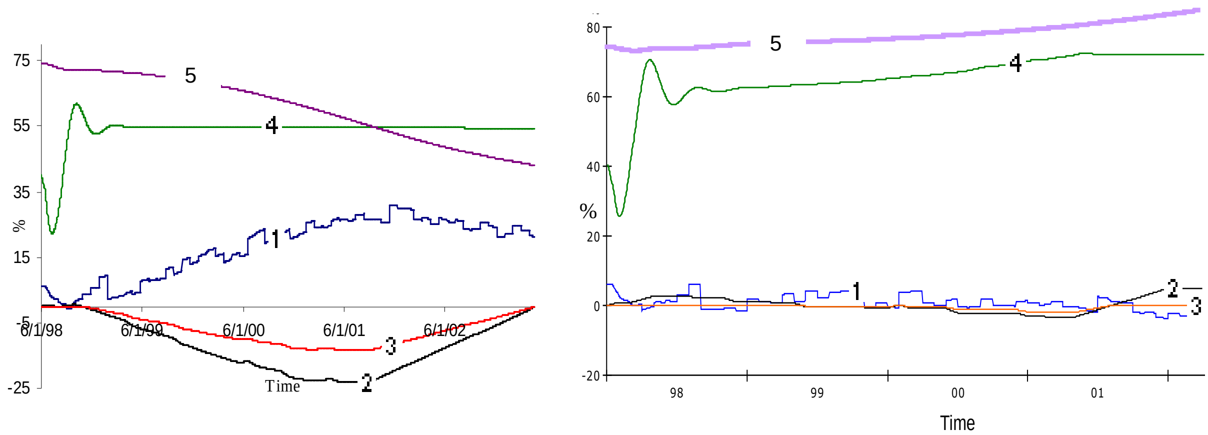
Formulation of Policies

While simulating the model, three major types of problems have been identified for both the projects as shown in Table 2. In order to identify a set of effective and implementable policies in order to improve performance of ICJV, extensive model simulations have been made. In these simulation runs, certain parameters value used for the degree of importance of the specific variables do not necessarily show the exact numerical values rather emphasis is given on the degree of importance of these variables.

Table 2: Policy formulation

Problems	Policy	Remarks
Delay, cost overrun and poor quality: Low productivity (unavailability of skilled labour and lack of motivation)	Performance based incentive,, Problem solving team, Multiple skilled training of workers(Policy I)	Apart from improvement in project output, significant positive changes observed in business competency for project A and satisfaction level in project B.
Negative value gap (difference between desired value and actual value) due to low adaptability	Training, Workshops, High performance team (Policy II)	Policy has made a significant impact on mutual trust, business competency and satisfaction level for both Project A and Project B
Ineffectiveness of information sharing	Integrated proactive team, 'Project web' (Policy III)	Policy has made a significant improvement in trust level for both project A and B

Initially, three policies are addressed as to improve performance components rather than whole performance and identified evolutionary change in the behavioural sensitive parameters but later on integrated all three policies to get the maximum performance improvement (Figure 4 b).



(a) (b)

Legends: 1-project cost discrepancy; 2-schedule pressure; 3-quality discrepancy; 4-value; 5-satisfaction

Figure 4: (a) Base run; (b) After implementing integrated policy

CONCLUSION

The paper explores the dynamic behaviours of ICJV performances by developing generic performance model. While calibrating and testing of the generic performance model with data from two ICJVs in Thailand, the simulated behaviour (base run) of the adopted model has been replicated with the historic behaviour (reference mode) for both cases. This implies that the generic system dynamics performance model can be able to facilitate managers of an ICJV to identify the factors and causes of problems related to performance gap by adjusting inputs of exogenous variables with their real scenario. Based on the case studies, three policies are suggested in order to improve ICJV performance level and integration of these three policies result maximum improvement of performance level. The future research directions related to this study are suggested to incorporate more government related (changes in government policies and inconsistencies in laws and regulations) and project related factors (incompetent suppliers or subcontractors and local business environment) in the performance model.

REFERENCES

Adler, N.J., Brahm, R., and Graham, J. L. (1992) Strategy implementation: A comparison of face-to-face negotiations in the People's Republic of China and the United States. Strategic Management Journal, 13(6), 449-466.

Cambell, N. C., Graham, J., Jolibert, A., and Meissner, H. G. (1988) Marketing negotiations in France, Germany, the United Kingdom, & the United States. Journal of Marketing, 52, 49-62.

Chowdhury, J. (1992) Performance of international joint ventures & wholly owned foreign subsidiaries. Management International Review, 32 (2), 115–133.

Dwyer, F. R., Schurr, P. H., and Oh, S. (1987) Developing buyer-seller relationships. Journal of Marketing, 51(April), 11-27.

Friedmann, W. G. & Beguin, J. (1971) Joint international business ventures in developing countries. New York: Columbia University Press.

Geringer, J.M., and Hebert, L. (1991) Measuring performance of international joint ventures. Journal of International Business Studies, 22, 2.

Huber, G.P. (1991) Organizational Learning: The Contributing Processes and Literatures. Organization Science, 2(1), 88–115.

Leonard, D., and Barton, D. (1992) Core capabilities and core rigidities: A paradox in managing new product development. Strategic Management Journal, 13,111-125.

Mohamed, S. (2003) Performance in international construction joint ventures: Modeling perspective. Journal of Construction Engineering and Management, 129(6), 619.

Pucik, V. (1988) Strategic Alliances, Organizational Learning and Competitive Advantage: The HRM Agenda. Human Resource Management, 27(1), 77–93.

Shenkar, O., and Li, J. (1999) Knowledge Search in International Cooperative Ventures. Organizational Science, 10(2), 34–44.

Sterman, J. D. (2002) System dynamics: Systems thinking & modeling for a complex world. MIT: Cambridge, MA.

Yoshino, M. Y., and Rangan, U. S. (1995) Strategic alliances: An entrepreneurial approach to globalization. Boston: Harvard Business School Press.

DATA FRAMEWORK FOR URBAN SUSTAINABILITY ACCOUNTING

Mohamed A. El-Haram, R. Malcolm W. Horner, and Yangang Xing
Construction Management Research Unit, Division of Civil Engineering,
University of Dundee, Dundee, UK
m.elharam@dundee.ac.uk
r.m.w.horner@dundee.ac.uk
yx@kinetic-aiu.com

Jan Bebbington
Centre for Social and Environmental Accounting Research, School of Management,
University of St Andrews, UK
Kjb10@st-andrews.ac.uk

One of the principal challenges facing urban sustainability decision makers is the difficulty of measuring costs and values which are expressed in different units and the difficulty of comparing the social benefits of a more expensive housing scheme for example that provides an environment which leads to improved health and wellbeing with a cheaper one that does not. Sustainability accounting requires large quantities of data if we are to properly assess the direct and indirect environmental and social aspects and potential impacts throughout the whole life cycle of a building. At present, there are large gaps in the data, and even where data exist, they have not been collected specifically for sustainability accounting analyses. As a result the amount of useful data available is limited and inconsistent. The paper describes the development of a sustainability accounting framework for constructed projects that can be used to analyse the environmental, social and economic costs and benefits at different stages in the life cycle.

KEYWORDS: urban sustainability accounting, sustainability assessment, sustainable urban developments

INTRODUCTION

Since the 1980s, there has been a massive increase in published and online materials dealing with sustainability and sustainable development. Although there remains much confusion and disagreement about the precise meaning of sustainable development, there is a broad consensus that the concept draws together economic, environmental and social objectives. The best known definition, however, is that in the Brundtland Report, where it is suggested that sustainable development means “development that meets the needs of the present generation without compromising the ability of future generations to meet their own needs” WCED, 1987). The UK Government has defined sustainable development as “ensuring a better quality of life for everyone now and for future generations to come” through the pursuit of four objectives (DTER, 2000):

- social progress which meets the needs of everyone
- effective protection of the environment

- prudent use of natural resources
- maintenance of high and stable level of economic growth and employment.

From the above definition, sustainable development is therefore a multi-dimensional concept which encompasses three broad themes: environmental, social, and economic. It is increasingly evident that solutions that address only environmental, only social or only economic aspects and concerns are fundamentally insufficient. What is needed is a form of multi disciplinary thinking that focuses on the integration of all the dimensions throughout the whole life of the system/ product/ project/ policy or programme. In order to integrate the economic with the environmental and social dimensions, new metrics, models and tools are required. The continuing debate on sustainability has raised wide concerns about how to integrate environmental, social and economic aspects into the decision-making process. The most significant factor affecting the potential for sustainable urban development today is urbanisation. It is projected that by 2050, when the world's population will have increase to nine billion, two thirds of whom will live in urban areas (Bos et al., 1994 and UN,1993). Of particular importance within urban areas is the built environment which includes buildings and structures of all types, such as offices, shops, factories, residential buildings, transport infrastructure, public utilities and other man-made modifications to the natural environment (Lombardi and Brandon, 1997). The built environment includes not only buildings and structures, but the spaces between them and the supporting infrastructure too. It encompasses a range of scales from functional units within buildings to entire urban areas. The sustainability of the built environment depends on a fundamental shift in the way resources are used: from non-renewable to renewable, from high levels of waste to high levels of reuse and recycling, and from projects based on lowest initial cost to those based on whole life costs and full cost accounting.

This paper describes the development of a generic framework for data structure for sustainability accounting which can be tailored to suit different contexts from building component to complete urban developments, from inception to demolition. The research described in this paper is part of a research programme, "Metrics, Models and Toolkits for Whole Life Sustainable Urban Development" undertaken by a consortium from Dundee, Loughborough, Glasgow Caledonian and St Andrews Universities and funded by the UK EPSRC under the Sustainable Urban Environments strand of activity.

SUSTAINABILITY ASSESSMENT

Assessment of sustainability firstly requires that the concept of sustainability be well defined. This has led to numerous definitions of sustainability assessment. For example: Pope et al. (2004) defined sustainability assessment as a process by which the implications of an initiative on sustainability are evaluated. Therivel et al. (1992) defined it as a formal process of identifying, predicting and evaluating the potential impacts of a wide range of relevant initiatives (such as legislation, regulations, policies, plans, programmes, and specific projects) and their alternatives on the sustainable development of society. Devuyst, (2001) defined sustainability assessment as "a tool that can help decision-makers and policy-makers decide what actions they should take and should not take in an attempt to make society more sustainable". Many tools have been developed to support the implementation of sustainable development. Each kind of tool is designed to assess one or more sustainability dimensions (environment, social and economic).

A holistic perspective is one of the Bellagio's principles of sustainable development assessment. This perspective requires a review of the whole system as well as its parts; consideration of the well-being of the human, environment and economic sub-systems and their component parts and the interaction between parts; and a consideration of both positive and negative consequences of human activity, in a way that reflects the full cost and benefits for human and ecological systems, in monetary and non-momentary terms (iisd, 1997).

The implementation plan of the Johannesburg World Summit of Sustainable Development (UN, 2002) has given added emphasis to the need for integration and encourages a greater integration in the use of different assessment tools. An integrated assessment approach is a starting point for sustainability appraisal for a project or programme within its context (Abaza et al., 2004). Two distinct forms of integration were identified by Salder (1999):

- substantive integration of the main type of impact (economic, environmental and social) linking together separate impact assessments, which are undertaken at different stages in the policy, planning and project cycle;
- horizontal integration of assessments, bringing together different types of impact into a single overall assessment at one or more stages in the planning cycle, linking together separate impact assessments which are undertaken at different stages in the policy, planning and project cycle.

Sustainable development requires decision-makers to account for environmental and social impacts in the same way they do economic impacts. Costing tools such as eco-efficiency analysis and whole life costing focus on cost implications. They are in essence divorced from social elements and there is in general little assessment of social costs, partly because these costs are very difficult to quantify. However, since environmental costs like pollution or noise impact directly on people and communities, they should not be omitted, and we seek to include them in the analysis. Recently, ISO Standard 15686, Part 5 (BSI, 2003) highlighted the need to include environmental and social costs in the estimation of whole life costing. However, Full Cost Accounting (FCA) is a holistic approach which demands a consideration of stakeholders and their surrounding ecosystem and both negative and positive implications of human activities (ACCA, 2002**).**

Full cost accounting (for recent published reviews see Bebbington 2007; Lamberton, 2005) is an accounting tool that seeks to identify all external costs associated with a particular activity and to incorporate this information in decision-making processes (Bebbington et al., 2001). The assumption underlying the desire for FCA is that if one were to account for externalities then society could be better informed as to which decisions would be more likely to make sustainable development achievable (Bebbington, 2001). Full cost accounting has been identified as one way forward to analyse the environmental, social and economic costs and benefits at different spatial scales and at different stages in the life cycle (Xing et al., 2007). Sustainability accounting therefore brings together different types of impacts - economic, environmental and social - into a single, overall assessment. Whether or not this is desirable is the subject of debate (Gasparatos et al., 2008)

URBAN SUSTAINABILITY ACCOUNTING DATA STRUCTURE FRAMEWORK

Urban sustainability accounting requires a large amount of data if we are to assess direct and indirect environmental and social impacts throughout the whole life cycle of a building component, building or a city. There are large gaps in the data, and even where data exists, they have not been collected specifically for sustainability accounting analyses. As a result the amount of useful data available is limited and inconsistent.

The proposed urban sustainability accounting data breakdown structure considers the spatial scale of assessment, the life cycle, sustainability impacts, and finally stakeholders.
The proposed urban sustainability accounting breakdown data structure is divided into 6 stages as shown in Figure 1. A brief description of the composition of each category of the data structure is given below.

Object of assessment

A key to effective urban sustainability assessment in general and urban sustainability accounting in particular is an understanding of the object of the assessment. This understanding will help the user of full costing accounting to collect data and information at the appropriate level, identify stakeholders and organisations that are involved at each level, and formulate the sustainability issues and related impact at the appropriate level. Bottom-up scaling consists of taking information at smaller scales (material level) to derive processes at larger scales (city) while top-down scaling consists of decomposing information at one scale into its constituents at smaller scales. The objects of an urban development can be broken down into the following levels: material, component, building, part of a city and city as shown in Figure 1.

Life cycle

Every object of assessment of urban development has a different life cycle defined as the set of stages from its inception to disposal at the end of its useful life. The life cycle of a component for example can be broken into: extraction of materials, manufacturing, construction, maintenance and replacement, recycle and reuse and finally disposal. The life cycle phases of a building can also be broken down into planning and design, construction, facilities management (operation and maintenance, reuse), and decommissioning at the end of its life. These phases can be further broken down into sub-stages: design stage for example can be broken down into feasibility, outline, scheme and detailed stages (El-Haram et al., 2007)

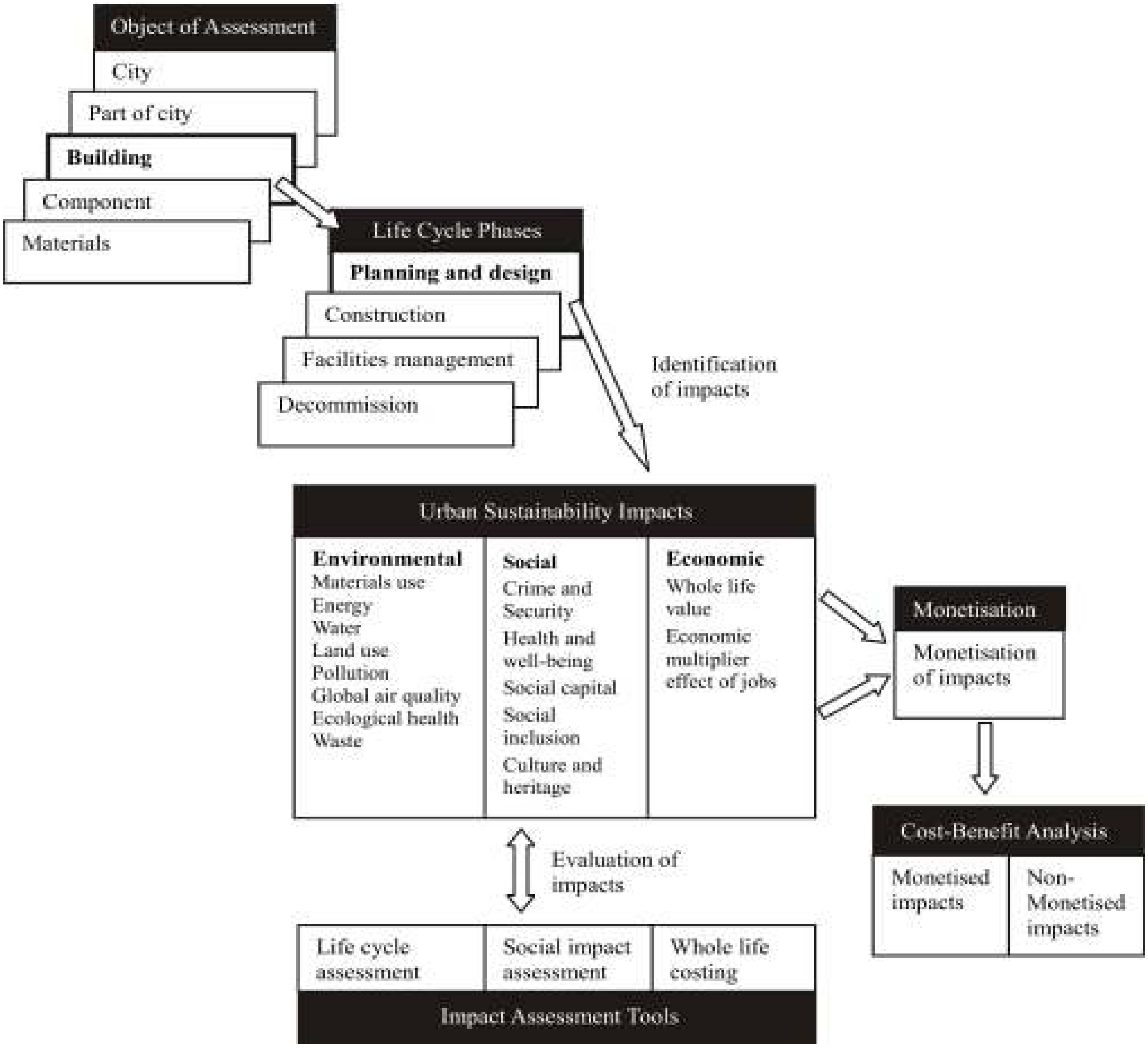


Figure 1: Framework for urban sustainability accounting model

Sustainability issues and impacts

An extensive literature review on urban sustainability undertaken as part of an earlier study by Walton et al. (2005) and El Haram et al. (2006) has identified 650 sustainability issues (environmental, social and economic) associated with each life-cycle stage of buildings, open spaces and on-site infrastructure of an urban development including those relating to the manufacture and transport to site of construction materials. The authors identified 900 sustainability indicators through a literature review, workshops and questionnaire survey.

A rigorous consolidation exercise was carried out to identify the major impact categories based on the 600 identified indictors. Table 1 shows the sustainability impacts of a building level identified in the three exercises (Xing et al, 2008).

Table 1: Sustainability impacts at the building level

Environmental impacts	Social impacts	Economic impacts
• Materials use • Energy • Water (including impacts on hydrological assets) • Land use • Pollution to air (Local Air Quality) • Global air quality (Climate change) • Pollution to land (Land contamination) • Pollution to water (Water contamination) • Ecological health (e.g. change in biodiversity) • Waste	• Health • Crime and Security • Safety • Social capital • Heritage • Mobility and Access	• Whole life value (e.g. construction, maintenance, operation costs, pollution cost, etc) • Economic multiplier effect of jobs

Assessment impact tools

In order to identify and assess the magnitude of the each impact identified in Table 1, it is necessary to use the tools that can help in identifying and quantify the environmental, economic, and social impacts for each object of assessment.

Life cycle assessment (LCA)

After the emergence of life cycle analysis and life cycle assessment (LCA) as an effective tools for analysing the various environmental impacts of a product or project in all stages, the need arises to analyse the cost of these impacts (Durairaj et al., 2002). Life cycle assessment focuses on the impacts not just of a particular component/building, but of the materials and energy required to produce the component/building, and the waste produced by the component/building. It is a "cradle-to-grave" assessment tool (Canter, 1996). There are already several LCA-based building-oriented decision support tools in use in various parts of the world, for example Envest in the UK, EcoQuantum and SimaPro in the Netherlands, and ATHENA in North America.

Whole life costing (WLC)

Just as LCA is a methodology for assessing the environmental performance of a product or project over its whole life cycle, WLC is a methodology for estimating the costs of a product/ project over its whole life cycle. It is defined as a technique for examining and determining all the costs - in money terms - direct and indirect, of designing, building and facility management (operating, maintenance, support and replacement) of an element/product/project throughout its entire service life including the disposal cost (El-Haram et al., 2002). Whole life cost analysis for a unit of the built environment, say a building, is an economic and engineering evaluation tool for choosing among alternative options by comparing all the significant, different design/build, operation, and maintenance cost options over a given time period in equivalent economic terms. Therefore, WLC is the logical counterpart of life cycle assessment for the economic assessment. WLC is a purely economic cost calculation which takes into account hidden costs and potentially external cost over the life cycle of an element, product, or project. WLC is recognised as a valuable method for comparing alternative building elements, enabling future cost and benefits to be evaluated against any initial cost increases (Aye et al., 2000).

Social impact assessment (SIA)

A framework for social impact assessment has been developed by Dreyer et al. (2005). The SIA method aims to help providing information about the potential social impacts on people caused by the activities in the life cycle of their component/ building. Although little work has so far been performed in social impact assessment (e.g. O'Brien et al., (1996) and Dreyer et al. (2005)), attempts are on-going to develop an approach for quantifying social impacts under the UNEP/SETAC Life Cycle Initiative, and a task force has been dedicated to this topic (UNEP, 2002).

Monetisation techniques

The challenge for sustainability accounting is to monetise the identified impacts. In a sustainability context monetisation can be defined as a process of assigning or determining the equivalent non-market value of environmental and social impacts (Gilchrist and Allouche, 2005). It forms the basis for stakeholders and key decision makers to decide whether or not the environmental and social impacts from a project are acceptable. Various techniques are available for monetization. Gilchrist and Allouche (2005) classified these valuation techniques in two groups – Direct valuation techniques and indirect valuation techniques. Table 2 shows the available direct and indirect valuation techniques (Gilchrist and Allouche, 2005). The selection of the appropriate technique will be based on the data available for monetizing the impacts under consideration.

Table 2: List of direct and indirect valuation techniques

Direct Valuation Techniques	Indirect Valuation Techniques
1. Damage Costs	1. Hedonic Valuation
2. Human Capital	2. Travel Cost Method
3. Changes in Productivity	3. Dose Response Method
4. Future Scarcity Value	4. Contingent Valuation
5. Lane Closure Cost	5. Conjoint Valuation
6. Control Cost	6. Compensation Value
7. Rehabilitation Value	7. User Delay Cost
8. Replacement Cost	
9. Remediation Cost	
10. Current Market Price Method	

One of the greatest problems in monetary valuation of environmental and social impacts is where the boundary should be drawn for calculating the sustainable cost. Once the boundaries or scale has been decided, it allows the user to collect the relevant data up to that level, identify stakeholders, affected persons and organizations that will be involved.

Confining the limits of calculation facilitates the definition of all the related sustainability issues and impacts.

Stakeholders and decision-makers

Stakeholder engagement underpins the Sustainability accounting model. It is critical that stakeholder engagement takes place early and often. Stakeholders may be numerous and various. . The broad urban sustainability stakeholder types can be classified into three main categories: a) those who affect the project (e.g. developer, owner, investor, contractor, local authority, regional and central government departments, etc); b) those who are affected by the project (e.g. users, general public, etc); and c) others who may be interested (e.g. environmental/social campaigning organisations, researchers/ academics, media etc) (Vivek et al. 2007). Identifying stakeholders for an object of assessment can be especially difficult. The method which will be used to identify the stakeholder is adapted from INVOLVE (Involve, 2005). In order to compare the sustainability of one option with another, an integrated sustainability accounting model must be capable of aggregating the economic, environmental and social impacts on every stakeholder at each stage of the life cycle of every level of an urban development.

CONCLUSIONS

This paper reports the development of a framework for a sustainability accounting data structure with the focus on urban developments. The data structure forms the basis for the development of a sustainability assessment model framework that will be tested on different objects of assessment at different stages in their life cycles. The sustainability assessment model is designed to be able to analyse the environmental, social and economic costs and benefits in monetary terms and the relative merits of alternative solutions to the design of urban developments in a common currency. The research team is currently working on the development of a detailed framework which will include issues of equity in terms of who enjoys the benefits and who carries the burden of urban developments.

ACKNOWLEDGEMENTS

The authors gratefully acknowledge the financial support of the United Kingdom's Engineering and Physical Sciences Research Council (grant reference: EP/C008030/1) and the support of other members of the SUE-MOT Consortium.

REFERENCES

Abaza, H., Bisset, R., and Sadler B. (2004) Environmental impact assessment and strategic environmental assessment: towards an integrated approach, United Nation Environmental Programme.

ACCA (2002) Industry as a partner for sustainable development: Accounting, Association of Chartered Certified Accounts and Untied Nation Environmental Programme

Aye, L., Bamfor, N., Charters, B., and Robinson, J. (2000) Environmentally sustainable development: a life-cycle costing approach for a commercial office building in Melbourne, Australia, Vol. 18, no. 8, pp 927-934.

Bebbington, J. (2001) Sustainable development: a review of the international development, business and accounting literature, Accounting Forum, Vol. 25, no. 2, pp 128-157.

Bebbington, J. (2007) Accounting for sustainable development Performance, CIMA publishing, London

Bebbington, J., Gray, R. and Kirk, E. (2001) Full cost accounting: an agenda for action, Association of Chartered Certified Accountants, London.

Bos, E., Vu, M., Masiah, E., and Bulatao, R. (1994) World Population Projections - 1994-1995 Edition, Johns Hopkins University Press, Baltimore, USA.

BSI (2003) BS/ISO Standard 15686-5 "Buildings and constructed assets - Service life planning", Part 5; Whole life costing, British Standards Institution/The International Organisation for Standardisation.

Canter, L.W. (1996) Environmental impact assessment, 2nd edition, McGraw-Hill, New York

DETR (2000) Sustainable development: what it is and what you can do, DETR Green Ministers

Devuyst, D., (Ed.) (2001) How green is the city? Sustainability assessment and the management of urban environments, Columbia University Press, New York

Dreyer, L.C., Hauschild, M.Z., and Schierbeck, J. (2005) A framework for social life cycle impact assessment. International Journal of Life Cycle Assessment.

Durairaj, S. K., Ong, S.K., Nee, A. Y. C., and Tan, R. B. H. (2002) Evaluation of life cost analysis methodologies, Corporate Environmental Strategy, Vol. 9, no. 1, pp 30-39.

El-Haram, M. A., Marenjak, S. and Horner, M. W. (2002) Development of a Generic Framework for Collecting Whole Life Cost Data for the Building Industry, Journal of Quality in Maintenance Engineering, Vol. 8, No. 2, pp. 144-151

El-Haram, M., Walton, J., Edum-Fotwe F., Horner R. M., Hardcastle C., Price A. and Maxwell D. (2006) Development of a visual map of urban sustainability, Edited by Monjur Mourshed , Proceedings of the GBEN2006 Conference, Global Built Environment: Towards an Integrated Approach for Sustainability, pp 98-108, 11-12 September 2006, Preston, UK.

El-Haram, M., Walton, J.S., Horner, R.M.W., Hardcastle, C., Price, A., Bebbington, J., Thomson, C.S., Atkin-Wright, T. (2007) Development of an Integrated Sustainability Assessment, Proceedings of the International Conference on Whole Life Urban Sustainability and its Assessment, Glasgow, June 2007.

Gasparatos, A., El-Haram, M., Horner M., (2008) A critical review of reductionist approaches for assessing the progress towards sustainability. Environmental Impact Assessment Review, 28, pp 286–311.

Gilchrist, A. and Allouche, E.N. (2005) Quantification of social costs associated with construction projects: state-of-the-art review. Tunnelling and Underground Space Technology 20, 89–104

International Institute for Sustainability Development (iisd) (1997) Assessing Sustainable Development: Principles in Practice. http://www.iisd.org/pdf/bellagio.pdf

INVOLVE (2005) People and participation: how to put citizens at the hart of decision making, INVOLVE, London.UK.

Lamberton, G. (2005) Sustainability accounting – a brief history and conceptual framework. Accounting Forum, Vol 29 7-26.

Lombardi, P.L., and Brandon, P.S. (1997) Toward a Multi-Modal Framework for Evaluating the Built Environment Quality in Sustainability Planning. In Brandon, Lombardi and Bentivegna (eds.), 'Evaluation of the Built Environment for Sustainability', E & FN Spon, London, UK.

Mathur, V. N., Price, A. D. F., Austin, S., Moobela, C. (2007) Defining, identifying and mapping stakeholders in the assessment of urban sustainability "International Conference on Whole Life Urban Sustainability and Its Assessment" (M. Horner, C. Hardcastle, A. Price and J. Bebbington, eds.), Glasgow, Scotland.

O'Brien, M., Doig, A., Clift, R. (1996) Social and Environmental Life Cycle Assessment (SELCA), International Journal of Life Cycle Assessment, Vol 1, No 4, pp. 231-237.

Pope, J., Annandale, D., and Morrison-Saunders, A. (2004) Conceptualising sustainability assessment, Environmental Impact Assessment Review, Vol. 24, pp 595-616.

Salder, B. (1999) A framework for environmental sustainability assessment and assurance, in Petts J. (ed.) Handbook of environmental impact assessment (Volume 1), Blackwell Scientific, Oxford, UK.

Therivel, R., Wilson, E., Thompson, S., Heaney, D., Pritchard, D. (1992) Strategic Environmental Assessment; Earthscan, London.

UNEP (2002) Life Cycle Initiative homepage: http://www.uneptie.org/pc/sustain/lcinitiative/home.htm

United Nations (1993) World Population Prospects, United Nations Department for Economic and Social Information and Policy Analysis, New York.

United Nations (2002) Report of the World Summit on Sustainable Development Johannesburg, South Africa, 26 August- 4 September 2002, United Nations, New York.

Walton, J.S., El-Haram, M., Castillo, N.H., Horner, R.M.W., Price, A.D.F., Hardcastle, C. (2005) Integrated Assessment of Urban Sustainability, Engineering Sustainability, pp 57-65

WCED (1987) Our Common Future, Oxford University Press, Oxford, UK.

Xing Y., Horner, R. M. W., El-Haram, M. A. Bebbington, J. (2008) A Framework Model for Assessing Sustainability Impacts of a Built Environment. Has been accepted for publication in the Accounting Forum Journal.

Xing, Y., Horner, R. M. W., El-Haram, M. A. and Bebbington, J. (2007) A Framework Model for Assessing Sustainability Impacts of a Built Environment. In "International Conference on Whole Life Urban Sustainability and Its Assessment" (M. Horner, C. Hardcastle, A. Price and J. Bebbington, eds.), Glasgow, Scotland

A CRITICAL REVIEW OF THE PRACTICES OF TARGET COST CONTRACTS IN CONSTRUCTION: THE CASE OF HONG KONG

Daniel W.M. Chan
The Hong Kong Polytechnic University, Hong Kong
bsdchan@inet.polyu.edu.hk
Albert P.C. Chan
The Hong Kong Polytechnic University, Hong Kong
bsachan@inet.polyu.edu.hk
Patrick T.I. Lam
The Hong Kong Polytechnic University, Hong Kong
bsplam@inet.polyu.edu.hk
James M.W. Wong
The Hong Kong Polytechnic University, Hong Kong
bsjamesw@gmail.com

Because of the increasing constraints on tight programme, limited budget and project complexity, there is a strong call for changes in contracting procedures in construction. Both the Guaranteed Maximum Price (GMP) and Target Cost Contracting (TCC) schemes are advocated as alternative procurement approaches to achieving more favourable overall project performance. This paper aims to review the perceptions of relevant industrial practitioners on GMP/TCC principles in general and to investigate the GMP/TCC implementation practices and project performance in Hong Kong in particular based on contemporary literature and recently completed local case studies. The research findings indicated that the overall project performance was favourable, especially on the aspects of project schedule, final project cost and dispute (claim) occurrence. Given the remarkable project performance outcomes, a wider adoption of GMP/TCC is anticipated with the purpose of delivering projects ahead of schedule, within budget, with high quality and far less disputes or claims. The research results are useful in assisting key project stakeholders in exploring alternative procurement strategies for application within the construction industry.

KEYWORDS: guaranteed maximum price, target cost contracting, procurement strategies, Hong Kong.

INTRODUCTION

The construction industry has long suffered from a lack of co-operation, limited trust and misalignment of objectives, often resulting in an adversarial working relationship amongst all project stakeholders, and eventually inducing poor project performance (Chan et al., 2004). Both consultants and contractors, beset with fragmented working culture, have therefore little incentive to put in efforts more than just meeting the minimum contractual requirements. Hence, various project stakeholders have been advocating for changes in construction contracting procedures to achieve better value for money and more satisfactory project performance (CIRC, 2001; Chan et al., 2007a).

In particular, incentivisation measures have been successfully implemented in both the United Kingdom and Australia, to integrate the construction delivery process and to motivate service providers to seek continuous improvements in project outcomes (CIRC, 2001). Previous overseas triumphant cases reflected that the guaranteed maximum price (GMP) and target cost contracting (TCC) procurement approaches with a gain-share/pain-share arrangement serving as a cost incentive mechanism, can accrue considerable mutual benefits to all of the parties involved, provided that they are properly structured, implemented and managed (Trench, 1991; Walker et al., 2000).

However, GMP/TCC is still relatively new in the Hong Kong construction industry, and exploring the local practices of implementing this alternative procurement strategy is therefore valuable in serving as a reference for other countries and future procurement development in construction. This paper aims at reviewing the notion of GMP/TCC in general and investigating the GMP/TCC implementation practices in Hong Kong in particular, based on published literature and some selected case studies recently completed in Hong Kong. An empirical questionnaire survey was launched between May and June of 2007 to examine various aspects of project performance outcomes of those indigenous GMP/TCC construction projects.

THE NOTION OF GMP/TCC

TCC is an incentive-based procurement strategy which will award a contractor for any savings made against the guaranteed price or target cost and penalise him when this sum is exceeded as a result of his own mismanagement or negligence according to a pre-agreed share ratio (Masterman, 2002). GMP is regarded as one of the forms of TCC with the sharing arrangement limited solely to the gain (Perry and Thompson, 1982). Figure 1 graphically illustrates the respective definitions of GMP and TCC together with their operational mechanisms. An agreed ceiling price and a gain-share/pain-share mechanism of a project are thus established in the construction contract under this agreement (Clough and Sears 1994; Cantirino and Fodor, 2003). This forms a unique arrangement that shifts from the fixed price approach to a target cost approach based on joint determination and agreement between the client and the contractor on the allocation of shared risks.

In a typical GMP/TCC project, two types of project variations are often pre-defined under the conditions of contract: (1) design development changes (i.e. non-GMP/TCC variations); and (2) GMP/TCC variations (Gander and Hemsley, 1997). The former does not trigger a re-calculation of the agreed GMP or target cost because they are deemed to be included in the fixed lump sum of main contractor's direct works finalised at the contract award stage. However, the GMP/TCC variations can allow for the re-calculation of the agreed GMP or target cost (Fan and Greenwood, 2004; HKHA, 2006) and they will be valued in accordance with the contract documents based on the measured works and schedule of rates. Generally, GMP/TCC variations arise only due to: (1) changes in scope of work such as change in floor area or volume; (2) change in function of an area; (3) change in quality of an area; (4) adjustment of provisional quantities or provisional sums; (5) corrected quantity errors by consultants; and (6) unexpected additional fees or charges imposed by statutory authorities (Fan and Greenwood, 2004). Extras should therefore be related to scope changes requested by the client. The net cost adjustment of such GMP/TCC variations will be added to (for 'addition' work) or subtracted from (for 'omission' work) the contract GMP or target cost.

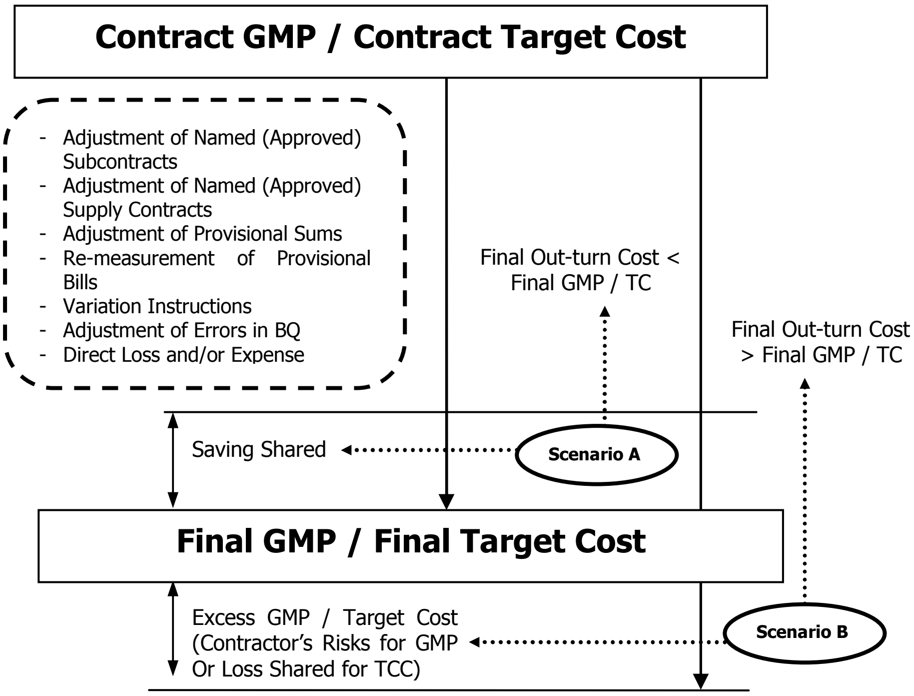


Figure 1: Gain-share/Pain-share Mechanism of GMP/TCC Procurement Strategy [adapted from Cheng (2004)]

The contractor should notify the architect in writing, advising the value and extension of time (if any) if the contractor wishes to make a claim arising out of a GMP/TCC variation; or he disagrees with the architect's decision as to whether or not the architect's instruction is a GMP/TCC variation, all in accordance with the agreed GMP/TCC methodology. If the architect and the contractor disagree on the definition of a GMP/TCC variation, the architect should convene a meeting of an Adjudication Committee to determine the nature and extent of the variation, and to facilitate the resolution of any unresolved issues, which involves representatives from the client, architect, quantity surveyor and main contractor (HKHA, 2006). The intent is to settle any issues at source with a view to enhancing efficiency and accountability. There must be a strong commitment and willingness by all contracting parties to make the GMP/TCC process succeed, and it is better through the teamwork spirit and co-operation of all project team members that this can be achieved (Tay et al., 2000).

SURVEY METHODOLOGY

An empirical research survey questionnaire was developed to solicit the prevailing practices of the GMP/TCC arrangements in the Hong Kong construction industry. A total of 191 senior staff of client organisations, consulting practices, major construction firms and subcontractors who have gained plentiful hands-on experience with GMP/TCC were approached between May and June of 2007 via a set of self-administered survey questionnaires. Respondents were requested to provide detailed information and data of those GMP/TCC projects with which they had been involved, including project name, type of client, nature of project, contract sum, contract duration, payment mechanism, tendering method, the initiating organisation and the stage to introduce GMP/TCC to the project, partnering practices, together with various measures of project performance outcomes.

Finally, a total of 41 valid completed questionnaires covering 12 GMP/TCC projects (Table 1) were returned and analyzed, which can substantially represent the GMP/TCC project pool in Hong Kong over the past decade of 1997-2007. The respondents included various key project stakeholders, i.e. clients (15 respondents), consultants (12 respondents), main contractors (10 respondents) and subcontractors (4 respondents). All respondents have acquired over 10 years of working experience in the construction industry and possessed direct hands-on experience with one or more GMP/TCC projects. Hence, they were well-experienced professionals in the construction sector who should be able to provide reliable information and data to the research.

Table 1: List of Surveyed GMP/TCC Construction Projects in Hong Kong

	Project Name	Project Nature	Project Time-frame
Residential			
i.	The Orchards	A twin tower private residential development in Quarry Bay	Aug 2001 – Sep 2003
ii.	Public Housing Development at Eastern Harbour Crossing Site Phase 4	A public rental housing development in Yau Tong as a pilot study project	Jun 2006 – Jun 2009
Commercial			
i.	1063 King's Road	A private rental commercial development in Quarry Bay	Nov 1997 – Aug 1999
ii.	Chater House	A prestigious private rental commercial development in Central	Oct 2000 – Jul 2002
iii.	Alexandra House Refurbishments	A prestigious private rental commercial development in Central	Nov 2002 – Nov 2003
iv.	Tradeport Hong Kong Logistics Centre	A private commercial logistics hub for the Asia region at Chek Lap Kok	Jul 2001 – Dec 2002
v.	Landmark Redevelopment Phase 6 – York House	A private rental commercial redevelopment in Central	Jan 2005 – Oct 2006
vi.	Three Pacific Place	A private prestigious rental commercial development in Wanchai	Jun 2002 – Aug 2004
vii.	Tseung Kwan O Technology Park	A private technology park	Nov 2001 – Dec 2002
Infrastructure			
i.	MTRC Contract C4420	Tsim Sha Tsui Metro Station Modification Works	Apr 2002 – Sep 2005
ii.	MTRC Contract 604	Yau Tong Metro Station	Jan 2001 – Jun 2002
iii.	Tung Chung Cable Car Project	A sightseeing transportation facility including civil and building works	Jun 2004 – Dec 2005

SURVEY FINDINGS AND DISCUSSIONS

GMP/TCC practices in Hong Kong

The GMP arrangement has been gaining popularity in Hong Kong amongst other alternative procurement strategies since the completion of the first GMP project: a private commercial development of 1063 King's Road developed by a leading private property developer, Hong Kong Land Ltd, in Quarry Bay completed in August of 1999. The project was completed on time and the final out-turn cost is 11%-38% less than similar buildings using the traditional procurement system (Ho, 2000).

Over recent years, the application of the GMP/TCC principles has not been limited to private commercial development projects. The quasi-government mass transportation service provider, the Mass Transit Railway Corporation (MTRC) has adopted TCC for their development projects such as the Tseung Kwan O Railway Extension and Tung Chung Cable Car Project (MTRC, 2003). Moreover, a focus on integrating contractor's expertise and innovation in both design and construction as well as providing financial incentives for contractors to save cost and work efficiently via GMP/TCC has been placed in the public sector by the Hong Kong Housing Authority for a public residential development (HKHA, 2006).

Table 2 summarises the GMP/TCC practices of those 12 surveyed projects under investigation. The projects covered in the survey can be broadly classified into three major groups: residential, commercial and infrastructure projects. It is interesting to note that for projects adopting the GMP/TCC practices, the GMP approach dominated the residential and commercial sectors (building sector) whilst TCC was frequently applied to infrastructure projects. These differing observations might be attributed to the possible higher risk profile associated with infrastructure projects, while GMP might not be adequately fair to the contractor side to bear high risks without the presence of pain-share mechanism. The adoption of either GMP or TCC, nevertheless, depended heavily on the client's experience and preferences. It was reflected that the two local leading private property developers (i.e. Hongkong Land Ltd and Swire Properties Ltd), together with the major railway transportation service provider (i.e. MTRC), are taking a pioneering role in introducing the GMP/TCC style of procurement to their projects in Hong Kong. In addition, most of the surveyed projects adopted selective tendering method in order to facilitate adequate competition amongst those competent pre-qualified contractors. Negotiated tendering is, however, not unusual for several surveyed GMP projects because of the long-term close working relationship between the client and their preferred contractor.

As also indicated in Table 2, GMP/TCC was introduced at different stages throughout the whole project life but mainly at either outline design stage or detailed design stage. Nevertheless, more recent projects introduced GMP/TCC at an earlier stage in order to tap in the contractor's expertise in design and innovative ideas in construction methods and selection of materials. For instance, in the York House Project developed by the Hongkong Land Ltd, they implemented the GMP contract at the feasibility stage to seek improvements in the buildability of project design, innovation and efficiencies through reaping the perceived benefits and mitigating unforeseeable risks together with her partnering contractor (Gammon Construction Ltd).

Table 3 further reveals the partnering practices introduced in the surveyed GMP/TCC projects. It is worth noting that all the surveyed projects implemented GMP/TCC scheme in conjunction with the partnering spirit so as to align the individual objectives of various contracting parties to common objectives of the whole project, enhance communication flow within the project team, and facilitate the implementation of gain-share/pain-share philosophy associated with GMP/TCC methodology. The majority of the surveyed projects introduced the partnering approach at the construction stage. The infrastructure sector (i.e. MTRC) included a partnering provision in the construction contract at the tender stage for Tsim Sha Tsui Metro Station Modification Works and Tung Chung Cable Car Project. More recently, the partnering approach has been adopted as early as at the feasibility stage, including the York House and the Tseung Kwan O Technology Park, so long as the client and their preferred contractor have developed a long-term close working relationship for years.

Table 2: GMP/TCC Practices of the Surveyed Construction Projects in Hong Kong

			Payment Mechanism		Tendering Method		Who introduced GMP/TCC?		At what stage was GMP/TCC decided to be introduced?				
	Start Date	Completion Date	GMP	TCC	Selective	Negotiated	Client	Main Contractor	Feasibility	Outline Design	Detailed Design	Complete Design	Construct-ion
Residential													
i. The Orchards	Aug 2001	Sep 2003	✓		✓		✓				✓		
ii. Public Housing at Eastern Harbour Crossing Site Phase 4	Jun 2006	Jun 2009	✓[†]		✓		✓			✓			
Commercial													
i. 1063 King's Road	Nov 1997	Aug 1999	✓			✓	✓			✓			
ii. Chater House	Oct 2000	Jul 2002	✓			✓	✓			✓			
iii. Alexandra House Refurbishments	Nov 2002	Nov 2003	✓		✓		✓				✓		
iv. Tradeport Hong Kong Logistics Centre	Jul 2001	Dec 2002	✓		✓		✓			✓			
v. Landmark Redevelopment Phase 6 (York House)	Jan 2005	Oct 2006	✓			✓	✓		✓				
vi. Three Pacific Place	Jun 2002	Aug 2004	✓		✓		✓					✓	
vii. Tseung Kwan O Technology Park	Nov 2001	Dec 2002	✓			✓	✓			✓			
Infrastructure													
i. MTRC Contract C4420 – Tsim Sha Tsui Metro Station Modification Works	Apr 2002	Sep 2005		✓	✓		✓			✓			
ii. MTRC Contract 604 – Yau Tong Metro Station	Jan 2001	Jun 2002		✓	✓		✓						✓
iii. MTRC Contract – Tung Chung Cable Car Project	Jun 2004	Dec 2005		✓	✓		✓			✓			

[†] According to a representative of the Hong Kong Housing Authority (HKHA) and relevant tender documents, the Modified GMP (MGMP) approach has divided the scope of work into two main parts: main contractor's direct works and MGMP works packages. For direct works, the traditional model of procurement is adopted. And the rest of the works (approximately 20% of the contract value), the GMP works packages are developed and the scope of work is defined. Those packages open up the room for the contractor's expertise and innovation that drive them to construct in a better and efficient way such as higher levels of sustainability and construction efficiency.

Table 3: Partnering Practices of the Surveyed GMP/TCC Construction Projects in Hong Kong

	Was partnering adopted?		At what stage was partnering decided to be adopted?				
	Yes	No	Feasibility	Outline Design	Detailed Design	Tender	Construct-ion
Residential							
i. The Orchards	✔						✔
ii. Public Housing Development at Eastern Harbour Crossing Site Phase 4	✔						✔
Commercial							
i. 1063 King's Road	✔						✔
ii. Chater House	✔						✔
iii. Alexandra House Refurbishments	✔				✔		
iv. Tradeport Hong Kong Logistics Centre	✔				✔		
v. Landmark Redevelopment Phase 6 (York House)	✔		✔				
vi. Three Pacific Place	✔						✔
vii. Tseung Kwan O Technology Park	✔		✔				
Infrastructure							
i. MTRC Contract C4420 – Tsim Sha Tsui Metro Station Modification Works	✔					✔	
ii. MTRC Contract 604 – Yau Tong Metro Station	✔						✔
iii. MTRC Contract – Tung Chung Cable Car Project	✔					✔	

Project performance

The survey respondents were also invited to assess the performance of their GMP/TCC projects in which they were involved, including: (1) time performance; (2) cost performance; (3) quality performance; (4) dispute (claim) occurrence; and (5) overall project performance. The overall survey findings are indicated in Table 4.

Time performance

Over 43% of the survey respondents found that their projects were completed on schedule and over 32% were completed ahead of schedule. The superior time performance might be due to the fact that the GMP/TCC scheme allows the early commencement of construction activities before the design is fully completed (Frampton, 2003). On the other hand, the overall project efficiency is enhanced with the increased involvement of the client in problem solving process, higher buildability of project design as well as the presence of 'open-book' accounting arrangement (Mills and Harris, 1995; Tang and Lam, 2003).

Cost performance

26.3% of the survey respondents claimed that their projects were completed on budget against the final GMP or target cost and about 58% opined achieving cost savings. Merely 15.8% of them incurred cost overrun. This evidently reflects the positive influence of the financial incentives generated from the gain-share mechanism for contractors to save cost and innovate in order to achieve cost saving (Perry and Barnes, 2000).

Table 4: Results of Project Performance Measures of the Surveyed GMP/TCC Construction Projects

	Frequency of respondents	Percentage of respondents		Frequency of respondents	Percentage of respondents
(1) Time Performance			**(2) Cost Performance**		
Ahead schedule by > 5%	4	10.8%	Saving on budget by > 5%	4	10.5%
Ahead schedule by 1-5%	8	21.6%	Saving on budget by 1-5%	18	47.4%
On schedule	16	43.2%	On budget	10	26.3%
Behind schedule by 1-5%	8	21.6%	Overrun budget by 1-5%	4	10.5%
Behind schedule by > 5%	1	2.7%	Overrun budget by >5%	2	5.3%
Total	37	100%	Total	38	100%
(3) Quality Performance			**(4) Dispute (Claim) Occurrence**		
Zero work	9	26.5%	Dispute free	14	43.8%
Below an average project by > 5%	3	8.8%	Below an average project by > 5%	8	25.0%
Below an average project by 1-5%	6	17.6%	Below an average project by 1-5%	5	15.6%
Above an average project by 1-5%	15	44.1%	Above an average project by 1-5%	5	15.6%
Above an average project by > 5%	1	2.9%	Above an average project by >5%	0	0%
Total	34	100%	Total	32	100%
(5) Overall Performance					
Very successful	9	24.3%			
Successful	20	54.1%			
Average	4	10.8%			
Unsuccessful	2	5.4%			
Very unsuccessful	2	5.4%			
Total	37	100%			

Quality performance

Nearly half of the survey respondents (47.0%) expressed that their projects were scored as 'above an average project' in terms of scope of rework measured as percentage of original contract sum, reflecting the quality performance of the GMP/TCC projects was not very satisfactory. However, it is worth noting that 26.5% of them had indicated a record of zero rework. These may be attributed to the higher buildability of project design, increased involvement from the client and more effective communications derived from partnering spirit under the GMP/TCC scheme.

Dispute (claim) occurrence

The occurrence of disputes/claims arising from the surveyed projects was reduced under the GMP/TCC procurement approach. Approximately 40% of the survey respondents perceived that the dispute/claim occurrence emerging from their projects was below an average project and 43.8% of the respondents even achieved a "dispute-free" record. This outstanding performance may be, to a great extent, on account of the ability to align individual team members' objectives with the overall objectives of the project. Yet again, the gain-share/pain-share mechanism generates strong impetus for an effective collaboration and partnering spirit between client and contractor (Chevin, 1996). Involving the contractor at the pre-construction stage for design development can also reduce intractable conflicts and potential disputes at the construction stage. Unquestionably, the dispute resolution mechanism and the communication opportunities by means of adjudication committee meetings could further lead to the reduction in claim/dispute occurrence.

Overall project performance

The overall performance of the 12 surveyed GMP/TCC projects was very satisfactory. More than three-quarters of the survey respondents (78.4%) evaluated their projects as either 'successful' or 'very successful'. Only 8.3% of the respondents described their GMP/TCC projects as either 'unsuccessful' or 'very unsuccessful'. These results indicate that the overall project performance of the local surveyed GMP/TCC projects was favourable, especially on the aspects of project schedule, final project cost and dispute (claim) occurrence.

Comparison between GMP/TCC with traditional procurement approach

Further to the evaluation of GMP/TCC scheme presented above, it is valuable to compare in general the performance of the GMP/TCC projects with a construction project procured by the traditional design-bid-build approach. Respondents were therefore requested to compare various performance measures based on a five-point Likert scale (1 = Much worse; 3 = Same and 5 = Much better). Results of the analysis are depicted in Table 5. It is worth noting that all performance measurement indicators are above the middle value of three, reflecting that the project performance in terms of time, cost, quality, innovation, occurrence of disputes/claims, risk management and overall performance is in general better than that of a project using the traditional design-bid-build approach. Amongst those indicators, it is found that GMP/TCC can considerably provide stronger incentive to innovation (mean = 3.93). Moreover, overall project performance (mean = 3.83), cost performance (mean = 3.76) and time performance (mean = 3.71) were also regarded as better when adopting the GMP/TCC approach rather than the traditional method.

Table 5: Comparing GMP/TCC with the Traditional Procurement Approach

Comparing GMP/TCC with Traditional Procurement approach	N	Mean[#]	Standard Deviation
1. Time performance	41	3.71	0.716
2. Cost performance	41	3.76	0.799
3. Quality performance	40	3.43	0.712
4. Incentive to innovation	41	3.93	0.685
5. Occurrence, magnitude and resolution of disputes (e.g. claims)	41	3.68	0.820
6. Risk management and control	41	3.61	0.833
7. Overall project performance	41	3.83	0.667

[#] Items were rated on a 5-point Likert scale with 1 = Much worse; 3 = Same and 5 = Much better.

CONCLUSIONS

The construction industry has long been beset with limited trust amongst contracting parties, lack of incentives and misalignment of objectives, which might eventually result in adverse project performance. Consequently, both the GMP and TCC approaches serving as a cost incentive mechanism, have emerged as alternative procurement strategies for clients to mitigate risks, avoid claims, integrate the diverse interests of a complex construction project and offer incentives to provide "value-added" services. Based on a set of selected case studies and an empirical questionnaire survey, this study aims to explore the local implementation practices and project performance of GMP/TCC scheme in Hong Kong.

Results reflected that the overall project performance was very satisfactory, especially on the aspects of project schedule, final project cost and dispute (claim) occurrence. Given the favourable project performance outcomes, a wider application of GMP/TCC in both the building sector and the infrastructure sector is encouraged in order to deliver projects ahead of schedule, within budget, with high quality and fewer disputes or claims.

The research results are essential in assisting key project stakeholders in exploring alternative procurement strategies including GMP/TCC-type contracts for the future construction industry by reviewing various aspects of performance outcomes of these completed projects. Other survey findings on the key attributes of GMP/TCC (Chan et al., 2007a) including the underlying motives, perceived benefits, potential difficulties, key risk factors, critical success factors and optimal project conditions for adopting GMP/TCC scheme will be compiled and reported to the research community and construction industry through subsequent journal publications (e.g. Chan et al., 2007b) and conference presentations.

ACKNOWLEDGEMENTS

The authors would like to express their sincere thanks to all the individuals who have kindly participated in the empirical questionnaire survey for providing their opinions and necessary project information and data to facilitate this research study. The authors also wish to thank The Hong Kong Polytechnic University for providing financial support to this research initiative (HK PolyU Faculty Internal Competitive Research Grants Allocation 2004/05 with Project Account Code: BRE-A-PG36). The work described in this paper was further supported by a grant from the Research Grants Council of the Hong Kong Special Administrative Region, China (RGC Project No. PolyU 5107/07E).

REFERENCES

Cantirino, J. and Fodor, S. (2003) Construction delivery systems in the United States. Journal of Corporate Real Estate, 5(2), 169-177.

Chan, A.P.C., Chan, D.W.M., Fan, L.C.N., Lam, P.T.I. and Yeung, J.F.Y. (2004) A comparative study of project partnering practices in Hong Kong. Summary report, Hong Kong: Construction Industry Institute – Hong Kong, Research Report No. 1, 40 pages, ISBN 988-98153-1-1, September 2004.

Chan, D.W.M., Chan, A.P.C., Lam, P.T.I., Lam, E.W.M. and Wong, J.M.W. (2007a) An investigation of guaranteed maximum price (GMP) and target cost contracting (TCC) procurement strategies in Hong Kong construction industry, Research monograph, Department of Building and Real Estate, The Hong Kong Polytechnic University, 152 pages, ISBN 978-962-367-593-2, October 2007.

Chan, D.W.M., Chan, A.P.C., Lam, P.T.I., Lam, E.W.M. and Wong, J.M.W. (2007b) Evaluating guaranteed maximum price and target cost contracting strategies in Hong Kong construction industry. Journal of Financial Management of Property and Construction, 12(3), December, 139-149.

Cheng, R.L.L. (2004) Investigation of the Application of Guaranteed Maximum Price in the Hong Kong Construction Industry. Hong Kong: Unpublished BSc(Hons) Dissertation in Construction Economics and Management, Department of Building and Real Estate, The Hong Kong Polytechnic University, Hong Kong. 58 pages.

Chevin, D. (1996) The max factor. Building, 17 May 1996.

CIRC (2001) Construct for excellence. Report of the Construction Industry Review Committee, Hong Kong SAR, 207 pages.

Clough, R.H. and Sears, G.A. (1994) Construction contracting, 6th Edition, New York: Wiley-Interscience Publication.

Fan, A.C.W. and Greenwood, D. (2004) Guaranteed maximum price for the project? Surveyors Times, The Hong Kong Institute of Surveyors, March, 20-21.

Frampton, J. (2003) Can't be too sure on paper. The Sydney Morning Herald. November, 2003.

Gander, A. and Hemsley, A. (1997) Guaranteed maximum price contracts. CSM, January, 38-39.

Ho, T.O.S. (2000) Enhancing construction technology through strategic partnering – a contractor's perspective. In: Proceedings of Quality Housing Partnering Symposium 2000, 19-20 October 2000, The Hong Kong Housing Authority.

HKHA (2006) Internal guidelines for guaranteed maximum price contract procurement Based on private sector model. The Hong Kong Housing Authority, Hong Kong SAR Government, 19 pages.

Masterman, J.W.E. (2002) Introduction to building procurement system, 2ed., London: New York Spon Press.

Mills, R.S. and Harris, E.C. (1995) Guaranteed maximum price contracts, Construction Law, 573/95, 28-31.

MTRC (2003) The Tseung Kwan O extension success story**.** Hong Kong: Mass Transit Railway Corporation Ltd, 133 pages.

Perry, J.G. and Barnes, M. (2000) Target cost contracts: an analysis of the interplay between fee, target, share and price. Engineering, Construction and Architectural Management, 7(2), 202-208.

Perry, J.G. and Thompson P.A. (1982) Target and Cost-reimbursable Construction Contracts, CIRIA Report R85, London: CIRIA.

Tang, S.L. and Lam, R.W.T. (2003) Applying the target cost contract concept to price adjustments for design-and-build contracts. Hong Kong Engineer, September, 18-19.

Tay, P., McCauley, G. and Bell, B. (2000) Meeting client's needs with GMP, The Building Economist, June 2000, 4-5.

Trench, D. (1991) On target – a design and manage target cost procurement system. London: Thomas Telford.

Walker, D.H.T., Hampson, K.D. and Peters, R. (2000) Relationship-based procurement strategies for the 21st Century. Canberra, Australia: AusInfo, ISBN 064243079-9, 112 pages.

ROLE OF CLIENT BEHAVIOUR IN THE RISK ENVIRONMENT IN CONSTRUCTION PROJECTS

A Arabiat, Loughborough University, United Kingdom
A.Arabiat@lboro.ac.uk

FT Edum-Fotwe
Loughborough University, United Kingdom
F.T.Edum-fotwe@lboro.ac.uk

R McCaffer
Loughborough University, United Kingdom
R.Mccaffer@lboro.ac.uk

The role of client hasn't been adequately covered and the industry needs that investigation to develop its risk management approaches. Studies have shown that the client risk practice can have a strong effect on the outcome of the project. The study aims to demonstrate whether the characteristics of certain behaviour create a risk management style for the client, and whether these characteristics affect the project risk positively or negatively. This is an ongoing research will investigate how the client behaviour toward risk is originated in its rational of risk and the internal protocols of the client as in the cultural web. This is done by surveying the market to find a relationship between these attributes. This should contribute to the development of new approaches of risk management.

KEYWORDS: Client; Construction; Organisation Behaviour; Risk Management.

INTRODUCTION

Risk is seen as an essential part of construction projects, where two key stakeholders, the contractors and consultants, are considered the originators, mitigators and managers of risk (Walker, 1996). However, risk association with the client has not been given an adequate consideration. Different case studies have shown that clients can contribute to the project outcome by their approach toward managing risk.

An examination of risk management approaches shows that there are numerous methods available to measure up the risks at early stages of the project, e.g. fuzzy logic (Tah and Carr, 2000), analytic hierarchy process (Mustafa and Al-Bahar, 1991), and risk management processes (Tummalaa and Burchett, 1999). However, the role of the client has not been adequately put into the equation of managing risk in early stages of the project comparing to other factors affecting risk. The research will investigate the clients' history in managing projects; in terms of perception of risk, organisational behaviour and the performance of clients. This will identify behavioural elements which are responsible for client's attitude toward risk. Better understanding of risk perception will address issues of confidence between the client and the contractor in the construction industry.

CLIENT ROLE IN MANAGING RISK

Construction risk is generally perceived as events that influence project objectives of cost, time and quality. Managing risk is defined as systematic risk assessment and management process that is staged as initiation, analysis, allocation and then response (Tehranchi and Flanagan, 2006). Risk management is implemented from the opening bidding process and its importance increases during the project as changes are made. During projects, contractors use systematic models such as construction risk management system to help them identify project risks and to systematically analyze and manage them (Al-Bahar and Crandall, 1990).

The client can be defined in respect to the perceived influence the client has on the course and the outcome of the project. Initially the client is seen as the body that initiates the project and has the authority to approve expenditure on the project (Walker, 1996). The client is categorised based on what type of projects the client is involved in, value of projects, expertise or skill and the size of organisation history (Pryke and Smyth, 2006).

There is a recent growth of interest in client organizations which reflects a concern that the decisions that clients make in setting up a project can have significant effects on construction project performance. Clients may be comparatively new to construction project management and, therefore, somewhat unsophisticated and inexperienced in their use of project management and contractual systems (Zaghloul, 2003). It is important for clients and project team leaders to ensure that clients are appropriately integrated into the project's organization structure because satisfaction at the construction stage is closely linked to the degree of control and supervision by the client himself (Walker, 1996). However, corporate client organisations are rarely suitable for providing client management of projects as the style of project management is likely to be more dynamic than that of corporate management (Walker, 1996).

Client evaluation

Client evaluation by construction consultancies is generally performed subjectively by construction professionals, focusing primarily on financial considerations, with superficial attention paid to management inputs and other characteristics of clients' organizations (Kometa *et al,* 1996). Client evaluation at the moment is regarded as a single attribute issue based on the client's financial stability. Financial stability is paramount, but is not the only client attribute impacting the consultant's performance (Kometa *et al*, 1996).

The client, especially as an organisation, reflects its relationship with the stakeholders on the project. This organisation, with its elements, defines the way the client reacts to change and perceived information. The paradigm of the client classifies its flexibility and the ability to condition its objectives based on the perceived risks of the project. Organisations are driven strongly by their stockholders (Johnson & Scholes, 2002). The client ability to balance between the demands of the stakeholders and the real objectives of the project is fixed within the character the organisation which is affected by the cultural web (Figure 1). Some parameters of the web were redefined to suit a project based environment.

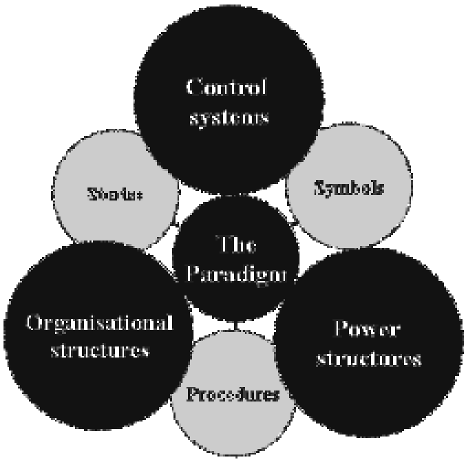


Figure 1 Cultural web (adapted from Johnson and Scholes, 2002)

Jackson (2002) makes clear that complete design information leads to more accurate budget estimates and client driven design change is the greatest risk during the project. These two factors are affected by many issues like decision making source, documentation, bureaucracy, and formality vs. informality within the organisation. All these elements reside within the pieces of the cultural web of the organisation (Johnson & Scholes, 2002).

A small, inexperienced client who has not previously handled large-scale, complex projects, or one who faces for the first time a project of untypical magnitude and complexity, may well find this information and advice of considerable use. But not all clients are like this. In fact, the industry is one in which there are a sizeable number of regular clients whose average project is one in which they have considerable experience (Michael, 1991). Such clients typically manage a fair-sized portfolio of projects varying in scale and type, and will often have some in-house capacity and well-established mechanisms and procedures for handling them. These clients are by no means the 'naive' clients often typified in the construction management literature. Indeed, they are sophisticated and experienced enough to understand the process of construction and the potential for problems that are inherent in its uncertainty and complexity. Such clients approach their projects with a consistency that belies the commonly held view that 'every project is different' and thus should be treated as such. In particular, the choices of project management systems and contractual forms are as much internally driven as project determined (Michael, 1991).

ANALYSING CLEINT RISK

The formal risk analysis and management techniques are rarely used by the construction industry due to the lack of knowledge and expertise. The industry is also sceptic about the suitability of these techniques to construction. In most situations, the contractors and consultants perceive risk based on their experience and judgment. The risk elimination and risk transfer to a specialty subcontractor were found to be the most favoured method of risk management (Ahmed *et al*, 2001).

Akintoye and MacLeod (1997) explain that risk analysis and management in construction depends mainly on intuition, judgement and experience. This strategy shows that project exclusive variables would play a major role and cannot be ignored by systematic models. These variables would add to an alarmist view toward risk. Studies have shown (Smith *et al*, 1999) that construction firms are assuming proportionally greater business risk than assumed by the literature on contingency. Managers reflect their perception of risk management using the concepts of return, risk and ruin (Pryke and Smyth, 2006). However, whether the measures used present a satisfactory insurance, these measures could be improved by introducing the variables as the financial factor into the design stage as part of a strategic benefit and not only at a later stage as a problem solving method (Pryke and Smyth, 2006).

Satisfaction at the construction stage is closely linked to the degree of control and supervision by the client himself. It is important for clients and project team leaders to ensure that clients are appropriately integrated into the project's organization structure because satisfaction at the construction stage is closely linked to the degree of control and supervision by the client himself (Walker, 1996). However, corporate client organisations are rarely suitable for providing client management of projects as the style of project management is likely to be more dynamic then that of corporate management particularly when the latter has a rigid hierarchical management structure linked to slowly changing long-term objectives (Walker, 1996).

This response by the construction industry is caused by problems of perception conflict toward risk between the client and the contractor. Pryke and Smyth (2006) explain that there is a common conflict between the client and the contractor regarding the long-term objectives vs. the short term, in the same way their perception of efficiency and effectiveness is rather different. In terms of dealing with cost, there is always the pressure to produce profit using either short or long term strategies. The priority of outcomes within the project itself would differ between the client and the contractor due to the difference of financial priorities, and the general objectives of the project itself.

These conflicts are rooted in the disputes between different approaches to identifying risk. There are many systematic and mathematical approaches to manage risk, and there have been social science approaches. For example, Harty (2005) says that there is high reliance on using analytical techniques based on a statistical approach in decision making for risk management in construction projects. However, when it comes to considering the complexity of construction projects, construction mangers cannot solely rely on mathematical approaches, but by identifying the sources of these risks within the decision making process and therefore, the participants in the decision process. There is inconsistency toward risk identification or the areas that need more attention regarding risk management. Edwards and Bowen (1998) explain that political, economic, financial and cultural categories of construction risk do not get enough attention, in comparison issues regarding quality assurance and occupational health and safety. Even in contract, identifying a high risk operational organization relies mainly in the contractors' quality of operation management and concentrate on experience and capabilities than anything else.

Between the cultural identity of the organization and its actions, the process is filtered by its structure and by tracing the role of the client in shaping the project risk by identifying generic features of the client's risk management by studying their history in managing projects. The outcome should identify the behavioural patterns of the client which are responsible for inducing risk. Any feasible changes for advancement would be easier the closer it get's to the outer surface of the organisation as an onion model (Figure 2) and it will be harder whenever changes are needed in the core of the organisation (Mitroff et al., 1989). Analysing the organisational behaviour of the client and its effect on risk would start from defining the organisational structure of the client. The organisational structure in term of the transformation of the core identity of the organisation into its behaviour toward risk can be linked to a successful or unsuccessful risk management. This can be achieved by a thorough investigation of the organisation of the client.

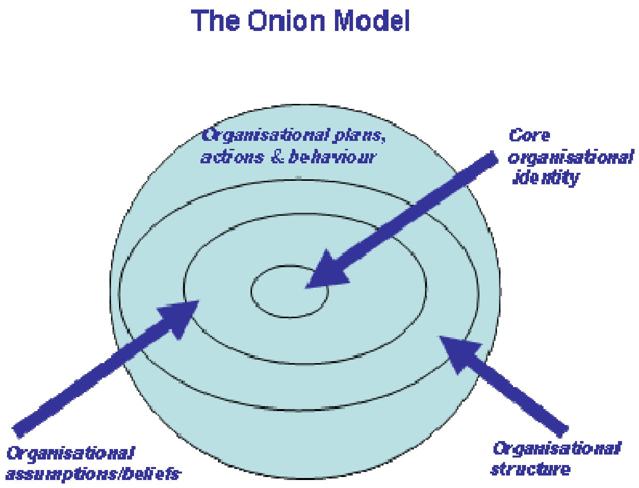


Figure 2 (Mitroff et al., 1989)

For the client to reach a decision making process in acting toward risks, the cultural background would reflect the conditions the organization is working within. In taking a decision, consideration need to be given to whether the risk can be effectively managed by the participant allocating the risk or whether the allocation causes a different, but more damaging risk; and whether the allocation of risk intended is effective and enforceable (Edwards and Bowen, 1998). In the source of the decision taken by the client, there should a trigger behaviour routed within the organization itself. This trigger behaviour can be routed within the cultural of the organization. The client, especially as an organisation, reflects its relationship with the stakeholders on the project. This organisation, with its elements, defines the way the client reacts to change and perceived information. The paradigm of the client classifies its flexibility and the ability to condition its objectives based on the perceived risks of the project. The client ability to balance between the demands of the stakeholders and the real objectives of the project is fixed within the character the organisation which is affected by the cultural web.

ANALYSING CLEINT BEHAVIOUR

The client and the contractor have their own approach to risk assessment to the project due to the different relationship the client and the contractor have with the project. The industry will benefit from reducing the blame culture between the client and the contractor and focuses on explaining why the construction industry, which behaves conservatively toward risk, still inherits many of the risks into its projects. For the client to reach a decision making process in acting toward risks, the cultural background would reflect the conditions the organization is working within. In taking a decision, consideration need to be given to whether the risk can be effectively managed by the participant allocating the risk or whether the allocation causes a different, but more damaging risk; and whether the allocation of risk intended is effective and enforceable (Edwards and Bowen, 1998). In the source of the decision taken by the client, there should a trigger behaviour routed within the organization itself. This trigger behaviour can be routed within the cultural web of the organization. The client, especially as an organisation, reflects its relationship with the stakeholders on the project. This organisation, with its elements, defines the way the client reacts to change and perceived information. The paradigm of the client classifies its flexibility and the ability to condition its objectives based on the perceived risks of the project. The client ability to balance between the demands of the stakeholders and the real objectives of the project is fixed within the character the organisation which is affected by the cultural web.

Market wise, the client plays a pulling force in the construction market, and this is the strongest force in defining the direction of the market. Therefore, risk will be approached retrospectively to the client background (Figure 3). The logic behind this approach is taken from the basic understanding of management theories.

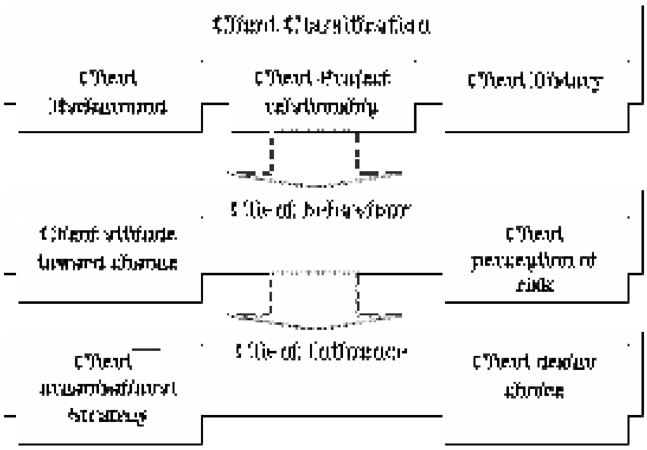


Figure 3 Approaching the client

The client classification is based on the client background, which serves putting the client into qualitative categories. While the financial stability is usually applied as it is on the client, the funding source should be addressed as a reflection of the decision making sources inside the company. Flexibility and type of funding source can define the relationship the client would have with the project and would reflect either the conservative or untraditional attitude the client has regarding projects. This will transfer into the priorities of the client toward the client investment as in the project.

The classification serves putting the client into qualitative categories. Funding reflect one of the decision making sources inside the company. The more the client relies on a non flexible funding source the more conservative it will be regarding projects. This can be verified by addressing the client himself. The information needed for this section is not complicated and can be obtained from the balance sheet. Loans – Investment ration reflect the internal financial strategy the client has in private companies. Unbalanced ratio reflects a high risk client to deal with. It shows how it affects is liquidity and cash flow. In addition, it shows how risky the client is when making investments.

The client behaviour toward risk is originated in its rational of risk and the internal protocols of the client as in the organisational cultural and its internal forces which affect its change attitude and its inclination to fall in organisational crises. An innovative client faces less risk during change, as change has a very strong association with risk. While clients Strategy reflects in the survivability of the client in deferent environments, clients' strategy derives from the clients' organisational focus, which reflects the way the client adapt its objective in different environments, and how it divides it resources. For the client to manage its short term and long term objectives, it needs innovative approaches usually developed by its general competitiveness in the market.

Client Behaviour:

Client perception of Risk

- Internal Forces of change: individual, organisational
- External forces of change: Market, transformation
- Client rational of risk : power, urgency, legitimacy
- Client rational of risk management :legality, power dependency

Client attitude toward Risk

- Client's degree of trust in project team members
- Definition of change
- Approach to change: Process, Content, context
- Rational toward crises

METHODOLOGY

The methodology combines both qualitative and quantitative information. The research will first identify the elements which will have an effect on the client regarding risk. Then it will clarify the effect of these elements based on the different categories of the client.

The objective of the research means that it is needed to examine risk from two different angles: risk management literature and organisation behaviour literature. The methods utilised for the study consist of a comprehensive literature survey followed up by semi-structured interviews. The literature survey was carried out in both construction risk management literature and business literature. The research is of analytical nature and the aim is to better understand the general attitudes.

The information consists of values reflecting the objectives of the organisation and transformation of these objectives into its activities within the project. These values would be compared with values representing the internal variables of the project that reflect on the risks. This Research starts from identifying the cultural background of the client and its effect on the managerial style of the client, then the effect of this background on the attitude of the client toward risk, the project, the contractor managing the project and finally how this relationship reflect on inducing risk. The clients weighing of objective has been covered by previous research (Hwee E and Yean F, 2002) however, this project will address these priorities prior to the start of the project. We will be looking into what client looks for in a good project. The outcome should provide a definition of the client based on these qualities and can be connected with other variable if correlations were found.

Clients Strategy is reflected from management theories to test the survivability of the client in deferent environments. Organisational Focus reflects the way the client adapt its objective in different environments, and how it divides it resource. This information can be obtained from the client management. Client Competitiveness reflects the innovative part of the client, and how he address long term an short term objectives. This can also be obtained from the client management. Both can analysed from the general client market strategy and his history. This will categorised based on the competing values dimensions (Figure 4). These dimensions were developed as the Dimensions of Effectiveness by Quinn (1981).

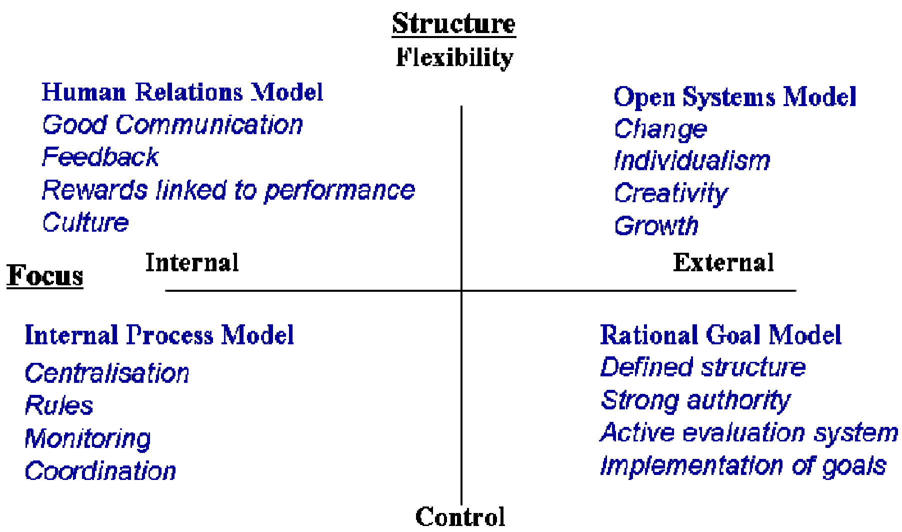


Figure 4 Competing Values Dimensions

Client perception of risk checks the area where the client assumes risk and how he prioritises them. This shows in details the client original behaviour toward risk, and we can conclude how this reflect on the project itself. The rational of risk shows if the client understands the importance of risk elements in behavioural terms, and there are signs which show if the client is prone to crises or not.

NEXT STEPS

The next stage of the research will involve locating interviews with suitable clients. Clients who have done a good number of projects will be investigated as case studies until a saturation of information is reached. The information collected can be tested on other projects and can be explored in term of its connection to the structure of the legal contracts, the value chain and the attitude of the industry in general. An arithmetic relationship between client variables will provide generic features which can be tested on other cases as the research goes on. This should allow the progress of the research where the influential behavioural patterns in inducing risk are identified and has reached a stage where new approaches of risk management can be adapted from the conclusions. This will be compared with analysis of risk tolerance of the company as risk averse, neutral or seeking. The triangular approach for this research means that it is limited by the experience presented by the sample. Taking a historical approach would be harder but will provide more accurate results.

CONCLUSION

The construction industry suffers insufficient knowledge about the nature of risk when it comes to client involvement and the growing concerns by the contractors of the influence of the client in inducing risk. This situation proposes the need to review the current risk management approaches and find new areas to develop. The research is investigating in the clients' involvement by integrating construction risk management theories and business strategy theories particularly in the area of organisation behaviour.

The role of the client starts from his background which is affected by cultural and organisational influences and this might drag his attitude toward risk into real practice in the project. This rule might have been undervalued due to lack on interest of the clients to take responsibility in managing the risk, but the changes in technological and financial tactics in construction could bring that role under stronger investigation

The conventional view acknowledges that the client approaches the projects in term of a financial investment, and that the contractor cannot deny the financial reasons which drive the behaviour of the client in the project. However, the failures in managing risk demand acknowledge that there is more into the client behaviour than just financial drive pressured by individual characteristics. There is more to investigate under the dome of financial risk. As clients are common users of borrowing, they would have developed a learning curve in managing their finances in the developing stages, which means there are more than financial failings to the factors that induces risk in projects. Client analysis will help clients to understand their involvement in the project and develop their approach toward risk in construction project.

REFERENCES

Ahmed, S.M., Azhar, S. and Ahmad, I. (2002) "Evaluation of Florida General Contractors' Risk Management Practices". Revista Ingeniería de la Construcción (Construction Engineering Journal), Vol.17, issue 1, pp. 4-10.

Akintoye, A.S. and MacLeod, M.J. (1997) "Risk analysis and management in construction". International Journal of Project Management, Vol. 15, issue 1, pp. 31-38.

Al-Bahar, J.F. and Crandall, K. (1990) Systematic risk management approach for construction projects. Journal of Construction Engineering and Management, Vol. 116, issue 3, pp. 533-46.

Bewsey, G. (2006) "No room for manoeuvre". Construction Manager (May, 2006). Available: http://www.construction-manager.co.uk/story.asp?storyType=143&sectioncode=12&storyCode=3066805

Edwards, P.J. and Bowen, P.A. (1998) "Risk and risk management in construction: a review and future directions for research". Engineering, Construction and Architectural Management, Vol. 5, issue 4, pp.339-49.

Jackson, S. (2002) "Project Cost Overruns and Risk Management". Proceedings, 18th Annual ARCOM Conference, Glasgow.

Johnson, G. and Scholes, K. (2002) Exploring Corporate Strategy (6th ed.). Harlow: Prentice Hall/Financial Times.

Harty, C. (2005) "Innovation in construction: a sociology of technology approach". Building Research and Information, Vol. 33, issue 6, pp. 512-522.

Hwee Lim, E and Yean Yng Ling F. (2002) Model for predicting clients' contribution to project success. Engineering, Construction and Architectural Management, Vol. 9 issue 5, pp. 388–395.

Klemetti, A. (2006) "Risk Management in Construction Project Networks". Helsinki University of Technology, Laboratory of Industrial Management Report 2006/2.
Available: http://lib.tkk.fi/Reports/2006/isbn9512281473.pdf

Kometa, S.T., Olomolaiye, P.O. and Harris, F.C. (1996) "A review of client generated risks to project consultants". International Journal of Project Management, Vol. 14, issue 5, pp. 273-279.

Michael J Bresnen a; Cheryl O. Haslam b (1991) "Construction industry clients: A survey of their attributes and project management practices". Construction Management and Economics, Vol. 9, Issue 4, pp. 327 – 342

Mitroff, I.I., Pauchant, T., Finney, M. and Pearson, C. (1989), Do (some) organizations cause their own crisis? The culture profiles of crisis-prone vs. crisis-prepared organizations. Industrial Crisis Quarterly, 3, 269-338

Mustafa, M.A. and Al-Bahar, J.F. (1991) "Project risk assessment using the analytic hierarchy process". IEEE Transactions on Engineering Management, Vol 38, issue 1, pp. 46-52.

Pryke, S. and Smyth, H. (eds.) (2006) The Management of Complex Projects: A Relationship Approach. Oxford: Blackwell Publishing.

Smith, G.R. and Bohn, C.M. (1999) "Small to Medium Contractor Contingency and Assumption of Risk". Journal of Construction Engineering and Management, Vol. 125, issue 2, pp. 101-108.

Tah, J.H.M. and Carr, V. (2000) "A proposal for construction project risk assessment using fuzzy logic". Construction Management and Economics, Vol. 18, issue 4, pp. 491 - 500.

Tehranchi, H. and Flanagan, R. (2006) The social and cultural construction of risk. Construction Information Quarterly, Vol. 8, issue 4, pp. 167-72.

Tummalaa, V.M.R. and Burchett, J.F. (1999) Applying a Risk Management Process (RMP) to manage cost risk for an EHV transmission line project. International Journal of Project Management, Vol 17, issue 4, pp. 223-35

Walker, A. (1996) Project Management in Construction (3rd ed.). Oxford: Blackwell Science.

Winch, G.M. (2002) Managing Construction Projects. Oxford: Blackwell Publishing.

Zaghloul, R. and Hartman, F. (2003) "Construction contracts: the cost of mistrust". International Journal of Project Management, Vol. 21, issue 6, pp. 419-424.

IMMIGRANT CONSTRUCTION WORKERS' SPENDING AND REMITTANCE PATTERN: THE MALAYSIAN PERSPECTIVE

Fara Diva Mustapa
Universiti Teknologi Malaysia, Malaysia
faradiva.m@gmail.com

Christine L Pasquire
Loughborough University, Loughborough, UK
C.L.Pasquire@lboro.ac.uk

The construction industry plays an important role in an economy through its multiplier-accelerator effects. This is mostly shaped by its unique character and project development. In addition, the industry relies heavily on immigrant construction workers. A pilot survey was undertaken to identify the spending and remittance patterns of immigrant construction workers in Malaysia. The results of the pilot survey showed that these workers spend less than Malaysian nationals and remit most of their income to their home country. Two factors driving the high level of remittances are the nature of the construction project and the immigrant workers' character and lifestyle. High remittance level is clearly linked to the transient nature of their lifestyle. This paper concludes with recommendations regarding the need to improve the construction industry's image and the economic impacts of the high remittance level of immigrant workers in the Malaysian construction industry.

KEYWORDS: construction nature, immigrant workers, remittances, spending patterns.

INTRODUCTION

Every sector in an economy has its own function and unique contribution. The construction industry shares equal importance as any contributions from other sectors. Its Gross Domestic Product (GDP) contribution constitutes 3% of Malaysian GDP in 2008 (Malaysian Economic Reports, 2008) and some 10% of Gross National Product (GNP) in the world (Hillebrandt, 2000). The GDP percentage, although comparatively low, contributes to economic development from its unique product character (Hillebrandt, 2000). The nature of the construction output is mostly used as a medium to either produce or transport other economic activities such as manufacturing and services (Ofori, 1990). Additionally, high reliance on its human workforce (Ive and Gruneberg, 2000) enables the construction industry to influence the demand and supply levels of commodities in an economy. That is why the industry is important to the economy where it performs as the output multiplier (Hillebrandt, 2000, CIMP,2007). In Malaysia, the industry employs approximately 800,000 employees (CIMP, 2007) which constitutes about 6 -7 per cent of total employments (EPU, 2007).

Its contributions, however, are over shadowed by poor image such as low productivity, high percentage of accidents, 3'D' image (dirty, dangerous difficult), low salary and high dependency on immigrant construction workers (Narayanan and Lai, 2005, Manning, 2001). From the Malaysian perspective, the construction industry has been suffering from labour shortages for decades (Mohd Yusof, 2005). This endless problem emerged from earlier mentioned as well as the transient project duration and reluctance of the locals to join the workforce. To overcome this problem, the Malaysian government has chosen to engage immigrant construction workers mostly from the nearest neighbouring countries. The move subsequently triggers another problem for the industry. Low quality of construction works, communication problems and influx of immigrant workers are some of the problems cited by Narayanan and Lai (2005). In addition, the high percentage of immigrant construction workers exposes the country and the industry to high remittances made by the immigrant workers which disturbs the economic cycle flow in the form of leakages (Mustapa and Pasquire, 2007).

This paper investigates the remittances and spending pattern among the construction immigrant workers in Malaysia as well as looking at any correlation between the spending and remittance pattern with the construction project nature. It starts with a brief explanation of the character of the remittance followed by the character of the construction industry and immigrant workers. Explanation on the methodology adopted, analysis of the survey, discussion, future research direction and a conclusion complete the paper.

Remittances and spending pattern: some preliminary observation

The existing literature is ambivalent as to the percentage of remittance made by the immigrant workers in Malaysia. As reported, Malaysia acts as both immigrant recipient and labour migrant source country (ADB, 2006). Rosli and Kumar reported in 2006 that the leakage in the form of remittances made in the Malaysian economy reaches about £72M monthly. The figure is not a surprise as according to the statistics prepared by the Malaysian Immigration Department in 2006, there were 1,869,209 registered immigrant workers. Of those, about 14.33% work in the construction sector. The high dependencies on immigrant workers in the Malaysian construction industry are anticipated due to over reliance of the industry on traditional construction techniques.

Most of the literature shows the benefit of the remittance to the labour source countries. A report by the Asean Development Bank in 2006 depicts the importance of remittance in the global economy. Many of them reveal contribution of remittance as one of the significant foreign exchange sources for the labour exporting countries. On the other hand, the benefit received by the host countries is not clear (Glytsos, 2005) apart from filling the labour shortage.

From the economic point of view, by studying disposable income of the immigrant workers, an understanding of their remittance pattern, the character and economic background of the immigrant workers can be justified. Hence, a pilot survey on their personal background, education background and spending trend could reveal the remittance pattern. The scope of this paper concentrates only on the construction immigrant workers due to the transient nature of construction projects.

The characteristic of the construction industry

In many ways, the construction industry is different from all other fields of economic endeavour. It is different particularly in its activities and its products where it is mainly used to produce other investment goods (Hillebrandt, 2000). According to Ofori (1990), after reviewing works of other authors, he was able to list several special characteristics of the construction industry. The size of the construction outputs is mainly large and immobile. Hence, the need to plan the investments to ensure investment return is essential. More-over, it has close links with the government due to the high capital investment required to construct buildings and infrastructure works. The project installation requires different resources at different stages of the construction period. The end products are very durable in order to fulfil the design and authority requirements to ensure safety in occupancy. Additionally, there is no guarantee to the contractors that they could win the next project bid. In consequence, the construction firms prefer to employ construction workers through labour supply contractors and minimise their purchases of plant and machinery to reduce their liability.

The project nature is also synonymous with the '3D' image, namely dirty, dangerous and difficult. The external work conditions expose the workers to extreme weather conditions and most of the time; the construction sites are messy, hazardous and untidy. The placement of building materials, construction plants and machinery exposes the workers to site hazard. Unlike the manufacturing sector, the industry uses much wider technologies and usually adapts the new technology to the old. This is a complete contrast with other sectors where they usually corresponds with the latest technology.

The project nature of the industry is also transient where the workers will move from one site to another after job completion. This applies to the construction project organisation where the team will be disbanded at the end of the construction period. Moreover, the industry is very famous for delay in completion time. This is due to the nature of the construction components and the process itself. Hence, the production of the output needs to be planned properly by taking account of the considerations stated earlier.

Additionally, the industry's role in the economy is crucial. It acts as a multiplier-accelerator provider (Mustapa and Pasquire, 2007) where its products are mostly used as factors of production in other economic sectors. Demand in the industry constitutes a combination of consumer and investment demand. Both respond differently to any economic changes. However, investment demand changes more proportionately than consumer demand which makes the demand in the construction industry more sensitive (Ive and Gruneberg, 2000). In other words, changes in demand for investment product will have a direct effect on the construction industry. The construction sector output multiplier in Malaysia is at 1.62 indicating that in return to produce an additional MYR 1.00 of output, the sector would affect production of all industries measuring to MYR 1.68 (CIDB News, 2007). Hence, any economic disturbance in the production cycle flow will affect the function of the industry in an economy.

Character of immigrant worker

Human migration to other countries in search of employment is globally not a new scenario (Wickramasekera, 2006). The motivations behind the migration are mostly derived from a yearning to receive higher wages and better opportunities. For some, they were forced to abandon their homes due to poverty, famine, natural disasters, environmental degradation, violent, persecution and political instability (ILO, 2004).

Normally, migration occurs between neighbouring countries. However, due to the improvement in global information and cheaper transportation, the geographic boundaries do not seem to be barriers to migrate (ILO, 2004). Some of the normal pull factors are economic stability, particularly on the level of national income, low inflation, employment and exchange currency rates of the host countries. Usually, the importing labour countries are those which have established themselves both economically and politically.

Methodology

In order to test the degree of the economic leakage created by the immigrant construction workers, it is best to study their household disposable income. Hence, a pilot study investigating the remittance and spending patterns among these workers in Malaysia was conducted from 1April to 22 September 2007. With the help of the Construction Industry Development Board of Malaysia (CIDB) in providing latest lists of on-going projects in the country for the year 2007. The choice of a quantitative approach using questionnaire was made by looking at similar research conducted focusing on immigrant workers. Also, the approach taken was to test the response rate as well as the limitations of the survey.

The questionnaire were posted at random to the main contractors from the lists provided by CIDB. The set of questionnaire was prepared in several languages, namely English, Bahasa Melayu and Bahasa Indonesia. The choice of languages was made according to the minimum requirements outlined by the Malaysian government for every immigrant workers intending to work in Malaysia. Each is obliged to undergo an induction course for immigrant workers to be able to speak Bahasa Malaysia or English before entering Malaysia (Ministry of Human Resource Malaysia, 2006).

The questionnaires were distributed randomly enclosed with additional envelopes and stamps administered to the respondents to ease and promote positive response. Out of 132 questionnaires sent which constitutes about 0.05% of the total registered population in the construction industry, only 27 questionnaires were returned. The response rate was however considered satisfactory at 20% return. As gathered from the CIDB, the normal response rate for a Malaysian perspective is usually less then 15%. Most of the contractors took the initiative in assisting the workers to answer some difficult questions. Hence, the result of the analysis presented in this paper represents only a snapshot description of a purposive sample.

The questionnaire

Analysis of the completed questionnaire was made by simple frequency analysis by tabulating answers. The answers were coded numerically to help the frequency analysis. Thirty eight (38) questions asked in three different sections, namely personal background; education background and spending trend, were geared to unveil the character, spending and remittance pattern of the immigrant construction workers. The simple analysis was made possible due to the small number of responses. However, should the responses received have been higher, the analysis would have been made using the SPSS software.

The first piece of analysis untangled the immigrant worker's personal background such as gender, age, nationality, number of years working in Malaysia, type of trade and current site location. All of the questions asked were aimed to benchmark the worker's character.

The second section asked about the respondent's level of education. Logically, the more educated the immigrant worker, the higher the wages received. And finally, the third section asked questions on monthly income, remittance percentage, and type of accommodation as well as the mode of payments. The immigrant worker's transport possession as well as the mode of acquisition and payments were also asked to study their consumption pattern. Further, the immigrant's average monthly utility bills were enquired. The immigrant worker's dependant will also reflect their spending and remittance pattern. Thus, questions were included about the number of their dependents in both home and host countries. In respect to the number of dependents, the immigrants were also asked about any loans made and the mode of payment in both home and host countries. Further, the respondents were also asked about their average monthly spending on rations and the frequency of item purchases. And finally, the availability of personal saving accounts in both home and host countries was asked about to study the degree of leakage. The mode of remittance made and the intention to stay were also asked to relate to the immigrant's spending and remittance pattern.

Analysis

As depicted in Figure 1, Indonesian immigrant worker monopolises the population followed by the Philippines. Most of the respondents are aged between 35 to 50 years old. This age could affect their spending pattern and their liability in both Malaysia and home country.

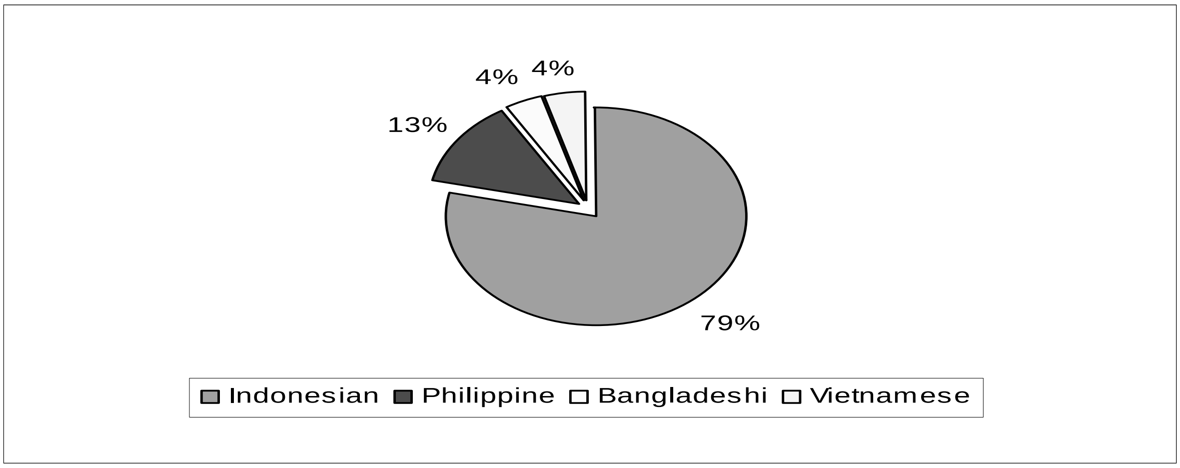


Figure 1: Respondent's Nationalities

From the literature, the more mature the households, the higher will be the liability, the wages and also the purchasing power. However, the spending habits of the household from this category will be lesser as they have obtained most of the basic things required for a living. The duration of stay in Malaysia will affect the immigrant workers' spending habits. The longer the work duration should reflect greater spending. However, this depends on the intention of the immigrants themselves whether or not to stay longer in Malaysia. From the analysis, most of the respondents have worked in Malaysia for more than three years which means they have managed to equip themselves with basic necessities.

Respondent's job type could affect purchasing power due to higher wages received for professionals and skilled workers. Most of the respondents' involved in this survey are skilled workers and professionals. This pattern could be due to the degree of difficulty of the questionnaires. It is noted that the higher the level of education, the higher will be the wages and, later the purchasing power. However, this has not always been the case from the pilot study findings. These showed only 6 professional workers as compared to 17 skilled. Hence it can be concluded that the immigrant workers, regardless of their job background, remit no less than 55% of their income to the home countries.

In analysis of the second section, only 10 hold a first degree. This scenario shows that there is the need to have a different approach in obtaining data from immigrant workers as there are tendencies for fallacy among the respondents. In the third section for analysis, the respondents' average monthly wages were shown to be as depicted in Figure 2. The pattern matches to the level of education.

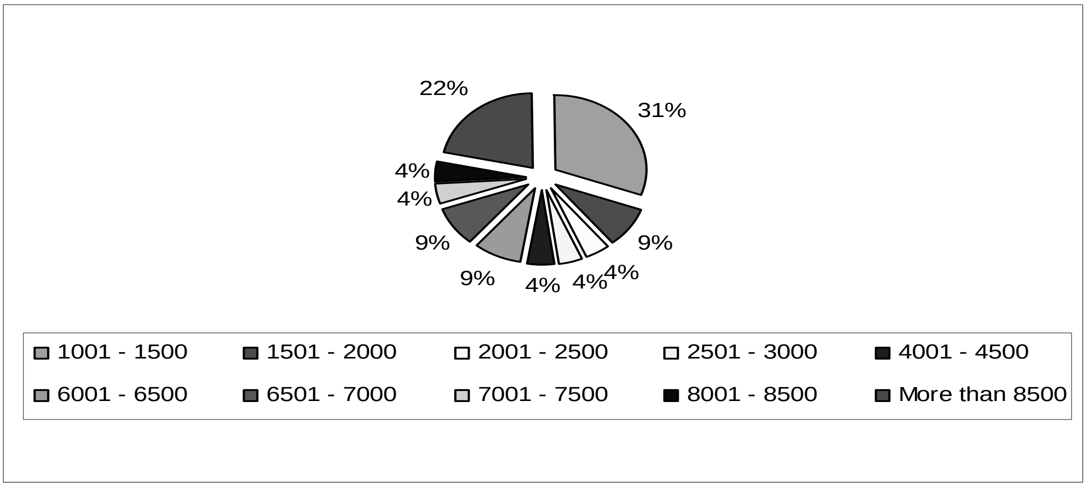


Figure 2: Respondent's Average Monthly Wages in Malaysian Ringgit (MYR)

From the literature, it is noted that job placement or demographics could affect the immigrant's remittance percentage. Logically and theoretically, immigrants who work in a rural area tend to spend less as there are not many shopping attractions. The remittance pattern shows that immigrant workers send most of their wages to their home country. This matches to the job demographics explained earlier.

Respondents' type of accommodation can be reflected in their monthly spending and remittance. The analysis shows that many of the immigrants are not obliged to pay for their accommodation. This is mostly due to the nature of Malaysian construction where the contractor will build temporary accommodation known as 'kongsi' to house the immigrant workers during their stay on site. The immigrants' transportation ownership will also reflect their monthly liabilities in Malaysia. The finding shows that most them do not possess any transportation. This could be due to the availability of transportation by the employer, the distance of the immigrants' 'kongsi' to the workplace and availability and validity of immigrants' driving licence. The survey shows that only one respondent purchased a car by monthly instalments and two purchased either a motorcycle or a bicycle by cash.

The need to pay utility bills monthly will also affect immigrants' purchasing and remittance pattern. From the survey, most of the respondents are not obliged to pay monthly utility bills. This again might be due the utility services being provided by the employer. Moreover, the transient nature of the construction hinders monthly bill payments by workers. Additionally, the presence of their dependants in Malaysia could also affect their willingness to share accommodation. It is also noted from the literature that a higher number of dependents implies higher remittance. The survey confirms the theory as shown in Figure 3 on respondents' number of dependents in their home country.

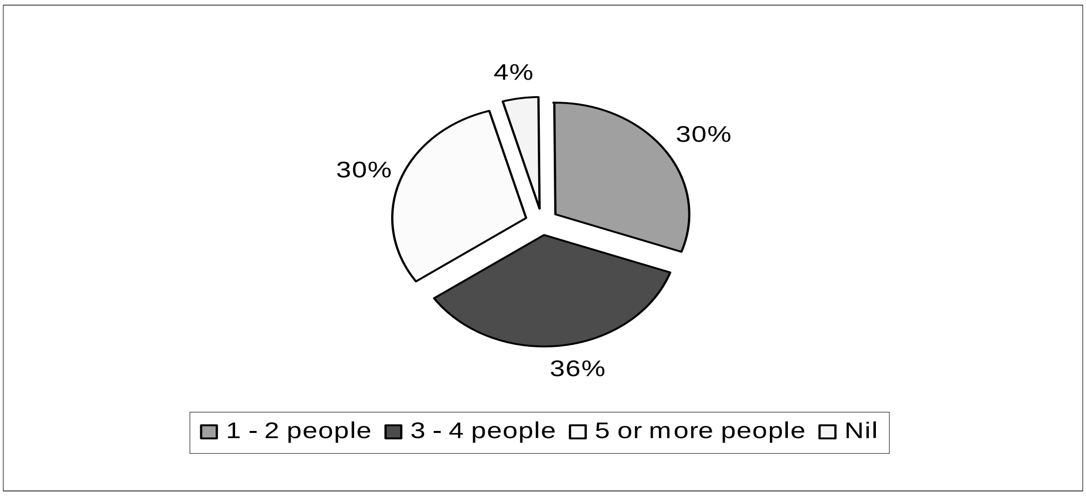


Figure 3: Respondents' Number of Dependents in Home Country

The age of dependants will also affect the percentage of remittance, as the older the dependents, the more the money required to educate and raise them. The same theory is applied to the effect of both the number and ages of immigrants' dependents in their home country and Malaysia on their spending pattern. The survey shows that most of the respondents do not have dependants in Malaysia.

Literature on econometric and remittance shows the higher the liabilities held by the immigrant workers in their home country will reflect higher remittance and lesser expenditure in Malaysia. Ironically, most of the respondents do not have many liabilities at both home countries and Malaysia. Their aim to remit was made mostly for their dependence back home. However, the liabilities in the form of monthly instalments are for those who received higher wages and considered as expatriate or professional. The monthly instalments made are below MYR 500 (£72) monthly. Most of the respondents do not have any mortgages in Malaysia. This pattern could due to their tendency to return to their home country at the end of their work contract, difficulty in loans approval, the duration of stay and lifestyle of construction industry. This scenario contributes to the importance to control the immigrant's remittance in return to help sustain the host country economic development especially in the construction industry.

The findings show that the respondents spend more than MYR 200 (£29) monthly. This amount, if compared to a Malaysian's average monthly expenditure is very low. On average, the Malaysian locals spend MYR1,943 per month in urban areas and MYR1,270 in rural areas (Department of Statistics Malaysia, 2004/5). This figure is 83% less than the locals' spending. The small amount spent by the respondents could be due to the nature of work, site location and their character. Most of the respondents will spend less during their job placement in rural areas as compared to those in urban areas. This encourages them to remit more. Study of shopping frequency will give an insight into spending habits. A higher frequency of shopping reflects a smaller percentage of remittance. Figure 4 shows the respondents' shopping items in Malaysia. Most of the items are groceries, wet and dry foods. A similar pattern emerged in the ranking of items mostly purchased in a month. It shows that the respondents spend no more than MYR 500 (£72) monthly, which is 60% less than the average Malaysian. This shows that little contribution was made to the Malaysian demand for commodities.

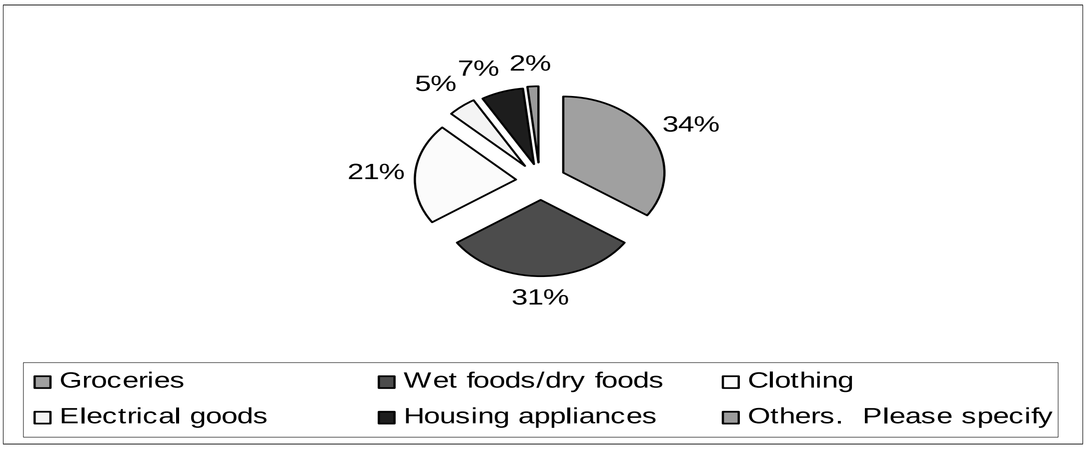


Figure 4: Respondents' Average Monthly Shopping Items

Looking at immigrant workers' saving pattern could reflect the possibilities of the immigrant workers to stimulate the economy by putting their savings into a proper channel namely banks. The survey shows that most of the respondents do have saving accounts, mainly in their home country. This trend does not help the local banks to invest their savings and multiply the economy.

Studying the channels used by the immigrant construction workers to remit will give an insight into whether there is a certain percentage or currency exchange rate involved during the remittance process. From the survey, most of the respondents send their wages by bank and Western Union. This reflects that most of the respondents have the privilege to send their wages to their home county and little contribution is made to the Malaysian economy. Finally, the intention to remain longer in Malaysia was asked about to reveal further their spending and remittance pattern. Most of them prefer to return to their home countries at the end of their employment contract which explains their minimal expenditure during their employment in Malaysia.

DISCUSSION AND FUTURE RESEARCH DIRECTIONS

The paper's findings open up to two possible realms of discussion. The first relates to the appropriateness of the methodological approach in conducting survey by questionnaires to tackle the issue. It shows that there is a gap in two types of immigrant workers based on their level of qualifications. The designed questionnaire was best distributed among the professional immigrant workers known as expatriates but a special type of questionnaire needed to be distributed to the non-professional immigrant construction workers. Hence a different approach needs to be considered in pursuing the next level of survey with regard to the issue mentioned.

The characteristics of both the nature of Malaysian construction projects and of the immigrant construction workers come second. Transient nature of projects duration and the management of immigrants' working place on site coupled with the immigrant workers' aims to save and remit their wages makes the industry exposed to the high degree of economic leakages. Furthermore, the current practice of the Malaysian construction industry should be revisited. Appropriate economic tools designed specifically for immigrant construction workers should be pondered to balance the inflow and outflow in the Malaysian economy.

Some of the steps towards balancing the economic leakage can be materialised by providing them proper rented housing where they can spend their income on basic necessities such as food, clothing, house rental, furnishing and household equipment to multiply the local economy. Another economic management viable to balance the leakage is by imposing immigrant construction workers to a work pension scheme. The accumulated pension deducted from their monthly wages can be claimed at the end of their employment before returning to their home countries. This is to reduce their purchasing power which later implies different spending pattern. Another approach is to encourage the immigrant workers to obtain local bank account to multiply their savings and later the local economy.

The way forward is by addressing three aspects namely the lifestyle, the current practice of managing construction projects and appropriate economic tools to control and balance the economy. Limitations from the use of questionnaire to delve into the immigrant construction workers' actual lifestyle and the identified degree of difficulty of questions, suggests that to overcome the problem is by conducting a semi-structured interview with the workers.

The appropriate methodology adopted for this research should be a combination of quantitative and qualitative approaches. Questionnaires can only provide some of the data while interviewing using semi-structures questions could delve into perceptions and opinions of the immigrant construction workers on the appropriate economic tools to be adopted. Consideration of the most suitable economic measures for the workers should take into account their character as well as maintaining the function of the construction industry in the Malaysian economy.

CONCLUSIONS

This paper has been able to give a snapshot of the current remittance and spending pattern among the immigrant construction workers in Malaysia. It unveils findings from a pilot study conducted by questionnaires. It also draws attention to re-visiting the current system of organising the construction immigrants' lifestyle in Malaysia. The construction immigrants' character as well as the nature of transient projects contributes to the economic leakage in the output multiplier of the Malaysian construction industry. The data presented reflect both the professional and non-professional immigrant workers in the Malaysian construction industry. In a nutshell, most of the immigrant construction workers spend less locally and remit most of their wages. This calls for drastic measures to balance the inflow and outflow of cash in the Malaysian economic cycles particularly in the construction sector. It deals with issues to improve the lifestyle and management of immigrant construction workers as well as finding the best applicable economic tools to balance the outflow. In addition, there is also the need to find solutions to attract the immigrant workers to spend locally and at the same time to help them in fulfilling their aims to remit their wages to their home country.

REFERENCES

Abdullah, F (2004) Construction industry and economic development - the Malaysian scene. Johor: Penerbit Universiti Teknologi Malaysia

Asean Development Bank (2006) "Worker's remittance flows in southeast asia", available at: http://www.adb.org/Documents/Reports/Workers-Remittance/default.asp

Bank Negara Malaysia (2008) Annual Report 2008. Kuala Lumpur: Bank Negara Malaysia

CIDB Malaysia (2007) Construction Sector Output and Multiplier Effects. CIDB News, Issue 3/2007

CIDB Malaysia (2007) Construction Industry Master Plan – Malaysia 2006 – 2015. Kuala Lumpur. Construction Industry Development Board Malaysia.

Department of Immigration Malaysia (2008) Survey of number of registered immigrant workers. Kuala Lumpur: Department of Immigration Malaysia

Department of Statistics Malaysia (2004/5) Report on household expenditure survey. Kuala Lumpur: Department of Statistics Malaysia

Glytsos, N. P. (2005) The contribution of remittances to growth - a dynamic approach and empirical analysis. Journal of Economic Studies, 32(6), 469-496.

Hillebrandt, P. M. (2000) Economic theory and the construction industry - third edition. London: Macmillan Press Ltd

International Labour Office (2004) Towards a fair deal for migrant workers in the global economy. Switzerland: International Labour Office

Ive, G., and Gruneberg, S. (2000) The economics of the modern construction sector. London: MacMillan Press

Manning, C (2001) The East Asian economic crisis and labour migration: A set-back for international economic integration? Departmental Working Papers with number 2001-03.

Ministry of Human Resource Malaysia (2006) Induction course for foreign workers working in Malaysia. Kuala Lumpur: Ministry of Human Resource Malaysia

Mohd Yusof, Z (2005) Kearah pengurangan kebergantungan tenaga kerja asing di sektor binaan. Jurnal Alam Bina, 7(1), 71-86.

Mustapa, F. D., and Pasquire, C. L. (2007) Immigrant construction workers and economic leakages. Proceedings Postgraduate Researchers of the Built and Natural Environment, Glasgow Caledonian University, pp. 351-360.

Narayanan, S., and Lai, Y, W. (2005) The causes and consequences of immigrant workers in the construction sector in Malaysia. International Migration Journal, 43(5), 31-57.

Ofori, G (1990) The construction industry - aspects of its economics and management. Singapore: Singapore University Press

Rosli S. M., and Kumar, S. A. (2006) "1.9 Juta Pekerja Asing Bawa Pulang MYR 500 Juta Sebulan". *In* the Mingguan Malaysia, 22nd October 2006.

Wickramasekera, P (2006) Asian Labour Migration - Issues and Challenges in an era of globalisation. Geneva: International Migration Programme.

CHANGE: a disconnected agenda?

Dr Scott Fernie
School of the Built Environment
Heriot-Watt University
Scotland, UK

ABSTRACT

Policy makers and change agents in the construction sector have repeatedly formulated and attempted to implement change. Efficiency gains arising from such change would undoubtedly improve the efficiency and competitiveness of the UK construction sector. Despite this, implementation of change has proved difficult. The main question highlighted in this paper is – why? The main assumption is that policy makers are disconnected from communities of practice such as project management. Consequently, the agenda for change fails to resonate with the concerns and interests of practitioners. Notably, developing and diffusing change in the construction sector is argued to be a large, complex, fragmented and contested arena that cannot remain the fiefdom of only strategic policy makers and large clients and contractors. Successful formulation and implementation of change it is argued should be the product of dialectic debate that captures and attempts to be sensitive to multiple voices from within the sector. The paper makes a case for engaging in research that attempts to bring deeper understanding and intellectual rigour to the way in which future change is formulated. It is to all intents and purposes a discussion paper and attempts to open up a debate on the subject of change from the perspective of 'formulation' rather than diffusion.

KEYWORDS: Change, policy development

INTRODUCTION

Perhaps one of the most interesting quotes to be found concerning 'change' would be that which has been translated from *Il Principe* (The Prince) (Machiavelli 1532):

> "*And it ought to be remembered that there is nothing more difficult to take in hand, more perilous to conduct, or more uncertain in its success, than to take the lead in the introduction of a new order of things. Because the innovator has for enemies all those who have done well under the old conditions, and lukewarm defenders in those who may do well under the new. This coolness arises partly from fear of the opponents, who have the laws on their side, and partly from the incredulity of men, who do not readily believe in new things until they have had a long experience of them*." (Machiavelli 1532 Chapter IV)

If we take a broad perspective on what is meant by *a new order of things* we can then safely assume that those who '*lead*' in the construction sector are perhaps overly familiar with the challenges described by Machiavelli regarding attempts to develop, propose and diffuse industry-wide innovation. Indeed in the construction sector the *introduction of a new order of things* could easily fit well with the objectives and content inherent in the Latham report

(1994), the DETR (1998) report and the ongoing 'rethinking construction' agenda. Arguably, the *innovator* and those who take the *lead* could be different individuals or indeed institutions. For example, is the construction sector unit at the Department for Business, Enterprise & Regulatory Reform (BERR) responsible for taking the *lead* and institutions such as the Strategic Forum for Construction (SFC) and Constructing Excellence (CE) responsible for innovating? If so, are the innovators' *enemies* actually the institutions within which such innovation will be diffused and/or, the practitioners and their *incredulity* regarding the way in which their long experience of practice is challenged by (re)thinking the *old conditions*? Notably, the quote suggests that those whose practice is challenged are disconnected from those who lead and have developed the new order and, by implication those who have criticised the old order and conditions. But, does this disconnect actually underpin the challenges and problems faced by the *innovator* and those who *lead*? The incredulity of men (practitioners) is also seen to be related to their inability to actually make 'sense' of the *new order* given their allegiance to *old conditions*. If nothing else the quote highlights the complexity inherent in implementing a *new order* but pays less attention to the way in which *new order*(s) are formulated and the inescapable connection between the process of formulation and diffusion. Notably, diffusing a new order suggests alterations to the old order or indeed its complete overhaul. The question is however; should those with an interest in the new order focus attention on how it is diffused or, the process of formulating a new order? Perhaps the answer is both!

These are interesting and thought provoking questions and issues regarding change. They are all the more interesting because the date of this Machiavellian quote belies the currency such questions and issues have to the theoretical and practical domain of change today – especially in the construction sector. Whilst this paper does not endorse a view that the approach to change in construction is Machiavellian or, that it should be, it is concerned with exploring and highlighting assumptions underlying the way in which change is formulated, mobilised and enacted. The paper will however, at certain points, draw upon aspects of the Machiavellian quote used above - if for no other reason than provocation or fun!

The paper is broken down into five main sections. The first provides a backdrop or canvass upon which the rest of the paper is drawn. The second explores the broad issue of change in construction and seeks to understand the main players involved, the rationale for change and success. The main questions driving this aspect of the paper are – who is involved in formulating change? And, how is change formulated? As the questions here suggest there will also be an argument for greater attention on 'formulation' rather than the 'diffusion' of industry-wide change. The third section of the paper is concerned with problems and issues that can be levelled at the way in which change is formulated, how it is understood and the limitations of the current dominant assumptions that underpin formulation and research. The fourth part of the paper is a discussion about the need for a new avenue of research that draws from alternative methodological approaches to improve the way in which change is formulated and by extension it's potential to steer the sector towards 'desired' outcomes. The last part of the paper presents some tentative conclusions and comments on the way forward for those concerned with developing an agenda for change. It is also concerned with discussing how to develop and execute an agenda for research that runs parallel with and supports the development of an agenda for change.

BRIEF BACKDROP OF CHANGE IN THE CONSTRUCTION SECTOR

Knowledge as innovation and change within organisations is typically assumed to be linked to future productivity gains, competitive advantage or survival (Bogner and Bansal 2007). This has been broadly supported by UK Government policy designed to encourage the development and diffusion of innovation across all industries in the UK. The construction sector has not escaped these ongoing concerns (Fairclough 2002; DTI 2007). Following the lead of the reformers, research has explored the diffusion of change (Dainty *et al.* 2001; Beatham 2004; Briscoe 2004; Cain 2004). Significantly, other funded research such as 'Cultural Change in Construction: Developing the Client's Management Role to Improve Project Performance' provided valuable insights into the link between proposed change and the culture of the sector (Bresnen *et al.* 2005).

Despite significant attention and resources given to diffusing change by policy makers (NAO 2001; Fairclough 2002; NAO 2005) and researchers (Bresnen *et al.* 2004), the UK construction sector remains largely resistant (because of their *incredulity*?) to repeated calls for change. Such change is largely driven by policy makers (*lead*ers) aspirations to improve productivity and competitiveness (Fernie *et al.* 2006). This resistance to change is rather problematic since the UK construction sector makes a significant contribution to the UK's GDP and is expected to continue to do so in the future. Whilst some limited change has been forthcoming, for example health and safety (via law and regulation), organisations concerned with policy such as the Department for Trade and Industry (DTI), the Strategic Forum for Construction and, the Office of Government Commerce (OGC) agree that the sector continues to be resistant to change (Ward and Holti 2006). Where there is less agreement is on the motivation for such resistance and its potential use in the process of formulation. In essence such resistance is viewed rather simplistically and negatively.

The ongoing problem of making change happen and improving productivity and competitiveness in the sector is thus widely accepted by academics and policy makers alike. The question of 'why' has been explored to some extent by looking at the process of diffusion. However, to what extent the degree of diffusion is determined or influenced by the way in which change is formulated has received little attention. Taking a more holistic view of change, policy formulation relating to change undoubtedly plays a pivotal role in the successful transformation of the sectors productivity and competitiveness. Notably, research that explores the breadth, depth, rigour and method drawn upon to formulate policy relating to change is largely absent.

This lack of emphasis on formulation and its disconnection from implementation is not an unusual phenomenon to be found and discussed in the strategy literature. The consequences of this lack of emphasis and connection within the context of the construction sectors repeated attempts to formulate and implement a *new order* is however underdeveloped. Indeed, few research projects have actually engaged with how policy-driven change is formulated. Such strategically important research was recognised as necessary by Adamson and Pollington's (2006) political review of the reform movement.

Clearly, based upon the above critique, developing yet another round of reforms, a new order or a plan to develop specific implementation frameworks is limited in the absence of a rigorous examination of the way in which industry wide change is formulated and connected to plans for diffusion. Should not the objectives of stakeholders in the construction sector be concerned with exploring and developing policy driven change that simultaneously resonates with the concerns and interests of all stakeholders? Or, at least concedes to the view of conflicting agenda between stakeholders and interest groups regarding change. To answer such a question and take forward such an aspiration there is a necessity first to explore the current ‘agenda for change’ and the way in which it has been formulated. In essence attempts should be made to broadly reflect upon why change has been repeatedly resisted and largely unforthcoming. Any future new order should thus be fully informed from a review and reflection on past orders, current orders, past resistance, environmental constraints and stakeholder engagement. New orders cannot escape the ‘heavy hand of the ‘past’, indeed they will undeniably be shaped by the past.

CHANGE IN CONSTRUCTION

From the Simon Committee Report (1944) to the widely cited and more contemporary Latham (1994), DETR (1998), Fairclough (2002) and NAO (2001; 2005) reports, the broad subject of change and reform has been, and remains, central to debate, discussion and research in the construction sector. Undoubtedly, any arguments underpinning the need for the construction sector to dramatically improve its project performance and effectiveness are difficult to dismiss. Thus, organisations within the sector arguably need to address and reform managerial practice to improve the productivity of the sector. However, success in achieving substantive, substantial and sustainable change in the construction sector has not been forthcoming (Langford and Murray 2003).

Past and current arguments for reform have not escaped the gaze and attention of professional bodies such as the: Royal Institute of British Architects (RIBA); the Royal Institute of Chartered Surveyors (RICS); or the Chartered Institute of Building (CIOB). Such bodies have been broadly interested in the change outlined by industry wide reports and rightly so since their members are central to the criticism outlined in these reports and to the successful diffusion of any proposed innovation. There have also been a significant number of governmental and non-governmental organisations with the remit to promote, disseminate and evaluate proposed reforms emanating from the industry reviews in the sector. Within this broad reform movement, numerous initiatives have been sponsored and promoted over recent years. However, despite calls for reforms over the last 6 decades diffusion of change in managerial practice in the construction has proved problematic at best.

Extending the reach of the reform movement, the Accelerating Change in Built Environment Education programme (ACBEE) attempts to make an explicit link between the ‘Rethinking Construction’ change agenda developed and promoted by the reform movement and the curricula of built environment education in UK universities (ACBEE 2005). This attempt to diffuse change in the sector ‘at source’ emphasises a move towards more novel and underdeveloped approaches to diffusing change. Few change initiatives have in the past attempted to mobilise the content of their reforms to evolving professionals with little or no experience and understanding of the competitive contours of the built environment and the current legitimised practice/recipes that characterise the sector. What is most surprising about the extraordinary sustained and innovative efforts of the reformers is that despite clear evidence of (re)thinking, strategic arguments for change and, significant resources thrown at the process of diffusion, substantive widespread reforms remain elusive.

Undoubtedly, the processes of formulating policy regarding change and diffusing change are highly interdependent. The dominance of research attention has however largely ignored the need to challenge and explore the strategic processes drawn upon to formulate policy regarding change and their connection to processes of diffusion. Indeed, there is very little evidence in the literature to help answer questions concerning what analysis is done, how this is done and who conducts the analysis. Given this lack of research, the basis upon which contemporary calls for change have been developed is argued by some to lack sufficient intellectual rigour (Woudhuysen and Abley 2004). It is not necessary to agree with this assertion to concede that the processes of 'formulation' are largely taken for granted by industry and researchers alike.

It is therefore very difficult to answer, with any detail or certainty, questions regarding the processes of formulating an agenda for change. Individual names of influential people and organisations involved in the grand project 'change in construction' are quite apparent but their roles, connections, interests and purpose are less obvious or scrutinised. These institutions and individuals are well known to researchers and include the Strategic Forum for Construction; the Construction Sector Unit (CSU) in the Department of Business, Enterprise and Regulatory Reform (BERR, formerly Department for Trade and Industry); and Constructing Excellence (CE). Notably, it is very difficult to ascertain what actual analysis is conducted, why it is conducted, how it is conducted, who actually conducts the research and how this is written up as a piece of research – including limitation. Indeed, there is not a single academic paper written that this author has been able to source that explains the underlying research methods used to develop the current 'agenda for change' or indeed, why they were chosen as the most suitable or only method. The absence of such detail is in itself interesting but for the purposes of transparency and openness provides little to those keen to make a contribution to the way in which change is formulated. Formulation is an exclusive domain and, not one that has drawn the attention of researchers or indeed, inclined to invite academic scrutiny. Given the importance attached to making change happen in the construction sector, this lack of scrutiny is all the more surprising. It is however, outwith the remit of this paper to fully explore this last point but, it would undoubtedly make for an extremely interesting research project –a grand challenge indeed!

At the time of writing, CE are busy mobilising a survey to explore the last 10 years of the Egan agenda as one of the foundations for developing the next industry report. To what extent this helps answer Woudhuysen and Abley's (2004) stinging criticism of a lack of intellectual rigour is debatable but, it would, on the surface, appear to be a transparent step. Such a survey, upon analysis, will however leave itself open to reflection by researchers exploring its efficacy in helping shape an agenda for change – assuming it is made public. Despite this however, the survey will not help uncover the mystique, motivations and interests that shape the strategic processes used for developing an agenda for change. The survey will also do little to connect policy with practice or indeed explore the ways in which change has been resisted and proved problematic. To what extent a survey of this nature can help provide robust reliable answers concerning the 'way forward' is limited. It is also questionable, in the context of the arguments mobilised in this paper, if another industry report holds the key to ensuring substantial and sustainable change in the sector. Is it not more appropriate to explore the process of 'formulation' rather than throwing resources at formulating yet another 'agenda'? Change is therefore important but research and industry attention has been capitalised on the need to diffuse change rather that critically reflecting upon the formulation of such change/policy. Why?

THE PROBLEM OF MAKING CHANGE HAPPEN

Underlying the contemporary view of change in the sector is the assumption that change is similarly interpreted by formulators and practitioners alike. However, there are undoubtedly any number of motivations to explain why practitioners obstruct change (Marchington and Grugulis 1998) and indeed why formulators propose change. It should not be assumed that formulators and practitioners share similar views about what change is required and how to achieve such change. An understanding of practitioners' interpretations of the content of change is therefore pivotal to any attempt to develop or diffuse change. Notably, prevailing views of the failure to see change significantly diffused has been to rely on arguments that the sector: is 'ill' (DETR 1998); has inherent 'bad ways of both thinking and practice' (Fischer and Green 2001); has a 'plague' (Kagioglou 2000); or, that the sector is populated by practitioners oblivious to its failings (Cain 2003).

The prevailing views also follow a well travelled path in dismissing resistance to change as irrational and/or counter productive behaviour (King and Anderson 2002). These views militate against any robust challenge or exploration into the processes of formulating policy regarding change. One such challenge would be that which is proposed by the concept of resonance. This concept provides an explanation for why proposed changes are positively acted upon by practitioners if they resonate with their concerns (Hodder 1998). If not, they may be rejected or pursued only symbolically.

Contrary to the prevailing views is an argument that resistance (action) is entirely legitimate once located in a wider debate about how practitioners interpret the structures within which practice (and proposed change) is embedded and legitimised (Fernie 2005; Fernie *et al.* 2006; Fernie and Thorpe 2007). Arguably, research that seeks to understand resistive action is a fundamental source of knowledge in furthering aspirations to achieve sustainable change. It is also necessary for policy makers to engage with, understand, and debate the 'legitimacy' of practitioners practice during the process of formulating policy and framing change.

Further to these ideas of legitimacy and resonance, it is also necessary to recognise that different industry sectors and organisations are characterised by organisational routines (Massini *et al.* 2002) that reflect a historical understanding of both context and practice. Managerial practice inevitably 'shape and are shaped by' these routines over time. Any analysis of the legitimacy of managerial practice must therefore be highly sensitive to context. Historical experience of change initiatives must also form part of any analysis regarding resistance to change. In essence it is necessary to engage with practitioners in uncovering the underlying assumptions that inform their resistive actions, 'legitimacy', concerns and interests. Connecting such engagement with policy development would arguably be instrumental in developing a more resonant agenda for change. The problem of making change happen is thus not simply a question of for 'diffusion' researchers to explore but, also for policy researchers and those that bridge the gap between policy and practice.

THE WAY FORWARD: CRITICAL RESEARCH?

Notably, the need for better connections between policy makers, practitioners and the research community have not escaped the attention of a small number of contemporary critical researchers in the construction sector. For example; Bresnen and Marshall (2000) describe the reformers desire for partnering as naively constructed; Green and May (2003) highlight how the research agenda appears to ignore the meanings and experience of the workforce regarding change; Fernie *et al*. (2003) argue for a need to engage in dialectic debate between stakeholders in exploring managerial practice as knowledge; Bresnen *et al*. (2005) argue for further research into how reforms tend to be insensitive to the legitimacy of well established ways of working in project based organizations; Green and May (2005) argue that managers could well be mobilizing the language of reforms whilst persisting with established practices and routines – symbolic activity (Leiringer and Green 2007); Fernie *et al*. (2006) argue that an agenda for change in the UK construction sector needs to engage with and be more reflective of the 'legitimacy' of current managerial practice and past change initiatives; and Fernie and Thorpe (2007) argue for a more inclusive environment within which the debate on an agenda for change in the construction sector is developed.

These researchers have begun to carve out a critically orientated perspective on how knowledge associated with change and innovation in project based organizations should be viewed and researched. They do not however directly focus upon the specific issue of formulating change. Notably, the disparity between proposed change and the successful diffusion of change acutely highlights the problem of separating those with the institutional power to develop a change agenda (policy makers) from those that hold the power to institutionalise change (practitioners) (Seal *et al.* 2004). Understanding and connecting these disparate power bases is arguably fundamental to developing and achieving widespread change. Therefore, whilst it is readily conceded that policy makers and practitioners are instrumental in any change agenda it is arguably common sense to connect their disparate views and actions regarding change. Indeed few research projects have sought explore the space within the context of change in construction between policy makers and practitioners. Such research, in doing so, would be pivotal and capable of making a significant contribution to many of the crucial aspects of connectivity between policy and practice suggested by the critical researchers above.

Arguably, widespread diffusion of an agenda for change that resonates with multiple stakeholders in the sector is undoubtedly preferable to limited diffusion of change that resonates with few interested stakeholders regardless of their institutional position in the industry. The former would achieve far reaching, sustainable improvements in the delivery of services and products and the goal of providing value for money to public and private sector clients. The latter runs the risk of perpetuating the cycle of industry reports that repeatedly reiterates overly familiar calls for change and casts project based organisations (predominantly practitioners) as dilettantes who stand in the way of progress rather than holding the key to progress (Fernie 2003). Thus, research that explores the space between policy and practice and attempts to make connections therefore explores what appears to be missing in the debate about change - politically charged questions surrounding who defines what reforms are necessary, when and how.

Notably, there are few challenges to the assumption that past and contemporary policy driven change makes sense to practitioners. Therefore, research that explores the breadth, depth, rigour and method drawn upon to formulate policy relating to change would be instrumental in deepening our current understanding of change in construction. The challenge is therefore initially to deconstruct, from a variety of perspectives using various methodological approaches, the development and diffusion of industry reviews and proposed reforms conducted by strategic thinkers and clients within the sector.

CONCLUSIONS

Calls for change in the UK construction sector seem compelling and convincing. Despite this, change in the sector has proved problematic. This paper has attempted to at least begin to explore the space between aspirations to change and the consequences of change initiatives designed to fulfil such aspirations. Critically gazing upon this gap, the question of how aspirations are transformed from rhetoric (change initiatives) into reality is readily conceded to be strategically important and cannot be denied. However, the gap also suggests hitherto unexplored and articulated questions and issues surrounding the aspirations themselves – How are they formulated? Who is involved in the formulation? Who do they represent? Indeed the question of connecting formulation to implementation is also rather compelling as a consequence of exploring the space.

Fundamentally, this paper presents a critical view of a single author on what is considered to be fundamental to the construction sectors ongoing project to change. The view presented is predominantly informed by an argument that policy and practice are disconnected and thus change initiatives are developed independently by one institutional social group that is largely disconnected from a separate institutional social group through which change will be negotiated. The overall process and objective of change in construction must be radically rethought and understood to be socially complex not only as a function of diffusion but also as a function of formulation. Indeed, to ignore their connection is to miss a significant part of the puzzle in moving from aspiration to substantive and sustainable change in the sector.

So, to return to the title of the paper now the content has been read – are policy and practice connected? Do they need to be connected? What is the value of their connection? How do we make this connection? What are the barriers to making these connections? You decide, but before you do, consider for a moment your role in the construction sector and where your dominant interests and allegiances lie with respect to your future. The connections described and called for in this paper may not be in your interests or future progression! Indeed you yourself may be the *men* [or women] of whom Machiavelli refers to when he talks of *the incredulity of men, who do not readily believe in new things until they have had a long experience of them*. Is the *new order* of research I am broadly proposing heading for a *perilous to conduct* journey that must be understood to be *uncertain in its success*. Does the current dominance of research in diffusion reflect *old conditions* where some have done well and others not so well – the *enemies* and *lukewarm defenders*?

Change is multi layered and complex and, there really is *nothing more difficult to take in hand* or manage. But, is it worth it?

REFERENCES

Adamson, D. M. and Pollington, T. (2006). *Change in the Construction Industry: An account of the UK construction industry reform movement 1993-2003*. Routledge. Abingdon, Oxon

Beatham, S., Anumba, C., Thorpe, T., Hedges, I. (2004). "KPIs: a critical appraisal of their use in construction." *Benchmarking* **11**(1): 93-117.

Bogner, W. C. and Bansal, P. (2007). "Knowledge Management as the Basis of Sustained High Performance." *Journal of Management Studies* **44**(1): 165-188.

Bresnen, M., Goussevskaia, A. and Swan, J. (2004). "Embedding New Management Knowledge in Project-Based Organizations." *Organization Studies* **25**(9): 1535-1555.

Bresnen, M., Goussevskaia, A. and Swan, J. (2005). "Organizational routines, situated learning and processes of change in project based organizations." *Project Management Journal* **36**(3): 27-41.
Bresnen, M. and Marshall, N. (2000). "Partnering in construction: a critical review of issues, problems and dilemmas." *Construction Management and Economics* **18**: 229-237.
Briscoe, G. H., Dainty, A.R.J., Millett, S.J., Neale, R.H. (2004). "Client-Led strategies for construction supply chain improvement." *Construction Management and Economics* **22**: 193-201.
Cain, C. T. (2003). *Building Down Barriers: a guide to construction best practice*. Taylor and Francis. London
Cain, C. T. (2004). *Performance Measurement for Construction Profitability*. Blackwell. Oxford
Dainty, A. R. J., Briscoe, G. H. and Millett, S. J. (2001). "New perspectives on construction supply chain integration." *Supply Chain Management: An International Journal* **6**(4): 163-173.
DETR (1998). Rethinking Construction. London, Department of Environment Transport and the Regions.
DTI (2007). The Construction Research Programme - Project Showcase, Department of Trade and Industry.
Fairclough, J. (2002). Rethinking Construction Innovation and Research: a Review of Government R&D Policies and Practices. London, Department of Trade and Industry (DTI).
Fernie, S. (2005). Making sense of supply chain management in construction: theory versus practice. Department of Civil and Building Engineering. Loughborough, Loughborough University. **PhD:** 284.
Fernie, S., Green, S., Weller, S. and Newcombe, R. (2003). "Knowledge Sharing: Context, Confusion and Controversy." *International Journal of Project Management, Special issue: Management of knowledge in project environments* **21**(3): 177-188.
Fernie, S., Leiringer, R. and Thorpe, T. (2006). "Rethinking change in construction: a critical perspective." *Building Research and Information* **34**(2): 93-103.
Fernie, S. and Thorpe, T. (2007). "Exploring change in construction: supply chain management." *Engineering, Construction and Architectural Management* **14**(4): 319-333.
Fischer, N. and Green, S. (2001). Partnering and the UK construction industry the first ten years - a review of the literature. *Modernising Construction*. N. A. Office. The Stationary Office London**:** 58-66.
Green, S. D. and May, S. C. (2003). "Re-engineering construction: going against the grain." *Building Research and Information* **31**(2): 97-106.
Green, S. D. and May, S. C. (2005). "Lean construction: Arenas of enactment, models of diffusion and the meaning of 'leanness." *Building Research and Information* **33**(6): 498-511.
Hodder, I. (1998). Creative thought: a long term perspective. *Creativity in Human Evolution and Prehistory*. S. Mithen. Routledge London.
Kagioglou, M., Cooper, R., Aouad, G., Sexton, M. (2000). "Rethinking construction: the Generic Design and Construction Process Protocol." *Engineering, Construction and Architectural Management* **7**(2): 141-153.
King, N. and Anderson, N. R., and King, N. (2002). *Managing Change and Innovation: A critical guide for organizations*. Thomson. London
Langford, D. and Murray, M. (2003). Introduction. *Construction Reports 1944-98*. M. M. a. D. Langford. Blackwell Oxford**:** 1-7.
Latham, M. (1994). *Constructing the Team: Joint Review of Procurement and Contractual Arrangements in the United Kingdom Construction Industry*. HMSO. London

Leiringer, R. and Green, S. D. (2007). The substantive and symbolic management of legitimacy in PFI procurement. *CIB W092: Interdisciplinarity in Built Environment Procurement conference*, Hunter Valley, Australia.
Machiavelli, D. N. (1532). *Il Principe*.
Marchington, M. and Grugulis, I. (1998). "Best practice human resource management: perfect opportunity or dangerous illusion?" *International Journal of Human Resource Management* **11**(6): 1104-1124.
Massini, S., Lewin, A. Y., Numagami, T. and Pettigrew, A. M. (2002). "The evolution of organizational routines among large Western and Japanese firms." *Research policy* **31**: 1333-1348.
NAO (2001). Modernising Construction. The Stationary Office, London, National Audit Office.
NAO (2005). Improving public services through better construction. The Stationary Office, London, National Audit Office.
Seal, W., Berry, A. and Cullen, J. (2004). "Disembedding the supply chain: institutionalized reflexivity and inter-firm accounting." *Accounting, Organization and Society* **29**: 73-92.
Simon, S. E. (1944). *The placing and management of contracts*. HMSO. London
Ward, D. and Holti, R. (2006). Towards more effective integration in UK construction, Constructing Excellence.
Woudhuysen, J. and Abley, I. (2004). *Why is Construction so Backwards?* Wiley-Academy. Chichester

ONLINE SURVEY: FACTORS DETERRING THE DEVELOPMENT OF AUTOMATED_QUANTITY_TAKING-OFF_SYSTEM

Evelyn Ai Lin TEO
Department of Building, National University of Singapore, 4 Architecture Drive, Singapore 117566
email: bdgteoal@nus.edu.sg

Abstract One of the computer-based automation areas that Singapore Institute of Surveyors and Valuers (SISV) is enthusiastic about is to develop an Automatic Quantity Take-off System (AQTS). The success of the development of such a system will very much depend on the implementation of the object orientated computer aided drawings to generate the quantities of the building models. The continuous adoption of two-dimensional drawings by the designers in the local scene will hinder the development of the AQTS. The purpose of this study is to develop a conceptual framework by identifying the determined factors that enabling the development of the AQTS. The survey findings show that the most important factor which hinders the development of 3D drafting is found to be *cost*. The paper concludes that the development of AQTS is feasible with the concerted supports of the industry, construction professionals, IT vendors, academics and government.

***KEYWORDS*:** Automatic Quantity Taking-off System; Building Information Model; Construction Electronic Measurement Standards

INTRODUCTION

Singapore Construction 21 (C21), the white paper fortifies the stimulus for change in construction processes and practices so as to improve performance. CORENET (COnstruction and Real Estate NETwork) is a key IT program in Singapore to re-invent construction. It uses an integrated total system approach by embracing IT Application to achieve the aim of C21.

To achieve a total approach system, requires the development of an Automated Quantity Taking-off System (AQTS) to smooth the progress of procurement. The success of AQTS will depend unequivocally upon ‘the quality of drawings, and the accuracy of information provided by the designers’ (Teo et al, 2008; p8). The aims of producing the new national electronic standards (the Construction Electronic Measurement Standards, (CEMS) and the National Productivity and Quality Specification (NPQS)) for building measurement are to facilitate the development of AQTS and to enable easy exchange of data between CEMS, NPQS and CAD drawings/objects. This means enabling seamless migration of data from architectural and engineering design, based on the Object-Oriented Computer Aided Design (OOCAD) technology and the two standards. The to-be-developed AQTS must be ‘capable of interfacing and synthesizing both upstream design information and downstream contracting and procurement activities’ (IAI(S), 2004a). With the launch of CEMS and NPQS, it was found that there is resistance from construction industry players with poor take up of the 3D CAD Measurement software (one of the tools recommended to smoothen the transition from present processes to the more efficient processes that follow the implementation of AQTS) offered by SISV. The possible reasons why the technology implementers are encountering resistance to the technology itself are many. The focus of this study is the exploration of the factors which impede the usage of 3D modeling [the Building Information Modelling (BIM) approach] for building works in Singapore construction industry, an important factor in the success of the development and implementation of AQTS.

The purpose of this paper is to find out the industry's apparent resistance to the current technology so as to design a conceptual framework for promoting the use of 3D modeling in the local construction industry and to increase the efficiency and competitiveness of the profession.

AQTS - IMPORTANCE OF TECHNOLOGY, PROCESS AND PEOPLE

According to Lee and Sexton (2007) for the development of 3D or nD modelling, there ought to be intrinsic links between ***Technology, Process*** and ***People***. They furthered stressed that the capacity by ***People*** to exploit ***Technology*** is extremely important so as to find the potential to exploit new developments by studying the capacity (***People***) to do the work.

Therefore, to develop AQTS, SISV has to take ***People, Process*** and ***Technology*** (refer to Figure 1) into consideration. Moreover, the prerequisite for any new development to work, in this case AQTS, is to ensure the synchronisation of ***Technology*** and ***Process*** as well as the readiness of the ***Technology*** and ***People***. Most importantly, the willingness to change (***People***) to ensure that the ***Process*** can be organised into useful developments which are required by AQTS to assist in measuring the quantities of the building works. The study by Lee et al (2005) stressed that the barriers in the up take of new technology is human. Barriers of this kind are cited as "most problematic in nature due to the unpredictability of the behaviour of groups and individuals, and the multiple effects that that behaviour can have" (Lee et al, 2005, p42). Attitudes play an important role in whether technological change proceeds smoothly or not (Sankar, 1991). Lee et al (2005) emphasized that the most significant problem in implementing new technology will be people management, not technology.

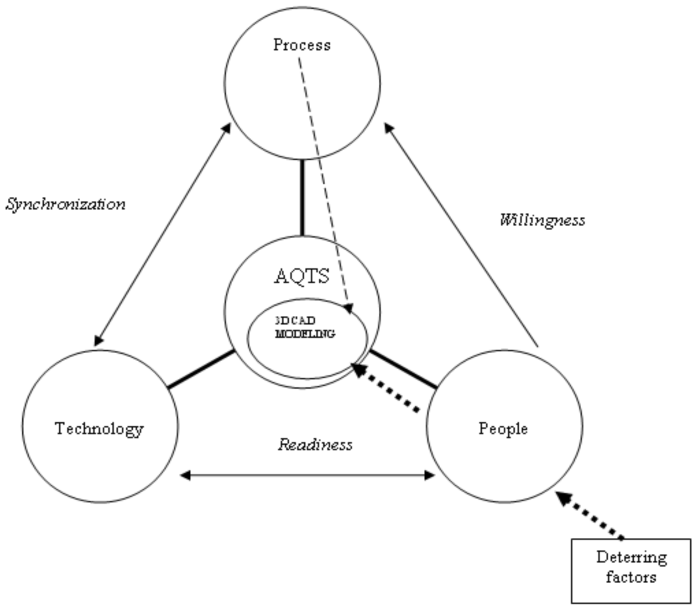


Figure 1: AQTS - The Importance of Technology, People and Process

As emphasized earlier, the success and accuracy of AQTS will depend upon the quality and accuracy of drawings provided by the designers. "Inaccurate and poor-quality drawings will result in (i) inaccurate measurements; (ii) double-handling as the Quantity Surveyors (QSs) will have to 'tidy' the drawings before measurement; (iii) reluctance on the part of the QSs to use AQTS if this double-handling persists; (iv) eventual failure of AQTS" (Teo et al, 2008; p8). It is important to ascertain the designers (architects and engineers) resistance to change in view of AQTS, because the quantities are generated from the CAD model developed by them. Moreover, QSs adoption rate of AQTS are dependent on the quality of Designers' CAD model. This paper concentrates on the willingness of ***People*** (i.e. designers) to adopt 3D CAD modelling in order to use AQTS.

RESEARCH METHODOLOGY AND THE FINDINGS

This study is part of a larger study of factors affecting the deploying of the 3D-based technologies in the construction industry in Singapore. A questionnaire was designed with the objective of determining the more important variables that affect the use of 3D CAD; which included factors that help organizations to deploy 3D-based technologies. This paper concentrates on the factors relating to enabling the development of AQTS. Based on the literature review, recent studies on new technology adoption (Lee et al, 2003; Bazjanac, 2002; IAI (S), 2004b; Teo et al, 2008) and interviews with local leading IT vendors, a list of factors hindering the usage of 3D modelling is proposed under five categories namely, software, hardware, drafting, internal and external environment as shown in Figure 2. The formation of the questionnaire was based on Figure 2.

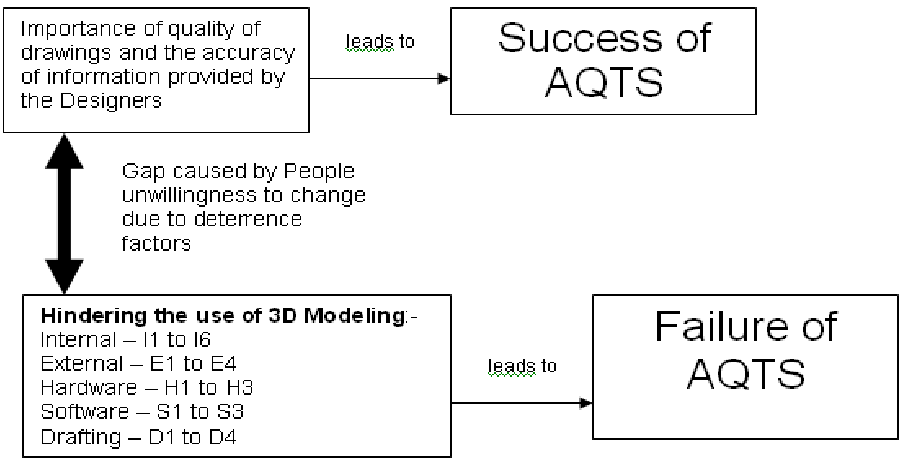


Figure 2: List of factors hindering the usage of 3D modeling based on literature review and interviews

In the questionnaire, respondents were requested to provide information relating to deploying 3D CAD in their daily routine to perform their work. Respondents were asked to rate the extent to which each of the variables hinder them to use 3D modeling, on a five-point Likert scale, where 1 = 'do not hinder' and 5 = 'hinder to extreme extent'.

The population comprised practicing architects and engineers and as well as the local undergraduates studying in the architecture and engineering disciplines. The sampling frame was the Singapore Board of Architects, the Singapore Professional Engineers, and the two local universities (refer to Table 1).

Table 1: Profile of respondents

Profile of Respondents	***Sent Out***	***Returned (Usable Response)***	***Percentage***
Architects	100	15	15%
Architects (undergraduates)	100	20	20%
Civil Engineers	100	15	15%
Civil Engineers (undergraduates)	100	25	25%
Total:	**400**	**75**	**18.75%**

From the 400 questionnaires emailed out, 82 responses were received within two months. Seven questionnaires that were not substantially completed were discarded (response rate of 18.75%). Data from the remaining 75 usable returned questionnaires were checked, edited, coded and analyzed. Statistical analysis was conducted using SPSS. T-tests of the means were used to check the significance of the responses to the issues raised in the questionnaires. The level of significance was set at 0.05 (5%). The H_0: $\mu \leq 3$ or H_1: $\mu > 3$. Therefore to accept H_0 is to say that the factor being tested is not significant and not hindering the usage of 3D modelling, while H_1 indicates that the factor is significant. The respondents consist of 40% working professionals and 60% undergraduates. Out of the 75 respondents, 76% prefer to use a combination of 2D and 3D, 16% prefer to use only 2D and 8% prefer to use only 3D drafting (Table 1).

The results of this survey are as shown in Table 2. The average scores given by respondents for each hindering factor deterring designers not adopting 3D modelling were calculated. The three most important variables (with highest means) are:

1. S1 - License fee of CAD software (mean = 4.24);
2. H2 - Extremely costly to support full 3D drafting (mean = 3.98); and
3. I2 - Present drafters are not trained in 3D (mean = 3.68).

The t-test results showed that 16 out of 20 variables are significantly hindering the adoption of 3D modelling. The four variables that are not hindering designers are:

1. D4 - Annotation in 3D is difficult and confusing (p = 0.105);
2. E3 - Construction Industry does not see the need to go 3D (p = 0.113);
3. D1 - Certain complex designs cannot be drawn in 3D (p = 0.387); and
4. E4 - Client does not appreciate 3D modelling (p = 0.200).

DISCUSSION OF RESULTS AND FACTORS THAT ENABLE THE DEVELOPMENT OF AQTS

In order to encourage incremental adoption of 3D modelling by the designers, gap caused by ***People*** unwillingness to change due to the deterrence factors must be addressed to ensure smooth implementation (Figure 2). Basically, the t-test results (Table 2) show that designers felt that the 16 factors are significantly deterring them from adopting 3D modelling ($p < 0.05$) and these factors are ***S1, H2, H3, I5*** (cost related); ***S2, I4, I6, E2*** (awareness related); ***S3, H1, I3, D2, D4*** (Technology/Process related); and ***I1, I2, E1*** (Training related). The results show that issues associated with adoption basically are related to cost, awareness, technology/process and training; a conceptual framework can be developed for the success of AQTS basing on the findings of this study. The following sub-sections will discuss the findings of the survey and the components of the proposed conceptual framework (Figure 3).

Table 2: Mean ratings and t-test results (* Significant at $p < 0.05$)

Rank	***Ref***	***Factors that impede the use of 3D CAD***	***Mean***	***T value***	***p***
SOFTWARE					
1	S1	License fee of CAD software	4.24	15.16	0.000*
9	S2	Best 3D CAD software is not known	3.40	3.57	0.001*
6	S3	Unfriendly user interface	3.61	6.41	0.000*
HARDWARE					
7	H1	Present hardware infrastructure cannot meet 3D drafting requirement	3.57	4.85	0.000*
2	H2	Extremely costly to support full 3D drafting	3.98	10.28	0.000*
11	H3	Maintenance of hardware	3.36	2.97	0.004*
DRAFTING					
19	D1	Certain complex design cannot be drawn in 3D	3.09	0.87	0.387
8	D2	3D drafting standard is not established in local Construction Industry	3.42	3.91	0.000*
4	D3	Extremely time consuming to draft in 3D	3.67	6.60	0.000*
17	D4	Annotation in 3D is difficult and confusing	3.19	1.64	0.105
INTERNAL					
10	I1	Training for 3D drafting is not provided by the company	3.40	3.49	0.001*
3	I2	Present drafters are not trained in 3D	3.68	6.71	0.000*
5	I3	3D drafting is too new resulting in uncertainty during implementation	3.63	6.00	0.000*
16	I4	Most Architect and Civil Engineer consultancy firms do not promote 3D drafting	3.30	2.51	0.014*
13	I5	Lack of funding	3.35	3.22	0.002*
12	I6	Useful benefits of 3D drafting for the company are not known	3.36	2.97	0.004*
EXTERNAL					
14	E1	Local institutions do not promote 3D	3.34	3.06	0.003*
15	E2	Companies are not aware of local authority's schemes in supporting 3D	3.32	2.86	0.005*
18	E3	Construction Industry does not see the need to go 3D	3.17	1.60	0.113
20	E4	Client does not appreciate 3D modelling	2.55	-4.51	0.000

Cost

The operational issues confronting designers that are cost related (S1, H2, H3, I5) can be very challenging. According to the respondents (engineering and architectural consulting firms), one of the reasons for resisting the use or non-use of 3D CAD is that there is *no reserved IT funding for 3D modelling training* (I5). They stressed that the ability to adopt technologies is also hindered by *high licensee fees* (S1). The findings showed that affordability is a crucial factor that can be the constraints to many companies. It is one of the critical hindrance factors, especially for the small firms (H2, H3). The findings also showed that affordability is also a crucial factor that can be the constraints to many architectural and engineering students. These student-respondents stressed that they cannot afford to pay a high cost for the software for use at home.

Lee and Sexton (2007) hihlighted that initially any strategy should be used to make systems affordable for widespread industry adoption. The IT vendors must realise that for an incremental adoption of the 3D modelling, there would need to have a critical mass of users of technology to encourage others in order to reap the full benefits of 3D modelling (Lee et al, 2005). Therefore, IT vendors should not make cost unaffordable and making it to be the barrier of widespread adoption. IT vendors must also realise that to ensure widespread

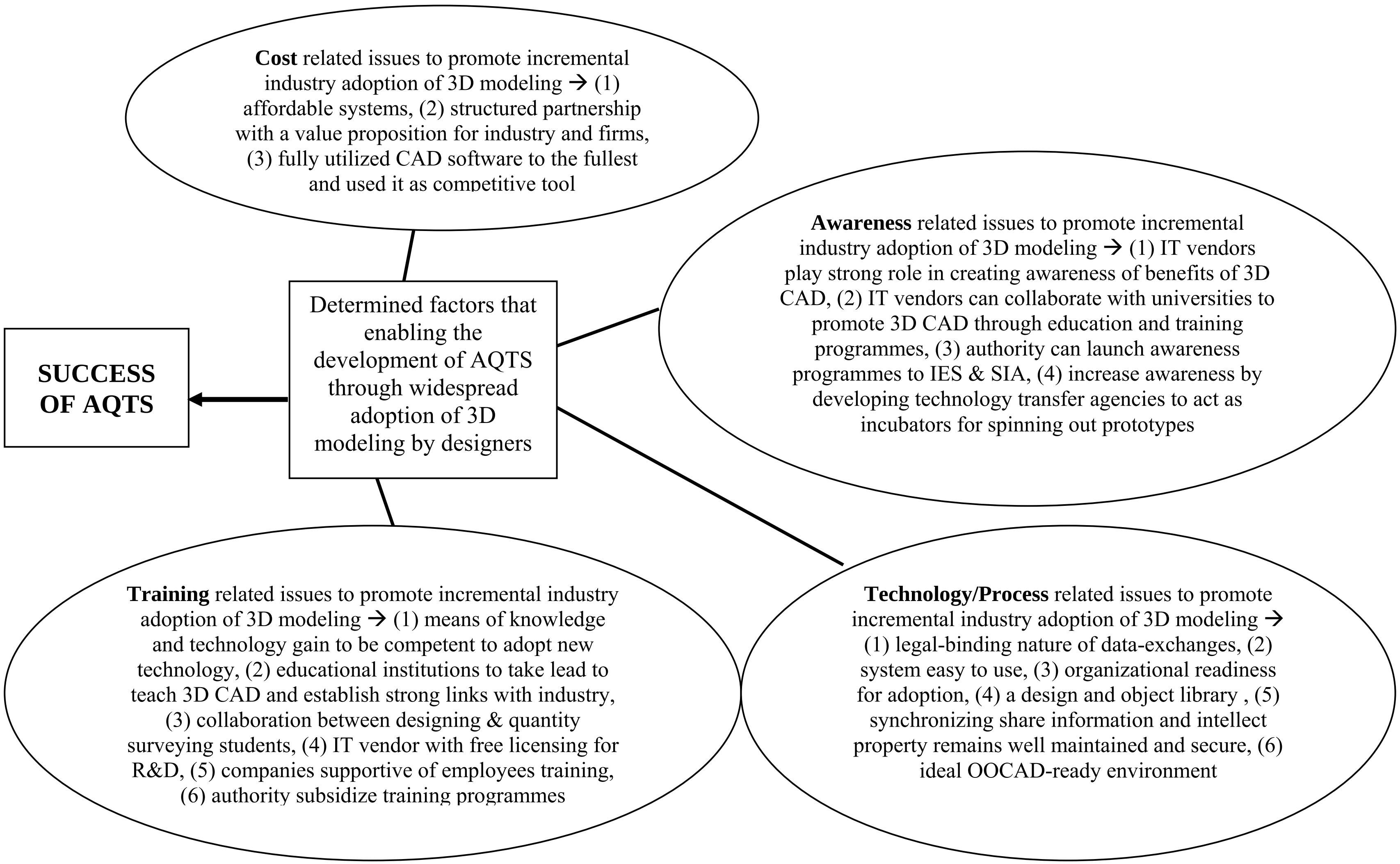


Figure 3: Proposed Conceptual Framework for Successful Implementation of AQTS

adoption, it is necessary to develop a 'structured partnership' with a 'value proposition' for both industry and firms. IT vendors can strategise their marketing program to allow monthly instalment to attract more users to come on board.

At the company level, management must realise that the cost of new technology is unarguably true to be expensive however this can be overcome by fully utilizing the CAD software to the fullest. It is a common fact that only 10-15% of certain software is utilized which is why software is always seen as expensive (Yetton *et al.,* 1994). The management must also realise that IT can be used as a competitive tool (Betts and Ofori, 1992). The competitiveness is driven by the business process and the process control mechanism has to be in place to ensure the right data can be served to be in business. It is already evident that the use of three-dimensional building models that are prerequisite for software interoperability is changing the process of how building components and systems are selected in the global construction scenes (Bazjanac, 2002). The management must realise that they cannot let high capital cost, high operation cost, too many changes in hardware / software that lead to high training cost, together with the difficulty keeping up with the changes; to become deterring problems (Chu, 1997) to hinder them from adopting 3D modeling; as there are too many benefits associated with 3D modelling, such as measurement, visualization and producing of 2D sections, elevations, and plans for construction. 3D modelling also leads to buildings that are much better thought out much earlier in the design process. This in turn leads to fewer mistakes, conflicts, misunderstandings and corrections (Bazjanac, 2002). Management must know that 2D drafting limitations are plentiful as compare to 3D drafting.

Awareness

The results show that the '*best 3D CAD software is not known*' (S2) and the '*useful benefits of 3D drafting for the company are not known*' (I6) to the designers. The reason may be that while computer software and hardware have progressed tremendously over the years, if they are not made known to designers the result will be that the adoption is slow (Clayton *et al.,* 2002). A study done by the International Alliance for Interoperability Singapore (IAI(S)) Charter clearly showed that local construction professionals, including architects and engineers are largely unprepared for 3D-based technologies and do not use 3D CAD in their regular daily work (IAI (S), 2004b). This IAI (S) study reported that the key 'upstreamer' for starting the 3D-based approach are the architects, but architectural firms do not see the immediate benefits of using 3D CAD. Hence IT vendors must play a strong role in creating awareness on the benefits and added values 3D modelling can bring to users by using projects and case studies to reveal advances in technology and process improvements. Such a practice can promote the take-up rate of 3D modelling. IT vendors can also collaborate with the universities to promote the 3D modelling through education and training programmes.

Though there are some architects and engineers whom have already started using 3D, according to the IT vendors and the respondents *most architectural and engineering consulting firms do not promote 3D drafting* (I4). Similarly to overcome the hindrance factor, I4; at the organisational level, the management must also support, encourage designers to adopt 3D modelling because benefits of 3D modelling are many. For example numerous users in the industry have achieved increased productivity gains of 3D CAD by moving toward BIM (Teo and Heng, 2007). The benefits of 3D CAD (BIM approach) are compelling, users embracing 3D CAD are finding that "(a) a higher level of abstraction (information over graphics) leads to higher productivity and better designs; (b) automated creation and coordination of documentation result in fewer errors/omissions; (c) designing-in-context across disciplines and automatically enforced standards lead to more correct-by-design; (d) increased IP security encourages a free exchange of information; (e) operations models and interactive facility maps, naturally derived from the building model, lead to more efficient operations" (Bentley, 2003). So, in order for AQTS to perform and scale, it must comfortably deal with a large, shared and mixed volume of data, not only to support measuring of building quantities, but also support a life cycle that transitions from 'creation-intensive' to 'review-intensive', and serve diverse participants of the project team.

The authority too has an important role to play to overcome the hindrance factors caused by awareness related problems. Though the authority (BCA) has launched a series of awareness programs for at least the past six years in encouraging the industry to adopt 3D approach by subsidizing 70% of the training course; the real fact is that majority of them simply took the opportunity to upgrade their old version of software to a newer version. These companies do not see 3D modelling/BIM as a way to increase productivity. Instead, they look at it as something which slows down their projects. Hence they would rather wait for other big players or big projects to adopt the 3D approach first, before they decide to follow. This shows a weakness in the local authority in helping with the industry to familiarize with 3D CAD. Despite all these programs from the government (in collaboration with the vendors), there is still a lot more designers whom are unaware of such schemes. To overcome this, the government has to send such programmes directly to the consulting firms via institutions such as Institute of Engineers, Singapore (IES) and Singapore Institute of Architects (SIA); to actively advertise with the right group of professionals and students. The government can further encourage this group of people by teaming up with IES and SIA, by granting CPD (Continuing Professional Development) points to those who attended the training and using 3D in real life application for their construction projects. Furthermore, the government (via IAI(S)) can promote 3D modelling through champions, thus to increase awareness of and drive the 3D agenda forward and to increase collaboration amongst developers, IT vendors and universities by developing technology transfer agencies to act as incubators for 'spinning out' prototypes.

Technology and Process

The integration of *Technology* and technical *Process* is found to be one of the barriers in slowing down the take-up rate of new technology (Lee et al, 2005). The results of this study showed that the majority of *architects and engineers are still skeptical and uncertain about the new technology* (I3). Therefore, there must be rules that control the way and media of transporting the drawings in order to (i) promote industry confidence in the legal-binding nature of such data-exchanges, and (ii) promote confidence in measurement particularly in CAD and AQTS; for overcoming the deterring factors of uncertainty in new technology (I3).

According to Tenner (1996) to overcome the hindrance factor of '*unfriendly user interface*' (S3), the take up rate of any new technology depends on the use of technology and the ability to make the resulting system easy to use. Users face a very steep learning curve with little time available to learn. The respondents emphasized that the '*present hardware infrastructure cannot meet 3D drafting requirement*' (H1) and this finding is congruent with the finding of IAI (S) (2004b). According to a survey by IAI (S) (2004b), most of the hardware infrastructure of the local consultant companies cannot meet 3D drafting requirement. This is especially true for smaller companies. The respondents also emphasized that not only is the '*standard of drafting in 3D format not established'* (D2), certain complex designs such as spherical or conical parametric projections are hard to model accurately, and '*extremely time consuming to draft in 3D*' (D3). As indicated by Lee and Sexton (2007), the taking up rate of 3D modeling is rather low if there is no organizational readiness for the adoption of 3D drafting because 3D drafting is an extremely tedious and time consuming process as compared to 2D drafting. Therefore situations may arise in which companies do not want to spend extra money to upgrade the skills of designers/drafters in 3D drafting or where the consulting companies are very comfortable with 2D drafting as most of the designers/drafters are already trained in 2D. To overcome the hindrance factors of S3, H1, D2 and D3; a design object library need to be introduced to smoothen the transition from the present processes to more efficient processes that follow the AQTS implementation with measurement based on CEMS, NPQS rules and CAD layering standards (CP83); to help the designers in 3D drafting. In accordance with Teo et al (2008), such a transitional tool/ standard framework must be a set of comprehensive data standards that would be transparent in which is capable of intelligent data automation. This means it has to ensure that the transportation of the drawings includes (a) CAD data format; (b) AQTS-specific draughtsmanship; (c) data exchange methodology; and (d) electronic exchange. It also must spell out the clear accountability of data ownership, with reliable security for process consistency (because process inconsistency inherent barriers). To make it work, it is important for users to share information with the extended project or operations team. Synchronising share information is of equal importance, if not more. Users must be confident that the data they share and receive is appropriately updated and reviewed by all team members, and that a historical record of who did what and when it was maintained. A secure environment for full collaboration is to enable all users to be confident that their intellectual property (IP) remains well maintained and secure, and that neither is comprised in the process of digital collaboration (Bentley, 2003; Teo et al, 2008).

Training

From the survey, it was found that the majority of consultancy firms were still working with 2D CAD (*present designers/drafters are not trained in 3D drafting* - I2) because *local institutions do not promote 3D drafting* (E1) and *training for 3D drafting is not provided by the company* (I1). The problem is a chicken-and-egg situation. Institutions cannot teach 3D-based technology to the students if such skills are not required by the industry. Successful development of AQTS depends on practicing designers (architects and engineers) as well as the students in these disciplines. One of the key findings of this study is that the local construction industry is adopting a wait-and-see attitude, the industry players claiming that if *institutes are not promoting 3D* in schools (E1) then they will not use it. Most institutes, except one, on the other hand, claimed that there is no point to train students if industry is not embracing 3D. According to Lee et al (2005), training is still the most successful means of knowledge and technology gain for skill and competence to adopt new technology.

The most imperative issue for the education and training group is understanding the needs of the industry and simultaneously having the mechanisms in place so that the new tools and techniques can be fed forward into organisations easily - the ‘teaching material must reflect the technology diffusion issues’ (Lee et al, 2005). Therefore, educational institutions should not adopt the wait-and-see attitude; educational institutions must take the initiative to go forward, to teach both 2D CAD (current industry demand) and 3D CAD. The solution put forward was to establish strong links with industry to review the content of the 3D modelling/BIM. Educational institutions must collaborate with vendors/industry to create opportunities for architectural and engineering students to participate in real life projects using 3D modelling. Such collaboration will make the students appreciate the benefits of 3D modelling and apply what they have learnt. Collaboration between designing (architectural and engineering) students and quantity surveying students; should be promoted in local institutions, so that 3D models are drafted by the engineering/architectural students and the latter group of students are able to use the 3D model for taking off purposes. A new field of study for 3D/BIM for measurement should be established and be taught in local institutions to train architectural, engineering and quantity surveying students. This new field of study will incorporate drawing techniques and formulae application techniques for measurement. Local institutions are a non-profit organization; therefore it is recommended that IT vendors would open up free licensing for students for research and development. This not only helps to promote the use of 3D modelling - it can also provide for the future deployment of the software into the local market in the future. In order for full adoption of 3D CAD and implementation of AQTS, company should be supportive and granting employees time-off to train, with flexible working hours; because company does not need to pay a lot as the government subsides 70% of the training fee. Company could motivate workers to go for training by giving special bonus for encouraging staff to upgrade themselves. Furthermore, Government can also help in the acceleration of the industry take-up rate by continuous providing subsidized training courses and software during the transition period and actively marketing such schemes to the targeted groups or organisation.

CONCLUSION

The purpose of this study was to determine the factors which impede the usage of 3D modelling among the practitioners (architects and engineers) and students (architectural and engineering) so as to develop a conceptual framework for enabling the development of AQTS. The results showed that the top most deterring factor was license fee (S1) and the second most important deterring factor is hardware cost (H2). Maintenance cost of hardware (H3) is also one of their main concerns. The respondents felt that the technology changes too rapidly hence affecting the organisational readiness to take up new technology, especially the investment in both software and hardware is not a small sum of money (***cost***). Only when designers are supportive of BIM, will it then complement the implementation of AQTS in the future. The designers' readiness (***training***) is extremely important enabler for AQTS as if the design consultants are not supportive of 3D modelling, AQTS will not be able to develop fully. The implementation of new technology also needs the thorough support from the IT vendors and government; lack of 3D promotional-cum-awareness programmes by them will discourage the designers adopting 3D drafting and thus affecting the development and implementation of AQTS (***awareness***). The transitional tools for 3D modelling must be simple, reliable, and easy to use, in a standardised format. The government has the responsibilities for funding standards for promoting incremental industry adoption and the academics; the neutral party has also the role to play in the formation of standards to enhance the 3D take-up rate (***technology and process***). The proposed conceptual framework was based on not only the results of this study but also the tested theories of many past related studies. This study demonstrated that the development of AQTS is feasible with the concerted supports of the industry, construction professionals, IT vendors, academics and government.

ACKNOWLEDGEMENT

The author gratefully acknowledges the International Alliance of Interoperability Singapore Chapter, for the IAI (S) report. Cheong's participation in various parts of the research project is also gratefully acknowledged.

REFERENCES

Bazjanac, V. 2002, *Early lessons from deployment of IFC compatible software*. Lawrence Berkeley National Laboratory, University of California, USA.

Bentley, K. (2003). *Does the Building Industry really need to start over? A Response from Bentley to Autodesk's BIM/Revit Proposal for the future*: Bentley System Incorporate January 2003.

Betts, M and Ofori, G. (1992). Strategic planning for competitive advantage in construction, *Construction Management and Economics*, 10, 511-32.

Chu, S. P. (1997). *Application of PC in Construction Project Management in Hong Kong*, Unpublished master's dissertation, School of Building and Real Estate, National University of Singapore.

Clayton, M.J., Robert, B. Warden. and Thomas, W. P. (2002). Virtual construction of architecture using 3D CAD and simulation, *Automation in Construction* 11, pp. 227–235.

International Alliance for Interoperability Singapore Chapter –IAI(S) (2004a). *Measure Work Group led by SISV has focused on the development of measurement related standards.* Retrieved 2 Jan 2004 from http://www.corenet.gov.sg/it_standards/iai/Group_MWG.htm

International Alliance for Interoperability Singapore Chapter – IAI(S) (2004b). AEC3 Report on Migration Plan for IAI (S) Chapter.

Lee, A., Marshall-Ponting, A.J., Aouad, G., Wu., S., Koh, I., Fu, C., Cooper, R., Betts, M., Kagioglou, M. & Fisher, M., (2003), *Developing a vision of nD-enabled construction*, Construction IT Report, IBSN: 1-900491-92-3.

Lee, A. and Sexton, M.G. (2007), Construction Innovation, vol 7, no. 3, p288-302.

Lee, A., Wu, S., Marshall-Ponting, A.J., Aouad, G., Cooper, R., Tah, J.H.M., Abbott, C. & Barrett, P.S. (2005), *nD Modelling Roadmap – A Vision for nD-Enabled Construction*, University of Salford.

Sankar, Y. (1991), *Management of technological change*. New York: John Wiley & Sons.

Tenner, E. (1996) Why Things Bite Back: Technology and the Revenge of Unintended Consequences. New York: Knopf.

Teo, A.L., Davis Langdon and Seah Singapore Pte Ltd., and KPK Quantity Surveyors (2008) *Building Quantities, An introduction using Construction Electronic Measurement Standards* (2nd Ed) Singapore: McGraw Hill Education.

Teo, A L and S.N. Heng (2007), "Deployment Framework to Promote the Adoption of Automated Quantities Taking-off System". *Proceedings of CRIOCM 2007 International Research Symposium on Advancement of Construction Management and Real Estate Sydney, Australia, 8-13 August 2007* (2007): 928-943. Sydney: The Chinese Research Institute of Construction Management, The University of New South Wales, Shenzhen University. (CRIOCM 2007 Research Symposium, 8 - 13 Aug 2007, Coogee Bay, Sydney, Australia)

Yetton, P.W., Johnston, K.D. and Craig, J.F. (1994). Computer-aided architects: a case study of IT and strategic change, *Sloan Management Review*, 35 (2), 57-67.

MULTICULTURALISM IN THE NIGERIAN CONSTRUCTION INDUSTRY: A COMPARATIVE STUDY OF FOREIGN AND INDIGENOUS FIRMS.

***Joseph Ojo Abiola-Falemu, **Olukayode Sunday Oyediran & *Deji Rufus Ogunsemi**
* Department of Quantity Surveying, Federal University of Technology, Akure, Nigeria
** Department of Building (QS Unit), University of Lagos, Lagos, Nigeria
Corresponding author: Joseph Ojo Abiola-Falemu – email: biolaojo2004@yahoo.com

Abstract
In the 1970s Foreign Construction Firms were engaged and encouraged to collaborate with the few immature Indigenous Construction Firms and professionals. As a result, sharing of the same or similar organisational culture with similar performance is expected but the situation presently seems to point to the contrary. The aim of this paper therefore is to compare the organisational culture and performance of the Foreign Construction Firms with the Indigenous Construction Firms. Questionnaires were administered on both categories of firms. Analysis was by simple percentage and mean score. Results showed that both categories of firms shared some aspects of organisational cultures but they differ in performance. The paper recommends that government should promote strategic alliances between the Indigenous Construction Firms and Foreign Construction Firms in order that the Indigenous Construction Firms may reap more of the benefit of multiculturalism viewed as an interpersonal relationship in this study.
Key words: Multiculturalism, organisational culture, construction firms, Nigeria

INTRODUCTION

The oil boom of the 1970s put Nigeria on the path of strong economic growth which subsequently put pressure on the government in the area of planning and execution of infrastructural development projects due to lack of competent Indigenous Construction Firms (ICF) and Professionals. There was a climate of co-operation which welcomed foreign management skills and technology. This led to the engagement of Foreign Construction Firms (FCF) and Professionals in collaboration with the ICF to plan and execute the various development projects. The expectation of Nigerian Government then was that the ICFs would imbibe the management skills, organisational culture and technology of the FCFs and grow and acquire the requisite competence to be able to handle future construction works of any magnitude in addition to being competitive.

The situation then was just like the British Columbia (2007) that reported strong and sustained economic growth but lacked the required workforce; and made efforts to attract skilled workers through immigration. Companies from different countries, cultural setting, ethnic descent and environment namely the UK, Germany, Italy, Israel and Korea among others were engaged. Many infrastructural development projects were constructed by these FCFs and they remain in Nigeria doing construction contracting business and employing Nigerian professionals and local firms as sub-contractors. Collaboration between the FCFs and the ICFs and professionals continued. With passage of time many of the indigenous construction professionals formed their own construction companies and started competing with the FCFs.

With decades passed, multiculturalism as an interpersonal relationship which affects people of different descent and nationality is expected to have had the desired effects on the ICFs in terms of management, competence and organisational performance. In any contemporary assessment of organizational performance, cultural forces are considered among other factors as having significant impact on performance and success (Sashkin and Kiser, 1991; Kotter and Heskett, 1992; Rashid et al., 2003) as culture simply means the way we do things. Therefore, how far does the organization culture and performance of the ICFs compare with the organization culture of the FCFs? This study therefore aims at assessing and comparing the organizational culture, organizational dimensions and performance including some other characteristics of the ICF with the FCF in order to evaluate the impact multiculturalism has on them and to identify the areas of need for improvement or change of culture of the ICFs.

.

Existing Situation of Indigenous and Foreign Construction Firms in Nigeria

Till date very few capable ICFs have emerged despite the continuous infrastructural development of the nation and their involvement. The FCFs appear bigger, most prominent and active participant in the Nigerian construction sector. The ICFs are still perceived less qualified and competent than the FCFs. For this reason, the ICFs are less patronized. This suggests that they are probably poor performers. Although there is growing empirical evidence showing that international firms perform better in almost all areas than their domestic counterparts (Crowe et al., 2007) but not to the extent of being the dominant player. However, their superior performance can be explained in the context of organizational cultures which have a long-term impact on organizational performance (Kotter and Heskett, 1992) and also on organizational success (Rashid et al., 2003). Therefore, since culture has crucial roles to play in organization performance, it is necessary to compare the organizational culture and performance of the two groups of firms.

CULTURE, ORGANIZATIONAL CULTURE AND MULTICULTURALISM

Culture

Culture is seen in a number of ways and has many definitions. Hodge and Anthony (1991) confirm this by claiming that a review of the literatures shows that there is little agreement on the precise definition of culture. Many definitions refer to it as the whole way of life of members of a society reflecting it as what we are and what we do. It is seen as embracing knowledge, beliefs, arts, morals, law, customs and any other capabilities and habits acquired by man as a member of society; collectively shared values; norms found within business firms for co-existence; ways of doing things here among others(Pheng and Leong, 2000; Taylor, 1972; ILO, 1986; Mead, 1998; Elashmawi and Harris, 1993 and Lundy and Cowling, 1996). From these various definitions, it is clear that the focus of culture is on people and ways of life which can be learned, shared, transmitted, adapted and integrated (Barthorpe et al., 2000) and not biologically inherited

(Bodley, 1994). As earlier stated, the collaboration and engagement of the indigenous Professionals by the FCFs led to the emergence of more ICFs with great expectations of exhibiting the cultural traits and performance of the FCFs. In this regard, what do they now have in common in terms of organizational culture and performance and what are the differences?

Organizational Culture and Performance

Organisational culture refer to a number of key elements and factors accumulated over many years' work (Mullins, 1993) and have been recognized as being inherent within organizations. It is described as a set of values specific to a work unit (Mallak and Kurstedt 1996). These values embody certain assumptions about work, working together, and how things should be done, given a specific context. Organizational culture is reflected in the way that people perform tasks, set objectives and administer the necessary resources to achieve objectives (Barthorpe et al., 2000). It is considered as the social glue that holds the organization to ensure that every employee in the organization is on the same track (Robbins, 1996). There exist significant relationships between organizational culture and performance (Van der Post et al., 1998). Organizational culture improves performance; brings about success; fosters internal integration and coordination and enhances commitment (Knights and Willmott, 1999; Sashkin and Kiser, 1991; Furnham and Gunter1993; Rashid et al., 2003).

Organizational Values

Culture consists of values held by members of a given group. Value defines what is important, worthwhile and worth striving for and is an essential component of organizational culture (Sinha, 1995) and serve many purposes (Hassan, 2007) like setting environmental tone, bonding people together and facilitating work behaviour. Mission and image, treatment of people, selection criteria for management and supervisory positions, work organization and discipline, management and leadership style, decision-making processes, circulation and sharing of information, communication patterns, ways of handling conflicts, performance evaluation are some of the organizational-specific cultural values . Without these values, interpersonal relationship would have been difficult between the ICFs and the FCFs.

Dimensions of Culture and Organizational Effectiveness

Martins (1997 as reported in Martins and Terblanche, 2003), identifies mission and vision, external environment, means to achieve objective, image of the organization, management processes, employee needs and objectives, interpersonal relationships and leadership as dimensions of organizational culture. Denison (2000, in Block, 2003) refines and expresses them as cultural traits and identifies mission, adaptability, involvement and consistency as important contributory traits to organizational effectiveness, which enhances performance. Involvement entails skill development, team work and sense of ownership and responsibility. It requires emotional encouragement, as well as an infrastructure to support it. Consistency is embedded in a set of core values that make organizational sub-units work together. Adaptability mirrors how the constraints and the stimuli of the business environment are translated into positive action. This then means that effective organizations need to develop norms and beliefs that support their capacity to receive, analyze and interpret impulses from their business environment and thereafter translate them into behavioural and structural changes within the organization.

Multiculturalism

Multiculturalism is a multidimensional concept with multifarious definitions. Defining it is akin to describing an abstract painting (Johnson and Mosk, 2004). It means different things to different people. Its definition depends heavily upon the context in which it is discussed. The various contexts of which it is seen are as a philosophy, a doctrine, a policy, a belief and an ideology. As a philosophy it advocates equal cultural and political status. As a policy it focuses on the inclusion of all cultures and ethnicities in a society. As an ideology it centres on amalgamating diverse culture into a mainstream culture.

An operational definition of multiculturalism is perhaps the one given by Rosado (1997) as a system of beliefs and behaviors that recognizes and respects the presence of all diverse groups in an organization or society, acknowledges and values their socio-cultural differences, and encourages and enables their continued contribution within an inclusive cultural context which empowers all within the organization or society. Wikipedia, a web-based dictionary describes multiculturalism as an interpersonal relationship characterized by the co-existence of people of different cultural descent and environment. On these two definitions we anchor our view as to the meaning of multiculturalism. In a society like Australia, Canada, Quebec, USA among others where multiculturalism is practiced it is valued for its contributions to society and accepted as a de facto status of development within the society.

RESEARCH METHODOLOGY

A structured questionnaire based on Denison Organizational Culture Survey (Denison OCS) was used. The Organizational culture questions were measured on a five point scale ranging from strongly agree (5) to strongly disagree (1). There were 60 questions measuring involvement, consistency, adaptability and mission as the dimensions of organizational culture as illustrated in Table 1. The reliability coefficients of the Denison OCS as determined by Denison, Cho, and Young, (2000, in Block, 2003) are noted to be generally high ranging from 0.87 to 0.92 for involvement, consistency, adaptability and mission and from 0.70 to 0.85 for each of the indices. As for organizational leadership, management of employees, strategic emphasis/direction and dominant characteristics, there were 4 multiple choices from which the respondents were expected to choose one that best describes each item in their organization. These questions particularly measured the type of culture in each of the sampled construction firms.

A total of 60 questionnaires were sent out to companies in Lagos where many of the construction firms are based out of which 30 were returned constituting 50% of the total questionnaire with the FCF and ICF having 11 and 19 respondents respectively as shown in Table 2.

Table 1: Organizational culture dimensions and their indices

Cultural dimensions	Index
Involvement	Empowerment
	Team orientation

	Capability development
Consistency	Core values
	Agreement
	Coordination and integration
Adaptability	Creating change
	Customer focus
	Organizational learning
Mission	Strategic direction and intent
	Goals and objectives
	Vision

Table 2: Category of construction firm

Category	*Number*	*Percentage %*
Indigenous construction firms	19	63
Foreign construction firms	11	37

RESULTS AND DISCUSSION

The Profile of the firms

Table 3 indicated the profile of the two categories of firms. In terms of business contracting, general construction contracting is prevalent among the FCF whereas building and civil engineering construction dominates the business preference of the ICF. None of the FCF operates building construction only as a mono type of business. Equally none of the ICF operates steel construction only as a mono type of business. Over 54% of the FCF have been in existence for more than 20years while majority of the ICF constituting approximately 53% fell between 5 and 10 years. None of the FCF had less than 5 years of existence. In terms of number of employees almost 64% of the FCF engaged 100 workers and above whereas about 36% of the IFC fell into the same level showing that the FCF is probably bigger than the ICF but they both showed a male dominated workforce with the FCF having almost 83% of their employees being male while ICF had almost 90% as indicated in Table 4. This suggests that the Nigerian construction industry is masculine in nature and they have masculine culture in terms of gender. With regards to educational qualification both favoured the engagement of diploma degree holders with requisite professional qualification. Almost 64% of the FCF had a turn over above ₦200million naira in contrast to the ICF with about 53% having less than ₦200million naira.

Type of Business Structure

Table 5 showed that the FCF operate only three types of business structure namely Partnership, Public limited and Private limited being the dominant business structure having almost 64% of the total sample. The ICF operate all the types of business structure but one, with Sole Proprietorship and Public limited being the dominant ones having equal share of 26.32%. None of the two categories of firms operate the Cooperative type of business structure.

Table 3: Profile of Companies

	Indigenous construction firms	*Foreign construction firms*
	Percentage %	*Percentage %*
Type of contracting business		
Building construction only	21.05	0.00
Civil Engineering construction only	21.05	9.09
Steel construction only	0.00	9.09
Building and Civil Engineering construction	36.85	36.36
General construction contracting	21.05	45.46
Years of existence		
Less than 5years	15.79	0.00
5-10 years	52.63	27.27
11-15 years	10.53	9.09
16-20 years	15.79	9.09
Above 20years	5.26	54.55
Number of employees		
10 to 99	63.16	36.36
100 to 499	5.26	36.36
More than 499	31.58	27.28
Turn over		
Less than ₦200million	52.63	9.09
N200million to ₦400million	21.05	63.64
Above ₦400million	26.32	27.27

Table 4: Profile of respondents

	Indigenous construction firms	*Foreign construction firms*
	Percentage %	*Percentage %*
Gender		
Male	89.48	81.82
Female	10.52	18.18
Educational qualification		
Diploma degree	42.11	45.46
Bachelor degree	36.84	18.18
Master degree	21.05	36.36
Doctoral degree	0.00	0.00
Professional qualification		
Graduate membership	68.42	45.46
Corporate membership	31.58	45.46
Fellow membership	0.00	9.08
Honourary membership	0.00	0.00
Professional designation		
Builder	21.05	9.09
Quantity surveyor	10.52	45.46
Architect	10.52	9.09
Engineer	36.86	18.18
Estate surveyor	0.00	0.00
Others	21.05	18.18
Hierarchical level		
Corporate or top management	21.05	54.55
Middle management	31.58	27.27
Lower/Executive	21.05	18.18
Supervisory	26.32	0.00
Years of experience in current company		
Less than 5years	47.37	54.45
5-10 years	31.58	18.18
11-15 years	15.79	0.00
16-20 years	0.00	9.09
Above 20years	5.26	18.18

Table 5: Type of Business Structure

	Indigenous construction firms	*Foreign construction firms*
	Percentage %	*Percentage %*
Ownership		
Sole Proprietorship	26.32	0.00
Partnership	10.52	18.18
Public Limited	26.32	18.18
Private limited	21.05	63.64
Cooperative	0.00	0.00
Statutory	15.79	0.00

Type of organizational culture

Table 6 showed the types of organizational culture in the sampled firms.

Table 6: Type of Culture

	Indigenous construction firms				*Foreign construction firms*			
	Percentage %				Percentage %			
Organizational dimension	People culture	Power culture	Task culture	Role culture	People culture	Power culture	Task culture	Role culture
Organizational leadership	0.00	0.00	5.26	94.74	9.09	18.18	9.09	63.64
Management of employees	73.69	15.79	5.26	5.26	27.27	18.18	18.18	36.37
Strategic emphases	31.58	26.32	21.05	21.05	18.18	18.18	27.27	36.37
Dominant characteristics	5.26	10.52	73.70	10.52	9.09	9.09	54.55	27.27

From table 6 it was found that role culture dominate both the ICF and the FCF in terms of organizational leadership with almost 95% of respondents in the ICF having role culture while almost 64% of the respondents in the FCF are having role culture. This shows that the leadership culture of the FCF has been transmitted to the ICF. As for the management of the employees, people culture was found to be predominant in the ICF and the FCF with almost 74% and 36% respectively. This again has shown that there was a cultural transmission from the FCF to the ICF in the way employees are being managed.

In the case of strategic emphases/direction, approximately 32% majority of the ICF were discovered to have people culture while 18% minority in the FCF shared the same culture with the ICF whereas majority 36% of the FCF had a role culture. This implies that they both have different goals and mission. However the dominant characteristics of both the ICF and the FCF are a task culture with approximately 74% and 55% respectively. It can therefore be seen that ICF shared the same organizational culture with the FCF in organisational leadership, management of employees and dominant characteristics. They differ only in strategic emphases. While the ICF had people culture in strategic emphases/direction the FCF had a role culture.

Organizational culture dimensions

Table 7 showed the organizational culture dimensions measured in both categories of firms with the mean scores. In terms of involvement of employees measured through empowerment, team orientation and capability development as indicated in table 7 the ICF had a mean score of 3.64 while the FCF had 3.69 meaning that they both involved their employees but the FCF involve their employees more than the ICF.

Table 7: Mean score for Organizational culture dimensions and their indices

Indigenous construction firms				Foreign construction firms			
Cultural dimensions		**Index**		**Cultural**		**Index**	
	Mean		***Mean***		***Mean***		***Mean***
Involvement	**3.64**	Empowerment	3.94	**Involvement**	**3.69**	Empowerment	4.02
		Team orientation	3.85			Team orientation	3.74
		Capability development	3.14			Capability development	3.31
Consistency	**3.60**	Core values	3.64	**Consistency**	**3.56**	Core values	3.73
		Agreement	3.42			Agreement	3.56
		Coordination and integration	3.73			Coordination and integration	3.38
Adaptability	**3.23**	Creating change	3.44	**Adaptability**	**3.38**	Creating change	3.46
		Customer focus	2.99			Customer focus	3.14
		Organizational learning	3.25			Organizational learning	3.54
Mission	**3.64**	Strategic direction and intent	3.52	**Mission**	**3.48**	Strategic direction and intent	3.40
		Goals and objectives	3.64			Goals and objectives	3.48
		Vision	3.76			Vision	3.57

As for adaptability which embraces creating change, customer focus and organizational learning, the FCF appears to be more adaptable than the ICF with the FCF having a mean score of 3.38 as against 3.23 of the ICF. However, the ICF appears to have a slight edge over the FCF in consistency comprising core values, agreement, coordination and integration with a mean value of 3.60 as against 3.56 of the FCF. The same thing can be inferred about mission measured through strategic direction and intent, goals and objectives and vision as its components. The ICF had a mean score of 3.64 as opposed to 3.48 of the FCF. This suggests that the ICF had a well defined direction and intent which of course can be linked to the earlier challenge given by the government and their commitment to the development of the nation as opposed to the FCF whose main objective is to make and repatriate profit to their home country.

Performance

Table 8 showed the performance of both the FCF and the ICF in terms of mean scores of the variables used. From the table, it can be seen that the performance of the FCF is generally better than the ICF except in the area of employee satisfaction where the ICF has an edge. This may not be unconnected with the difference in the treatment of employees. In terms of market share, the FCF had a mean score of 3.82 as against the 3.21 of the ICF suggesting that the FCF has a larger market share than the ICF and hence a higher profitability with the mean score of 4.00 as opposed to 3.68 of the ICF.

Table 8: Performance

SN	Performance criteria	Indigenous construction firms	Foreign construction firms
		Mean score	***Mean score***
1	Sales/Revenue growth	3.89	4.36
2	Market share	3.21	3.82
3	Profitability	3.68	4.00
4	Quality of product/services	4.53	4.55
5	New product	3.42	3.91
6	Employee satisfaction	4.21	3.73
7	Overall organization performance	3.90	3.91

Mean of mean: ICF = 3.83 FCF = 4.04

This may not be unconnected with financial capability, plant and equipment, technical capability among others which are a measure performance and patronage. In sales/revenue growth and new product/services the FCF were shown to be slightly better with 4.36 and 3.91 respectively in contrast to ICF with 3.89 and 3.42 respectively. In terms of the overall organizational performance both categories of firms are almost on the same pedestal, viewed against the backdrop of available resources at their disposal.

CONCLUSION

It seems that the encouragement of multiculturalism by the government is a narrow approach to the development of the Indigenous Construction Firms and professionals. Rather, a holistic approach which involves development of appropriate institutions along side the encouragement of multiculturalism would probably have yielded better results than shown in this study.
The results of the study showed that the Foreign Construction Firms had transferred some organisational cultural values to the Indigenous Construction Firms in terms of management techniques and practices. It is however worthy of note that the Indigenous Construction Firms are still bedeviled by technical and managerial difficulties that make them poor performers. On the contrary, the Foreign Construction Firms are better performers. This is attributed to their skill, experience, management expertise and capacity for big projects. This comparison supports the growing evidence according to Crowe et al., (2007) that international firms perform better in almost all areas than their domestic counterparts.This situation also reflects the opinion of Adebayo (2000) on the industry situation in other African countries like Kenya and South African. Though the Indigenous Construction Firms seemed to be as adaptable as their foreign counterparts, they however showed inadequate involvement of their workers. The degree to which they empower and develop the capability of their workers is less than that of their foreign counterparts.
The Indigenous Construction Firms are therefore at the much lower value-added end of construction activities in Nigeria than the Foreign Construction Firms which are at the high value-added end of the industry due to their competitive advantage. This situation also replicates itself in some other African countries. The lesson for other African countries from the situation in Nigeria is that without the development of appropriate institutions alongside the encouragement of multiculturalism which are necessary ingredients for facilitating improvement of the Indigenous Construction Firms they will remain a net importer of construction services and will rely on foreign construction firms for most of their important construction projects.

To improve the Nigerian construction industry therefore, there is need to develop appropriate institutions necessary to facilitate the development of the industry; and to promote multiculturalism by encouraging strategic alliances such as joint ventures between the indigenous and foreign construction firms. Joint partnership with foreign firms where it is expected that managerial and technological know-how and expertise would be transferred to the indigenous construction firms (Ofori, 1991) should be encouraged through policy formulation. A holistic approach which is fundamentally important to policy articulation, formulation, and implementation should be adopted. Above all efforts should be geared towards the development of the economy as a whole as the development of the construction industry rests on the development of the economy.

REFERENCES

Adebayo, A.A. (2002). Sustainable Construction in Africa. Available at www.sustainablesettlement.co.za. Accessed on July 18, 2008

Barthorpe, S. Duncan, R. and Miller, C. (2000). The Pluralistic Facets of Culture and its Impact on Construction. *Property Management, 18(5),* 335-351

Block, L. (2003). The leadership-culture connection: an exploratory investigation. *Leadership and Organization Development Journal,* 318-334

Bodley, J. (1994). An anthropological perspective, Cultural Anthropology: Tribes, States and the Global System. Available at http://www.wsu.edu:8001/vcwsu/commons/topics/culture/culture-definitions/bodley-text

British Columbia (2007). Attracting Skilled Workers to British Columbia Multiculturalism and Immigration. Author

Crowe, D., Vecchi, A., Brennan, L.and Coughlan, P. (2007). Manufacturing strategy and innovation in indigenous and foreign firms: an international study. *International Journal of Manufacturing Technology and Management), 11(1)*

Elashmawi, F and Harris, P.R (1993). Multicultural Management New Skills for Global Success. Houston, Tx US: Gulf publishing company

Hodge, B.J. and Anthony, W.P. (1991). *Organization Theory: A Strategic Approach (4th Ed)* Massachusetts: Allyn and Bacon, Inc.

International Labour Organisation (1986). *Managing Consulting: A Guide to the Profession 2nd Ed* ILO, Geneva. p.85

Johnson, D and Mosk, M (2004). Multiple Views of Multiculturalism The Washington Post, May 14.

Knights, D. and Willmott, H. (1999). *Management Lives: Power and Identity in Work Organizations.* London: Sage

Kotter, J.P. and Heskett, J.L (1992). *Corporate Culture and Performance.* New York: The Free Press.

Lundy, O. and Cowling, A. (1996). *Strategic Human Resource Management,* Routledge, London.

Mallak, L. A. & Kurstedt, H.A. Jr. (1996). Using Culture Gap Analysis to Manage Organizational Change. *Engineering Management Journal, 8(2),* 35-41.

Mead, R. (1998). *International Management: Cross-Cultural Dimension.* 2nd Ed.Cambridge: Black Well Business

Mullins, L.J. (1993). *Management and Organisational Behaviour*, Pitman Publishing, London

Ofori, G. (1991). Programmes for improving the performance of contractors in developing countries: a review of approaches and appropriate actions. *Construction Management and Economics. 9*, 19-38.

Pheng, L. S. and Leong, C.H.Y (2000). Cross-Cultural Project Management for International Construction in China. *International Journal of Project Management, 18(5).*

Rashid, M. Z. A., Sambasivan, M. and Johari, J. (2003). The Influence of Corporate Culture and Organisational Commitment on Performance, *Journal of Management Development, 22(8),* 708-728.

Robbins, S. P. (1996). *Organisational Behaviour: Concepts, Controversies, Applications, 7th ed.*, Prentice-Hall, Englewood Cliffs, NJ.

Rosado, C. (1997). Toward a Definition of Multiculturalism. Available at www.rosado.net.

Sashkin, M. and Kiser, K.J. (1991). *Total Quality Management.* Seabrook, MD: Ducochon

Sinha, J.B.P. (1995). *The Cultural Context of Leadership and Power*, Sage International, New Delhi.

Taylor, E.B. (1972). *Primitive Culture.* London: John Murray.

Van der Post, W.Z., de Coning, T.J. and Smit, E.V. (1998). The Relationship Between Organisational Culture and Financial Performance: Some South African Evidence, *South African Journal of Business Management, 29 (1)*, 30-41.

PARTNERING HEATHROW TERMINAL 5

Kate Carter
Heriot Watt University, Edinburgh, UK
k.carter@sbe.hw.ac.uk

Aaisha Mukhtar
Laing O'Rourke Scotland Limited
amukhtar@laingorourke.com

The relationship between client and contractor is fundamental to the success of a partnered approach to procurement. BAA and Laing O'Rourke have been involved in a long term relationship in order to deliver the T5 project. The rationale behind the agreement and the overall objectives are to achieve a high quality terminal building. Under the T5 agreement BAA rewards Laing O'Rourke for completion under the target budget, consistency in safety and for time and quality performance. The agreement developed over a number of years has been designed to tackle the perceived barriers of 'culture change' and 'reluctance to acknowledge risk'. An in-depth study of the way the partnering agreement has been used throughout the delivery of T5 examines the issues that the project team have encountered. The benefits and negative aspects of the partnering are explored and the issues of integration and culture change are examined.

KEYWORDS: Partnering, culture change, procurement route.

INTRODUCTION

BAA (British Airport Authorities) has welcomed the ethos of partnering for the delivery of better quality, better development value from the space built and better value for their money. BAA's objective for supplier relationships is to create an environment for success with collaborative, proactive management of risk and opportunity and joint ventures (BAA 2006). Furthermore, by 2016 it intends to invest a total of £9.5 billion to deliver major projects including the Heathrow East terminal. The delivery programme will be established via a framework of partners over a ten year period. BAA will be committed to its partnering approach and the new agreements will reinforce BAA's commitment to long-term relationships with its suppliers (Monaghan 2006). Moreover, BAA has been involved in the process of developing Heathrow terminal five with one of the delivery partners (LOR) Laing O'Rourke. The partnering agreement between the partners is referred to as the T5 agreement which affirms that suppliers are expected to work in integrated teams and display the behaviours and values akin to partnering. The T5 agreement is a unique experience for LOR due to the scale and complexity of the project. A partnering agreement with BAA was more suited because it would enable LOR to be in a stronger relationship with the client and remedy any problems that may occur with other procurement methods (Terminal 5, Heathrow 2006).

> '*The challenges and complexities of a prestigious global project like Heathrow terminal 5 have demonstrated the synergies that derive from 'one team working'* (Ray O'Rourke LOR annual review 2007).

The main purpose of this study is to examine they way in which LOR have performed their role in the T5 framework agreement and whether partnering with BAA has been successful. The T5 agreement is unique to the construction industry simply because of the size of the project and the various contractors and sub-contractors involved in the agreement.

BAA

BAA was established over 40 years ago in 1965 and now owns and operates seven UK airports with additional management contracts in eleven airports outside of the UK. Due to the extensive nature of their projects, BAA is one of the major clients in the UK construction industry. Their approach to construction has evolved over time and their principles led them to move away from a traditional client/contractor relationship to a more integrated partnership. Their principles convey their focus on meeting their objectives through a series of processes and behaviours:

- Defining the product
- Long-term relationships
- Integrated project teams
- Following a defined process
- Measuring performance

In addition, these initiatives enabled BAA to participate in the government's construction task force (chaired by BAA's former chief executive Sir John Egan) culminating in the Egan report. The report published in 1998 continues to influence both government and industry to develop improvements to benefit the construction industry as well as its clients (BAA 2007).

Laing O'Rourke – 1st tier supplier

Laing O'Rourke goes back to the 1800s when the Laing business built its first home in 1848. Over 150 years later in 1978 R O'Rourke and son were formed. Both businesses joined forces and merged to become Laing O'Rourke main contractors in 2001. It now has three main hubs – European, Australian and the Asian and Middle East hub. LOR believes in working with the construction industry to improve performance in construction. LOR believe in adopting new attitudes to clients and supply partners to ensure value is driven from framework and partnership agreements (LOR Annual report 2007).

Commercially, framework arrangements are the most beneficial for Laing O'Rourke in comparison to the different procurement strategies used. The group commercial director states that the most attractive contract type is 'frameworks'. A commercial basis is set out at the beginning for a long-term relationship. The success is determined by how the company delivers against a set of performance indicators. The success of delivery determines how much work the client will give (Infoworks 2007).

Both client and contractor have been involved in framework agreements since the mid 1990s although R O'Rourke & Son were the suppliers at that time. In terms of T5, Laing O'Rourke can be described as a first tier supplier as the principle works contractors for the civil construction infrastructure and logistics delivery. Under the T5 agreement BAA rewards Laing O'Rourke for completion under the target budget, consistency in safety and for time and quality performance (T5 Handbook 2005).

PARTNERING ON T5

> *'Whichever way you view it, BAA's Terminal 5 project is mind bogglingly big'* (Milford 2006)

John Milford (2006), T5 head of buildings shares his view on the construction of Europe's largest and most complex construction project. The project has been in the pipeline since 1985 and approval for T5 was only reached after the longest public inquiry in British history of forty six months. Eventually on the 20th November 2001 the government announced its decision. The UK construction industry had never witnessed such a thorough examination of a project. The T5 agreement is the legally binding contract between BAA and its key suppliers. Described as groundbreaking, it is unique to the construction industry (BAA, 2007).

Developing Heathrow terminal five was perceived as crucial to meet the demand for travel and passenger growth. Heathrow airport accounts for almost 30 per cent of all passengers from UK airports and directly or indirectly supports 100,000 jobs. According to a progress report by the department of transport published in 2006 the government has set out a long term strategy for the development of air travel until 2030. In particular, the progress report recognises the importance of Heathrow airport to the national economy and its unique role in the UK as a major hub airport (Department for Transport 2006).

The T5 agreement

The contract for T5 named 'the T5 agreement' is based upon the NEC contract incorporating the full suite of options. The T5 agreement is the legally binding contract between BAA and its key suppliers. The total cost of terminal five is reported to be around £4.3 billion (Morgan 2006). There are a total of 16 major projects and 147 sub-projects. The scale of the construction work and the risk of such a huge infrastructure project prompted BAA to use a new management approach for this project to ensure it was built on time and within budget. The agreement is based upon an open book commercial arrangement with fair profit for good performance and incentives for exceptional performance. Success is claimed to be rewarded and failure is shared by all.

Research conducted by BAA into major construction projects concluded two key areas that seemed to diminish progress. Culture barriers and the reluctance to acknowledge risk were identified as the main areas of weakness. The T5 agreement claims to be different because it tackles these areas by defining an integrated approach to partnering and the management of risk (T5 Handbook, 2007). In order to ensure integration exists on T5, all those working on the project are assembled in teams comprised of individuals from a variety of different companies. All are united under the single banner of T5 with a shared sense of values. BAA's decision to accept all risk has been vital in the development of the unique culture. As accountability is lifted, those working on T5 can work positively as the emphasis is placed on delivering solutions and results.

Many suppliers on the T5 project were involved from the early stages of the planning process. This enabled completely integrated expert teams to work together to identify potential problems and issues before designs were finalised and construction began. BAA only has a direct contractual relationship with 60 of the 'first tier' suppliers. The first tier suppliers are responsible for the appointment and management of 'second tier' suppliers or subcontractors. The second tier suppliers are also expected to adhere to the spirit of the T5 agreement (T5 Handbook 1999).

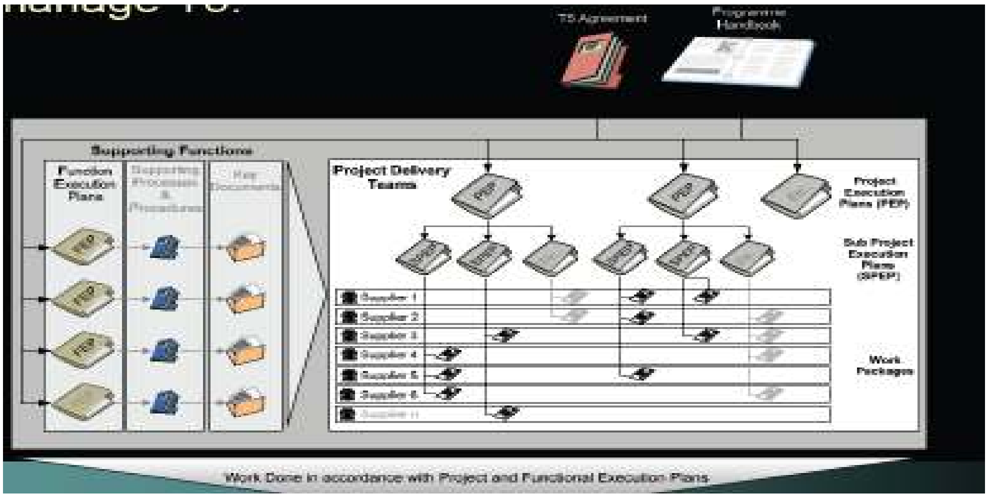


Figure 1: The T5 agreement and supporting documents (Riley 2005)

RESEARCH DESIGN

The detailed examination of a framework partner provides the reader with Laing O'Rourke's perception as a contractor of the partnering relationship with BAA. The 'intrinsic case' study would best describe its status as this type of study does not generalise but tries to understand the case in its entirety and its context. To achieve this aim, a series of interviews and a questionnaire were undertaken.

The research questionnaire devised endeavours to capture the opinions and perceptions of those working on the T5 project. The questions have been developed in order to elicit information which aims to explore the way in which the partnering arrangement is working. The questionnaire was piloted with a small number of people working on the T5 project to ensure the terminology correctly represented the context of the study. Constructive feedback from the respondents was received which was incorporated into the questionnaire before sending it to relevant members of the T5 project.

An interview was held with a production leader who had worked on T5 during the early delivery stages. A second interview was held with a LOR project manager. The interviews provide a rich source of contextual background to some of the issues emerging from the questionnaire and helped to gain a better understanding of the project

The questionnaire was sent to approximately sixty respondents who were working on the T5 project. A total of nineteen questionnaires were completed representing a 32% response rate and the response sample is included in the following table.

Table 1: Survey Respondents

Profession	Questionnaire issued	Responses
Director	2	0
Project Manager	14	2
Commercial Integrator	5	2
Production Integrator	6	3
Site Engineer	8	3
Quantity Surveyor	6	2
Planner	9	4
Other	10	3

T5 FRAMEWORK IN PRACTICE

The production integrator described the T5 framework as being different from other framework agreements due to the scale of the project. Laing O'Rourke was chosen due to their size and scale and not many other contractors would have been able to complete a project such as T5. He described the partnering charter as a document stating the

> '*prerequisites for involvement and a timetable for assessment and upgrading'*.

The project manager described the agreement as being a unique way of working together with the client and other suppliers. It had given LOR the opportunity to show that they could be flexible and develop ideas with BAA which strengthened their relationship opening up new opportunities. This has allowed LOR to take a lead role on the project. Both felt the T5 framework as being distinctive from other projects due to the size of the project and the method of working.

Benefits of Partnering

Benefits to BAA – The benefits described by the production leader resembled some of the benefits of framework agreements evident in the body of literature on partnering. These included the construction and design partners working together on the project from the outset; and being involved on the project a year before it started helping the contractor establish the design process thus understanding the client's quality and specification requirements. Cost reduction and adding value was another benefit to BAA.

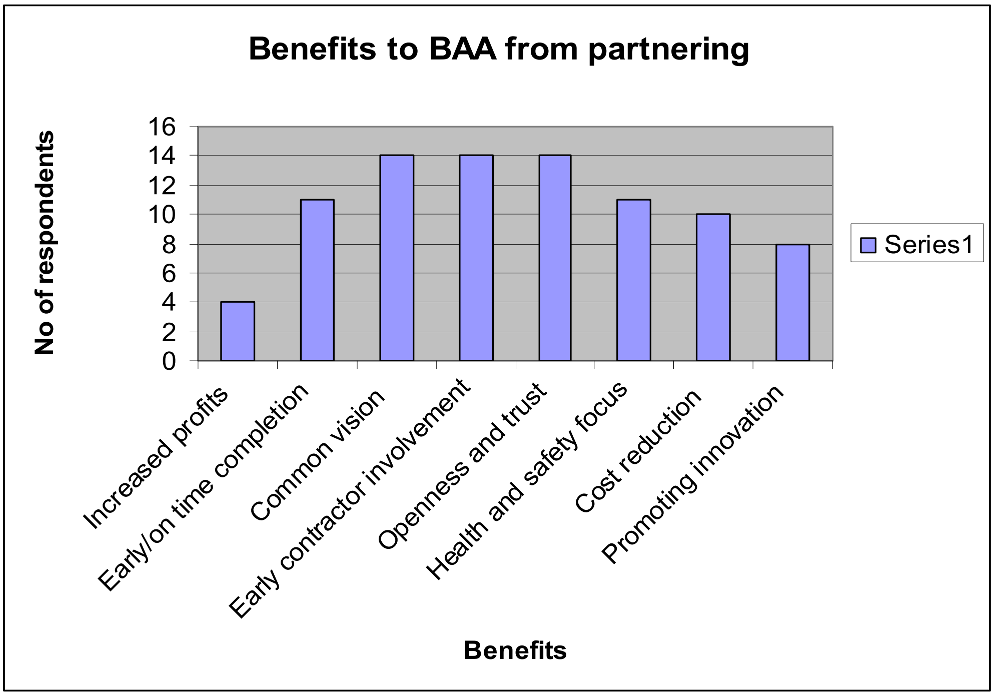


Figure 2: Benefits of Partnering to BAA

Which of the following do you think benefits BAA from being in a partnering agreement? A common vision; Early contractor involvement; and Openness and trust, were all identified as being the most beneficial aspects to BAA from the partnering agreement. One respondent stated that BAA benefited from improved performance:

> *'Good working relationship with BAA, LOR regarded as one of the suppliers more likely to follow the ideals of the agreement'*

Benefits to LOR – The production leader described the benefits contractors sought as being different benefits from the client. LOR's benefits included being on a challenging project and working with a previous client thus they were familiar with the client's style of working. BAA introduced initiatives, such as 'Incident and Injury Free training', which is adopted across all LOR sites. BAA has also sponsored LOR on productivity improvement research and a new IT system referred to as Project flow.

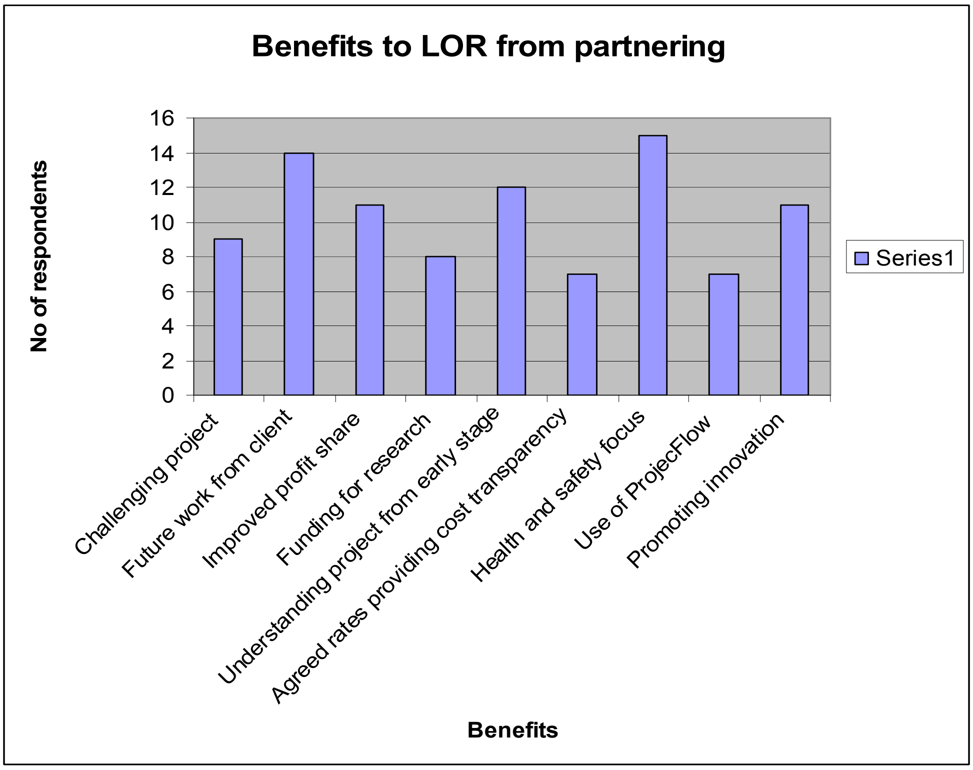


Figure 3: Benefits of Partnering to LOR

'*Which of the following do you think benefits LOR from being in a partnering agreement'?* The largest benefit to LOR is the focus on health and safety which is in contrast to BAA who viewed health and safety focus as a secondary benefit. One respondent stated:

'Allowing the development of various innovative processes such as Project flow, Incident and Injury Free and 4D modelling and methods of working which would not have been achieved working on smaller projects and other clients'.

Other major benefits included the potential for more work from the client. Understanding the project from an early stage was also perceived as highly beneficial.

'It has given LOR opportunity to shown that they can be flexible and develop ideas with BAA which strengthens our relationship opening up new opportunities. This has allowed LOR to take a lead role on the project.'

Negative Aspects of Partnering

Conflict arising from integrated team working and the 'Tying up of management resources were considered to be negative aspects of partnering on the T5 project. Delayed decision making and communication problems were also seen as a negative aspect of being in a large partnering arrangement. One comment from a respondent emphasised this:

'Working in partnership with BAA has been helpful although when trying to work alongside other companies things get interesting. Every company wants the appearance of their employer to be better than the next and this can often hold back integrated teamwork'.

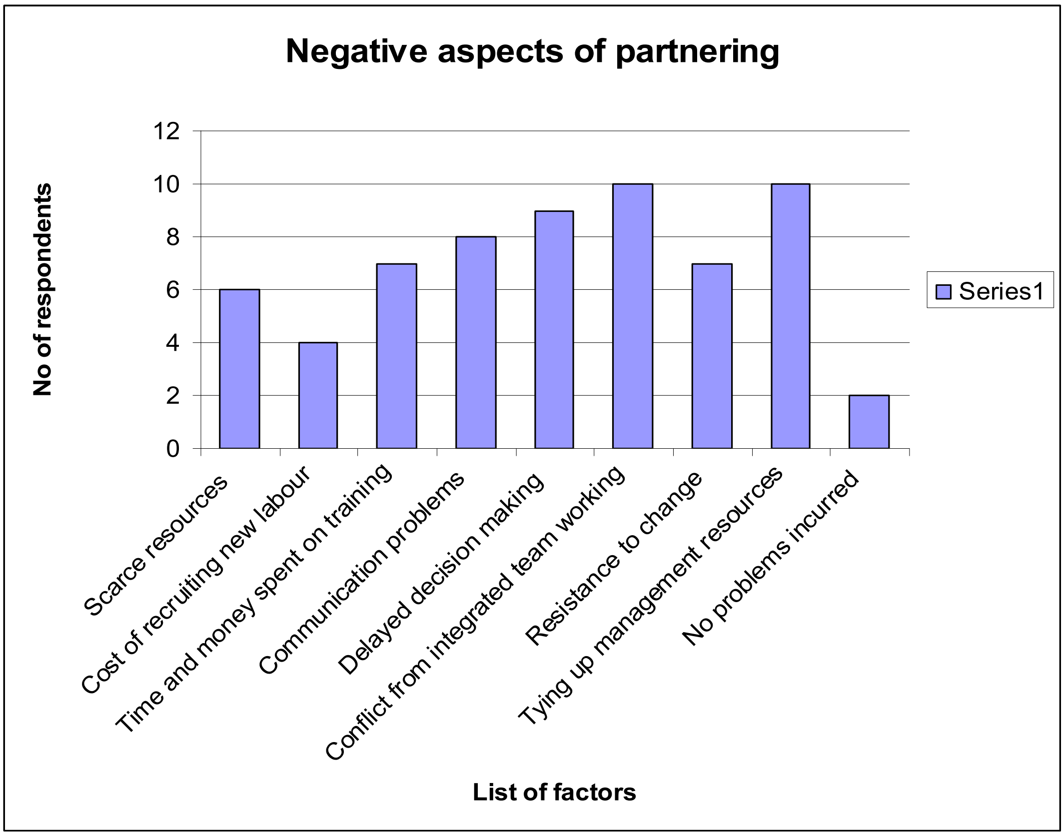


Figure 3: Negative aspects of Partnering

Integration

'Culture barriers' and the 'reluctance to acknowledge risk' were identified as the most significant issues in the partnering arrangement. The manner in which BAA created an ethos of teamwork was established by arranging all partnering members in the one office and was known almost as a virtual company or project team. The project team were given T5 specific job titles i.e. production integrator or design integrator. A mindset was instilled that the individual was not working for BAA but for the project. Conflict was resolved by the project execution plan which details a problem resolution process. A conflict resolution procedure in the partnering charter is used when conflicts arise. Everyone has gradually worked together as a team towards a common goal with any confrontational issues placed to one side. The pain/gain share mechanism in terms of cost meant BAA took all the pain but BAA and the suppliers shared the gain. The target cost was for the whole project and not on individual companies' target costs.

Building relationships between team members and changing the culture are viewed as methods of delivering the T5 project. Partnering literature suggests the process of integration can incur problems. Establishing trust between the partners can take time and honesty and openness can be difficult to attain. Respondents of the questionnaire responded to questions with regards to the development of a T5 culture on the project. The relationship between categories of response were explored and the link between 'Listening to different views' and 'Integrated team working', and 'Continuous communication' and 'Mutual objectives' both emerged strongly. The positive correlation may imply team working can only be achieved if the team members are able and willing to listen and understand other members of the team. It also suggests mutual objectives can only be shared and met if there is continuous communication between the team members. A strong link also emerged between respondents who believed 'trust between all parties' is effective in developing a partnering culture and those that believed 'Continuous communication' as essential to develop a partnering culture.

Table 2: Correlations from Partnering survey

		Q14 Integrated team working
Q13 Listening and understanding different views	Pearson Correlation	.775(**)
	Sig. (1-tailed)	0.000
	N	19.000
		Q16 Sharing mutual objective

Q15 Continuous communication between team members	Pearson Correlation	.698 (**)
	Sig. (1-tailed)	0.000
	N	19.000

CONCLUSIONS

Overall, the conclusion drawn from the correlations with regards to integrating teams and developing a partnering culture is positive. Team work and continuous communication appear to be the key sources of success for the partnering arrangements. Most of the respondents thought trust, continuous communication, listening and understanding other views were essential to develop a partnering culture and these clearly exist in the T5 project. In addition when the respondents were asked if they thought a partnering culture is a good way to manage teams on a project 95% replied 'yes'. The T5 handbook has also encouraged building relationships and changing the culture to deliver the project successfully. Nonetheless, respondents also thought there were negative aspects to integrated working. Conflict in teams is a major problem and 53% of the respondents felt conflict arising from working with integrated teams occurred at T5. A respondent who replied to the open ended questions claimed:

> *'Some companies including design teams have been able to push the boundaries too far holding back others'.*

Another respondent commented '*Every company wants the appearance of their employer to be better than the next and this can often hold back integrated teamwork*'. This conveys the competitive environment which can exist when trying to develop a partnering culture. LOR acquired a specialist in-house mechanical and engineering company to work on T5. The impact on labour resources was the major issue where people who had previously worked on a BAA framework arrangement had more experience thus were called to work on T5 for a short period. Conversely, the T5 agreement did not suit every contractor because some did not fully understand the concept thus the benefits had not been realised and BAA are penalised with bad performance. The T5 agreement states all risk is given to BAA but it appears that contractors still have elements of risk. As with other partnering agreements fair risk sharing is being adopted to solve any problems timely and efficiently.

REFERENCES

BAA (2006) BAA annual report. Online www.investis.com/reports/baa_ar_2006_en (19.12.07)

BAA (2007) The T5 agreement. Online www.baa.co.uk/assets/B2Cportal (21.08.07)

Department for Transport (2006)The future of air transport. Online www.dft.gov.uk (14.10.07)

Infoworks (2007) Right people, right place, right time. Laing O'Rourke publications, 17

Milford (2006) Mission Impossible. *Global leaders academy.* Online www.globalleadersacademy.com (19.12.07)

Monaghan (2006) BAA Launches procurement strategy for next 10 years. Bulding. Online (2.11.07)

Morgan (2006) Heathrow's T5 will be ready 11 months early. The Observer. 17.12.06

LOR (2007) Laing O'Rourke Annual Review.

T5 Handbook (1999) *The T5 Agreement.* Internal Document

T5 Handbook (2005) *Making History.* Internal Document

SYNCHRONIZING URBAN AND BUILDING DESIGN: EXPERIENCES FROM COMPETITIVE PLANNING IN PARTNERSHIP

Pertti Lahdenperä
VTT Technical Research Centre of Finland
pertti.lahdenpera@vtt.fi

The work presented in this paper is based on the view that the planning process of new areal development projects can be developed in cooperation between society and developers and their designers. While the traditional practice is based on sequential local detailed planning and building design, municipalities have now started selecting partner consortia prior to completion of the plan. The selection is made through a competition in order to find the most potential actors and the best ideas for implementation that produce an urban structure of high quality and are incorporated into the local detailed plan. Candidates are attracted by offering them the right to implement a block as a developer. Thus, the target application here involves the practice where the municipality acquires a land area and draws a plan for it although alternative routes also exist. The approach was applied in the implementation of two actual greenfield housing developments both consisting of five adjoining blocks. In general, the gained experiences support the workability and usefulness of the developed practice which will be dealt with alongside the discussion on change drivers and practical process solutions.

KEYWORDS: urban planning; design-develop competition; PPP; collaboration

INTRODUCTION

In municipality-led land development the municipality usually draws the plan or commissions the task to a consultant. The plan largely dictates the built solutions. The real estate developers step in only once the plan is ready which means that their knowledge and know-how are not available during the drawing of the detailed plan. This study, again, is based on the idea that the planning process can be developed in cooperation between society and developers and their designers. This means selecting private actors for development projects who cooperate with the municipality on a detailed plan solution for the area and on its completion implement the construction as a developer at own risk.

As will be substantiated later, such developer selection emphasises quality and competition where an implementer is chosen simultaneously for each block in a group of adjoining blocks. Initially, for instance, all developer teams (consortia) compete against each other for actual slots in the parallel competitions for blocks based on general competence. The aim is to then select the team that comes up with the best plan in each parallel competition as the implementer (since the studied case deals with a type of fixed-price competition). Building rights serve as a competitive incentive, and participation in competition is a means for developers to acquire building land. One-stage selection is also a possible alternative.

The paper first discusses the change drivers: why cooperative planning is worthwhile and what advantages can be derived from the competitive approach. Thereafter, the pilot projects are introduced in outline including a brief description of the district and the processes used. The last part sheds light on the experiences gained from the development.

CHALLENGES OF DEVELOPMENT

Aim of cooperation

The prevailing planning and construction practice in many countries is that municipalities carry out the city planning and hearing process without involving the developers – the latter are brought in only after the detailed plan is ready (Kurunmäki, 2005). Sequential areal planning processes of this type have, however, been criticised for slowness and inflexibility, especially in the case of growth centres, where land for residential construction has been in short supply (e.g. Group for construction business cycles, 2007). Plots have become available for construction at a slow rate, and the process has reacted slowly to changes in demand. At the same time, construction is controlled quite tightly which may decrease developers' interest in the development of some areas (Taylor, 1998).

Väyrynen (2007) has recently redefined the problem of the traditional sequential process by suggesting that the formal detailed plan constitutes a sort of point of discontinuity in real estate development, especially from the viewpoint of knowledge utilisation. Only formal information transfers when planning and implementation-phase actors are different parties that perform their work at different times. Also, the innovative ideas and market knowledge of the parties implementing the construction cannot be utilised by the planner.

Development of planning cooperation between municipalities and developers is suggested as a solution to more effective community and detailed planning. The procedure based on cooperation can also be partly justified by practical experiences. Rowley (1998) reported about research focusing on private sector development projects which indicated that especially close cooperation between the public and private sectors is factor common to successful projects. Resources must also be invested in initial phase planning. The criterion is good urban planning which areal developers also regard as being in their interest. Kreukels and Spit (1990) also emphasise the benefits of the cooperation model that integrates different kinds of expertise.

Utilisation of competition

The cooperation model does, however, set new requirements for the selection of implementers. In the traditional model, the plan sets sufficiently accurate boundary conditions for areal development together with building regulations, which means that implementation of construction can in principle be entrusted to any competent actor. Meeting of statutory obligations suffices, and selections can be based on criteria other than those that guide areal development (e.g. according to an alternation principle).

The situation is essentially different when the aim is to develop the process by overlapping detailed planning and construction design. Then, the implementers are in fact selected to develop the detailed plan proposal at a time when societal control mechanisms for the future construction are still undeveloped. This requires selecting partners whose input most likely leads to an excellent result in areal development. The developer consortia are expected to contribute added value to the urban planning process.

Many potential actors operate in a functioning market which means that the best partners can be found through a competition. Developers compete on the basis of various demonstrations, ideas and plans, but the decision making authority remains with the municipal organisation. Excellent solutions, later to be made part of the detailed plan, are developed on the basis of the best proposals. Thereby the views of various parties and market demand are taken into account, providing preconditions for quick construction.

The procedure based on design competition has proved superior in developing innovative solutions compared to engaging a single actor as designer straight away (Alexander and Witzling, 1990; Fisher et al., 2007). It allows charting a broad range of possibilities during the competition while a large number of alternative competition processes are produced for meeting different challenges (Alexander and Witzling, 1990; Eley, 1990; Stenberg and Kadefors, 2000). Also in Finland design competition has been applied to conveyance of plots (in addition to procurement), but only in areas covered by a completed town plan (e.g. Kauppinen, 2001). The aim of this study is to apply a similar procedure already during the urban planning process to improve the outcome.

PILOT APPLICATIONS

Description of development areas

The idea of competition-based partnership in local detailed planning was developed and tested in the context of the development of Vuores, a new municipal district of the City of Tampere, Finland. Vuores will be home to nearly 14 000 people with workplaces and comprehensive services by year 2015 (City of Tampere, 2008).

Mäyränmäki is the first section of Vuores to be built. In the component master plan it is designated primarily as an area of compact low-rise housing. Mäyränmäki comprises a workplace- and service-weighted central block, adjoining residential blocks and a one-family housing area to the north. The primary pilot project on the cooperation process covered five residential blocks (total building rights for 24 000 floor sqm). The one-family house areas and the so-called central block were excluded from the competition. The competition was launched in June 2005 (City of Tampere, 2005a), partners were selected half a year later in December (City of Tampere, 2005b), the plan proposal for the display (for public inspection) was accepted in November 2006, and the plan was accepted by the City in March 2007.

Vuoreskeskus is another area whose development has also begun. It will form the activity centre of entire Vuores with its commercial and public services. Due to its urban character, the dwellings are also chiefly in multistorey blocks. The other pilot project involved a wall of multistorey buildings five blocks long in the centre along the main street (total building rights for 33 000 floor sqm). The idea was to have four-storey building masses line the streets with space for commercial, office and other service facilities on the ground floors. The competition was opened in December 2006 (City of Tampere, 2006), partners were selected in May 2007 (City of Tampere, 2007) and the plan proposal for the display was accepted by the City in June 2008. Fourteen consortia entered both competitions.

The Mäyränmäki project is the primary application reported in the paper. The competition for Vuoreskeskus was over by the time the last experiences were collected from the parties involved in the project, and the practices applied in the latter reflected the results of the former. Therefore, Vuoreskeskus is introduced in outline as a secondary application. The success of the processes was also generally promoted by developing a joint vision of the city and the companies beforehand for defining and communicating the desired state of the area (cf. Riihimäki 2006).

Starting points for process development

The participants considered the first pilot project the first one of this kind implemented in Finland. The process was developed on the basis of existing knowledge as concerns procurement methods including design, prequalification procedures of construction and design competition practices (Lahdenperä 2007). Various possible alternative processes were generated and assessed in cooperation with sector actors. To be precise, the work is based on the social constructivism approach; the process was developed in close cooperation with the public and private sector actors that were to be involved in the actual implementation.

When plans are drawn for areas, significant new building rights are created. Therefore, it was considered sensible to select several implementers for the entire area in order to maintain competition in the market – such as a consortium for each block. Competition for a group of blocks involves a sufficient volume to spark the interest of construction sector actors. Simultaneous competition is naturally a logical consequence of the objective of coordinating adjacent block-specific solutions. A key question is how to secure the actors' interest toward each block so that the expected value of winning from the viewpoint of consortia is sufficient for them to get seriously involved in the competition and that it results in the best possible outcome from society's viewpoint? This, along with some other issues, requires development of sufficiently uncomplicated, fair and transparent competition models.

Competitive selection and cooperative processes

In the case of the Mäyränmäki competition, a process was developed to respond to the presented challenge where the best consortia having announced their candidacy are allocated to parallel block-specific design competitions for selecting planning partners. On the task level, the two-stage selection process is as follows (Figure 1):

1. *Opening of competition*. As the draft of the detailed plan is finished and the block layout has taken shape, the competition is publicly announced opened. The goals set and the rules of the selection process are recorded in the competition programme.

2. *Preparation of account of qualifications.* Companies organise into consortia with comprehensive expertise in areal planning and implementation. The consortia prepare participation applications whereby they prove their competence.

3. *Assessment of competence.* The municipality ascertains the general competence of the consortia having submitted an application for participation (societal obligations, min. experience). Here we are dealing with definite factors that are either met or not met.

4. *Assessment of qualifications.* The municipality together with its experts assesses the strengths of the consortia deemed competent in relation to preset criteria (know-how, references, etc.). In the assessment the different degrees of properties are identified.

5. *Establishment of ranking order*. Consortia are ranked solely on the basis of how they fared in the assessment of qualifications. These assessments are used to arrive at a definite reference figure for consortia which is used to rank them in each case.

6. *Allocation of competitors.* Consortia for parallel design competitions are selected so that a finite number of competitors participate in each block-specific competition (e.g. 3). The competitors are selected in ranking order on the basis of their stated priorities.

7. *Preparation of design proposal.* Competing consortia prepare their proposals for the blocks assigned to them. The design proposal is a technical and functional description of the target's architecture. Process-related issues may also be the subject of design.

8. *Assessment of proposed solutions.* An expert group set up by the municipality evaluates the proposed solutions submitted under a pseudonym in accordance with the criteria of the competition programme (building properties, etc.).

9. *Conditional selection.* The consortium that did best in the design competition is selected as the partner to implement the block (or part thereof) in question. The assessment of qualifications is not considered here (or it carries little weight).

10. *Planning in partnership.* The municipality and the selected consortia continue development of the plan and the blocks on the basis of proposals. Earlier presented goals guide design and become increasingly specific along the way.

11. *Confirmation of selection.* When the detailed plan produced in cooperation has been approved and is legally valid, the preconditions for confirming the plot division and subsequent disposal of plots to the partners involved in planning (sale/rental) exist.

The selection process and related criteria are described in detail in an article by Lahdenperä (2008) which focuses especially on the allocation algorithms that pertain to step 6 of the process: how competitors are selected from among the ranked consortia for parallel design competitions in a multi-target competition when different guiding principles are available.

As to final selection based on design solutions, the development of the area as an entity often requires deviating from the ranking order which means that the winner must be rewarded by other means. That was also true in the case of one block where the consortium judged best by a close margin was assigned another block in the immediate vicinity of the competed blocks. In all cases, the terms of disposal are made to include a condition concerning the as-designed construction while the detailed plan can be less restrictive than usual.

The selection process was simplified to a single stage for the second pilot project, i.e. the Vuoreskeskus competition. There the companies were to provide the material necessary for assessing their competence and qualifications as well as a concept-level plan proposal simultaneously. The selection started with evaluation of the plan proposal to secure anonymity. The ranking of plans of equal quality was decided on the basis of assessment of qualifications. The higher ranked companies were selected as planning partners after confirming their competence. Figure 2 depicts the process where the contents of tasks correspond closely to the earlier presented contents of tasks of the Mäyränmäki process despite the different order.

The competition was special in that all competitors prepared their plan proposal for the same block even though only a single consortium would be selected to implement it and the others would be assigned four other blocks. This was done to improve comparability. It was also assumed that the solutions are reasonably well applicable to other similar blocks along the same street on the same side. To avoid unnecessary work, the plans were not assumed (allowed) to be as detailed as in the previous Mäyränmäki competition where there were major differences between various competed blocks.

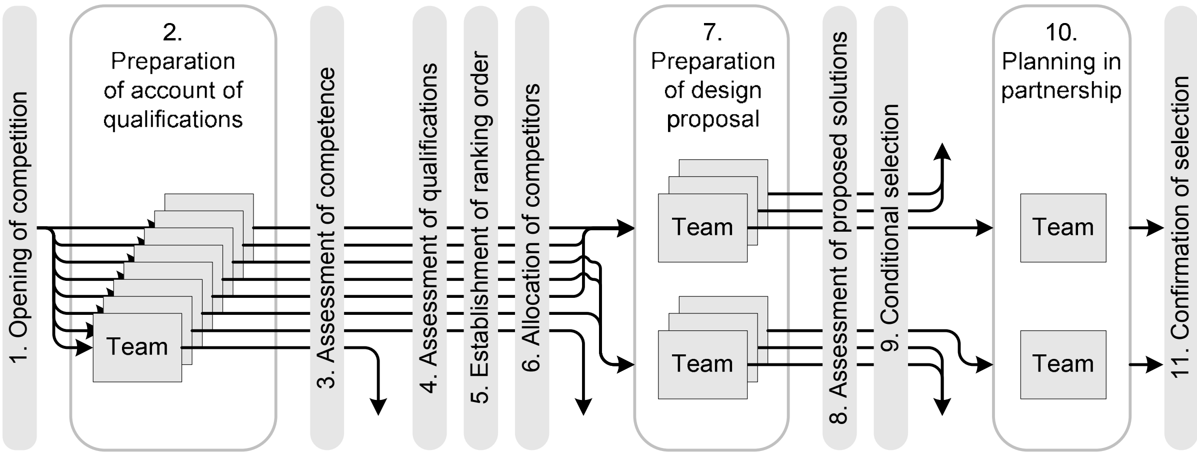


Figure 1. Two-stage process for selecting planning partners for Mäyränmäki area.

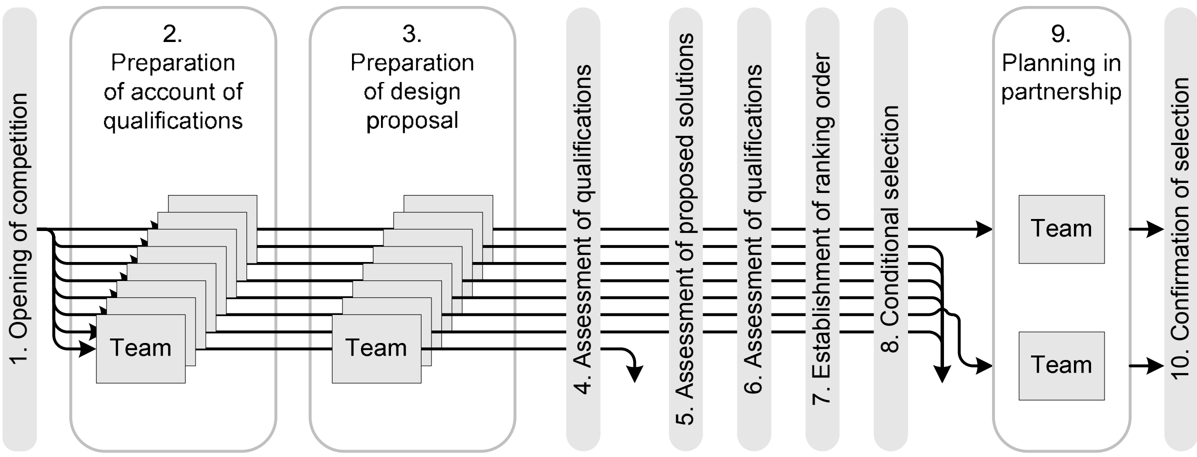


Figure 2. One-stage process for selecting planning partners for Vuoreskeskus area.

WORKABILITY OF PLANNING IN PARTNERSHIP

Evaluation bases

The development of competitive planning in partnership involved a cooperation process between the municipality, companies and researchers where also the views of companies had an impact of the evolving procedure. At various phases of implementation, inquiries were directed at representatives of the consortia participating in the competition and the cooperation process for Mäyränmäki area (Nykänen et al., 2007). The inquiries were complemented by requests for feedback from the companies made at a feedback workshop held at the end of the process. Reports on company feedback, the workshop and the city's experiences are presented in the following.

Inquiries to developers

The first inquiry (reported here) was directed at companies immediately after the selection of partners for the planning of Mäyränmäki. All participants in the competition were targeted although less than half responded (see Table 1).

Table 3. Results of feedback inquiry ("■" depicts a response; note that the scale information in most cases is presented in the connection of statements).

INQUIRY 1 (*		*Poor*	*Passable*	*Adequate*	*Good*	*Excellent*
1. Appropriateness of information requested for assessing qualifications				■	■■■■	
2. Content and clarity of competition programme			■	■■■	■	
3. Content and clarity of competition and selection criteria				■■■■	■	
4. Appropriateness of resources required by competition				■■■■	■	
5. Possibility of later recouping competition-phase design input		■			■■	■■
6. Appropriateness of master time schedule for competition		■	■■	■	■	
7. Probability of your future entry in similar (compact and low) competitions				■	■■	■■
8. Number of competitors (3) per block	*[Too few < Just right > Too many]*			■■■■■		
INQUIRY 2		*30%*	*50%*	*60%*	*80%*	*90%*
9. To what extent did the city direct the further development of block plans? (**		■■	■■	■	■	■■
INQUIRY 2 (*		*Poor*	*Passable*	*Adequate*	*Good*	*Excellent*
10. Alterations to competition entry in follow-up design	*[Many <> Few]*		■■	■	■■■	■■
11. Impact of alterations and follow-up design on end result	*[Weakened <> Improved]*		■	■	■■■■	■■
12. Detailedness of plot-use plans required of companies	*[Too detailed <> Too general]*		■■■	■■■■■		
13. Work input required by follow-up design	*[Too big <> Just right]*		■■■■	■■■	■	
14. How did follow-up work proceed	*[Very slowly <> Very efficiently]*		■	■	■■■■■	■
15. How well did the programme predict the themes of follow-up design	*[Poorly <> Well]*		■■■	■	■■■	
16. How many risks related to the process did you identify	*[Many <> Very few]*		■■■	■■■■■		
17. General view of usefulness of the planning in partnership process	*[Poor <> Excellent]*			■■■	■■■■■	

*) Questions not directly connected to the overall planning in partnership process were not included in this summary. They concerned other special features and development themes that had to be excluded due to limited space. **) The posed question was open-ended, but the responses clustered around five values; the scale was created on the basis of responses given and is thus not evenly graduated.

The responses indicate that the content of the competition programme was in some respects considered ambiguous and the time reserved for planning short since the state of readiness of the plans was high in this project. The critique was actually expected and was considered to be the result of the busy schedule of the planning department and several personnel changes besetting this specific project rather than a problem related to actual planning in partnership. The participants informed having spent 30–50 000 € to prepare their plan proposal. On the other hand, the information requested for preselection and the selection criteria were considered unproblematic, even fairly good. All respondents also thought three competitors per block an appropriate number. The companies regarded participation in the construction as profitable if they were to be selected as a planning partner. Thus, it appears natural that the companies said they be interested in similar competitions also in the future.

Another inquiry was made after the completion of the detailed plan proposal as the actual cooperation phase was coming to an end. The inquiry targeted all companies selected as implementers of the area including their designers – and all responded. The degree of detail of the design and the work it required were for the most part found suitable although some responses indicated the desire for a lighter workload. The general feeling was also that the cooperation had been efficient. The need for follow-up design differed by blocks, but the amount was not considered totally unreasonable in the case of any block. Alterations were also found to have clearly improved the end result. The initiator of alterations varied which appears natural when matching solutions for parallel blocks of different kinds. One mentioned risk was the launching of detailed design much earlier than construction when future demand is still highly uncertain. The overall view of the procedure was positive, and the process was for the most part found useful.

Feedback workshop

The feedback workshop was conducted for representatives of companies that had been planning partners in the Mäyränmäki project. By the time of the workshop, the detailed plan had been approved by the City Council but was not valid due to complaints against it. On the other hand, the planning partners for the blocks of Vuoreskeskus had just been selected meaning that several actors had experiences from two different selection processes.

As concerns the competition phase, the companies felt that the accuracy and work required by the competition entries should be reduced from what was required for Mäyränmäki. Especially accurate floor plans of dwellings were not deemed necessary at such an early stage, and the competition should have been focussed more on the features of the townscape. Consequently, the lighter ideas/concept competition for Vuoreskeskus was preferred even if it could be expected to require applying plans to other blocks in the case of most selected partners as all competition entries focussed on a single block. This was not, however, mentioned as a problem by the companies.

It was generally considered a strength of the procedure that it did not build on a ready-made detailed plan that would constrain ideation. Companies were given the chance to seek new implementation solutions. The planning authority raised questions for which the companies sought answers. The companies, however, considered it a problem that planning discontinued between the submission of competition entries and the start of follow-up design as well as between the completion of the detailed plan proposal and implementation. The biggest risk was considered the fact that complaints delay significantly the start-up of construction and market demand may change in the meantime. Naturally, the companies wish that design could adjust to the situation in the markets.

The city's experiences

The city also had quite favourable experiences from planning in partnership. It learned that competition produced first-rate block plans which were found to improve significantly during later planning cooperation. The procedure brought in the best actors in the field while the evolving network served as a significant additional resource that supported the city's own planners. Multiple actor networks naturally chart different solutions and consider various viewpoints more broadly. The city also found it valuable that market know-how was introduced into the process through the companies.

The first pilot project gave rise to these views which have since gained strength as the second pilot project has moved forward. As a consequence, the city intends to apply the competitive planning in partnership model also to future development projects in Vuores. Procedures superior to the tested ones will still be sought. One possibility is a process where planning is continued in cooperation while possible complaints about a more general plan are being heard by courts. After all, complaints seem to delay planning and construction occasionally but seldom have any other impact (Ministry of the Environment, 2005).

CONCLUSIONS

The presented development work was based on the idea that changeover from separate and consecutive planning and construction processes to a process based on cooperation makes for more effective operations. The pilot projects supported that idea by yielding first-rate block plan proposals which were developed further in good cooperation. The work combined the planner's conception with the implementers' market savvy and production know-how whereby the design of parallel blocks was viewed as a whole. The end result was a top-notch local plan from the viewpoint of cityscape and functionality which, according to the city representatives, could not have been achieved without the competitive cooperation procedure.

The city and society were clear beneficiaries, and based on the inquiries, also the companies' experiences were favourable enough to secure actors for future projects. The procedure was seen as directing development in the right direction and as the planning model of the future. However, the implemented projects have not been able to accelerate the overall planning and building process which was one of the goals. Yet, the actors assume that planning in partnership can speed up the overall process if complaints do not slow down the process.

REFERENCES

Alexander, E. and Witzling, L. (1990) Planning and urban design competitions: introduction and overview. Journal of Architectural & Planning Research, 7(2), 91–104.

City of Tampere (2005a) Competition for Mäyränmäki blocks of Vuores. Competition programme. (in Finnish)

City of Tampere (2005b) Competition for Mäyränmäki blocks of Vuores. Assessment report of the jury. (in Finnish)

City of Tampere (2006) Selection of planning and implementation partners for the western part of Vuoreskeskus. Selection programme. (in Finnish)

City of Tampere (2007) Selection of planning and implementation partners for the western part of Vuoreskeskus. Assessment report of the jury. (in Finnish)

City of Tampere (2008) Vuores – New pleasant living environment of human scale for today's urban dwellers, <http://www.tampere.fi/vuores> (in Finnish; section in English)

Eley, J. (1990) Urban design competitions: a British perspective. Journal of Architectural & Planning Research, 7(2), 132–141.

Fisher, P., Robson, S. and Todd, S. (2007) The disposal of public sector sites by “development competition”. Property Management, 25(4), 381–399.

Group for construction business cycles (2007) Construction 2007. Ministry of Finance, Helsinki. (in Finnish)

Kauppinen, H. (2001) Design competitions for plots in Helsinki. In: Construction projects 2001, 17.–18.5.2001. Helsinki: The Real Estate Education and Training Institute. (in Finnish)

Kreukels, A. and Spit, T. (1990) Public-private partnership in the Netherlands. Tijdschrift voor Economische en Sociale Geografie, 81(5), 388–392.

Kurunmäki, K. (2005) Partnership in Urban Planning. “Development Area” in National and Local Contexts in Finland, Germany and Britain. Tampere Univ. of Technology, Tampere.

Lahdenperä, P. (2007) Systematic selection of partners for areal development projects. VTT Research Notes 2380, Technical Research Centre of Finland (VTT), Espoo. (in Finnish)

Lahdenperä, P. (2008) Disposal of land by phased multi-target development competitions: Algorithms for competitor allocation. (under review)

Ministry of the Environment (2005) Effectiveness of the Land Use and Building Act. Evaluation of the experience gained from the Act. Finnish Environment 781. (in Finnish)

Nykänen, V. et al. (2007) Collaborative urban planning. Case Beyond Vuores. VTT Research Notes 2393, Technical Research Centre of Finland (VTT), Espoo. (in Finnish)

Riihimäki, M. and Vanhatalo, M. (2006) Vision as a tool to develop town district planning. VTT Working Papers 58, Technical Research Centre of Finland (VTT), Espoo. (in Finnish)

Rowley, A. (1998) Private-property decision makers and the quality of urban design. Journal of Urban Design, 3(2), 151–173.

Stenberg, A.-C. and Kadefors, A. (2000) Procurement practices and innovation processes: A case study of a developer competition for green building. In: CIB W92 Symposium, Santiago, Chile, April 24–27. Santiago, CL: Pontificia Universidad Católica de Chile. Pp. 767–782.

Taylor, N. (1998) Urban Planning Theory Since 1945. Sage, London.

Väyrynen, E. (2007) Planning and implementation–from separation to joint processes. Nordic Planning Research Symposium "Local Authority Planning in Change: Beyond Dichotomies", August 16–18, 2007, Oulu. University of Oulu, Department of Architecture. 11 s.

WORKPLACE SAFETY AND EMPLOYEE ENGAGEMENT

Deborah Phillips
Georgia Institute of Technology, Atlanta, Georgia USA
Deborah.phillips@coa.gatech.edu

Work-related injuries continue to be a major financial issue for employers, particularly in small construction firms across the United States. The financial burden of serious work-related injuries and illnesses impacts large and small firms alike, as do the hidden indirect costs that come with work-related injuries, such as lost work time, replacement workers, administrative costs, low morale, and decreased productivity. This paper presents a case study of a U.S.-based construction firm which dramatically reduced its number of on-the-job injuries. The company's efforts to alter its corporate culture to promote safety are discussed, and the specific strategies that were implemented are outlined. The relationship between workplace safety and employee engagement is also explored in this research. This research offers practical solutions to address the growing challenges of small construction firms in their efforts to improve worker safety, reduce accidents and increase profits.

KEYWORDS: safety; accidents; employee engagement.

INTRODUCTION

Employee absenteeism, whether injury-related or not, causes disruption in day-to-day business operations, and is one of the most expensive hidden costs an organization faces. These costs include: lost productivity; overtime paid to other staff members; payments to temporary workers hired to fill in; decreased productivity for workers having to put in extra hours; and decreased employee morale which leads to further problems in productivity and turnover (Blumberg, 2006). According to the Bureau of Labor Statistics, 4.3 million full-time employees miss at least one day per week, which is over five percent of the total workforce. In the real estate sector, including property management companies, employees miss an average of six days of work per year as a result of work-related injuries (Bureau of Labor Statistics, 2006). Unplanned absences cost American employers between $60,000 and $3.5 million each year (CCH, 2005).

This paper examines workplace safety particularly within the multi-family housing sector. A case study approach is used to demonstrate how one company reduced workplace accidents and improved its overall financial performance through adoption of a corporate culture change centered on safety. New strategies for improving employee engagement are discussed and measurable results of the company's successful efforts are presented.

Overview of the Apartment Industry

The National Multi-Housing Council (2004) estimates there are about 18 million apartment units in the United States. Experts expect an additional 2 million new apartments will be available by

2010 (National Multi-Housing Council, 2004). The majority of the apartments are located in buildings with 10 or more units, and are managed by paid staff working directly for the owner (in-house management) or by a third-party management company. The financial health of a given property is dependent on both internal and external factors. One of the most significant internal factors influencing the financial health of a property is Net Operating Income (NOI), which is measured by the difference between total revenue collected and total operating expenses. The largest increase (10.5%) in operating expenses was in the category of salaries and personnel (Sheehan and Freeman, 2006). The majority of expenses from injuries are reflected in this category.

According to the U.S. Department of Labor Bureau of Labor Statistics, employment in the apartment industry totals 637,900 jobs in January 2006. Employment trends predict a rise by at least 10,000 to 12,000 jobs annually, to reach nearly 740,000 jobs in 2010. Along with this increase in overall workforce, property management companies experience an average of 39 – 60% employee turnover per year, which is high for the service industry sector (CEL & Associates, 2006). The labor shortage, combined with the increase in operating expenses related to salaries, personnel and payroll insurance, forces multi-family management professionals to take a closer look at employee engagement and the role it plays in accident prevention.

Statement of the Problem

LCM Real Estate Company[1] is a Georgia-based firm specializing in multi-family construction and management. LCM Real Estate has three primary business entities – development, construction and management – and the majority of its nearly 900 employees work on-site at over 116 locations, primarily in the Southeast United States.

LCM Real Estate was experiencing an elevated level of injury-related claims that were negatively affecting the company's financial performance. Between March 2001 and March 2002, the company documented cases of 114 claims totaling $704,292 in direct costs. By the end of March 2002, the company was spending more than $1 million related to workplace injuries; 75% of the claims are reported by the maintenance departments on the properties. When a closer look is taken at these work-related injuries, it is found that during this particular year of elevated claims, the company was spending $22.02 for every $1,000 dollars of payroll, and the average claim was costing $6,178. These injuries result in over 450 days lost from work. Thirty-four percent of these claims are due to strain, followed by 20% lacerations and 13% of contusions.

These work-related injuries cause both a drain to the company's financial resources, and directly impact the daily management operations. For example, a traditional garden-style apartment community with 340 units is typically staffed with one property manager, one assistant manager, two leasing consultants, one maintenance supervisor, two maintenance technicians, and possibly one housekeeper/groundskeeper. If the apartment community houses more than 700 people, including married couples and families, workplace injuries and employee absences can become extremely stressful for employees, particularly at the beginning or end of the month when

---

[1] For the purposes of confidentiality, a pseudonym has been used, "LCM Real Estate Company". LCM and LCM Real Estate are also used interchangeably. Executives interviewed for this project are identified by first and last initial.

residents are moving out or new residents are moving in. If an employee is out of work due to an unplanned absence, there can be a higher level of stress to the remaining employees who do report to work.

National studies indicate that more than 85% of workplace injuries and accidents can be linked to human errors or omissions (LaBar, 1996). Some of these problems occur because policies and procedures have not been established. Other key factors within the work environment that can influence safety performance are poor communications between co-workers including work pressure, poor social climate, or weak communications between supervisor and his/her team members. Most employees find themselves trying to correct a problem or performing a task in a tight time frame, which can also contribute to injuries (Ayers & Kleiner, 2000). Liberty Mutual reports the top three causes of injury are a result of overexertion, falls on the same level, and bodily reaction. These injuries represent 51.3 percent of the total costs of serious workplace injuries in 2004, costing about $25 billion a year or $480 million a week (Liberty Mutual, 2006).

Service-providing industries make up 79 percent of private industry employment and have a rate of 122.4 injuries and illnesses with days away from work per 10,000 workers, a decrease of 3.4 percent from 2003. The most-prevalent event for these industries is overexertion- especially overexertion in lifting, followed by contact with objects and equipment (BLS, 2006). LCM Real Estate claims are very similar to those on a national level. The most prevalent injuries at LCM Real Estate occur in three areas: being struck against an object; slips and falls; and being caught in or compressed by an object.

Employee Engagement and Safety

Employee engagement can be defined as the cognitive and emotional activity demonstrated in daily occurrences that lead to a bonding of an individual to their co-workers, their job and their organization (Harter, Schmidt, & Keyes, 2002). There has been considerable research on the impact of employee engagement as it relates to safety. Research by the Gallup Organization (2006) supports the connection between worker morale and overall well-being. Companies where employees feel a strong emotional bond to the organization have reduced absenteeism, fewer accidents, and increased productivity, and, in turn, are more profitable (Wagner & Harter, 2006). When the employee feels a strong connection with the mission of the company, commonly referred to as mission-driven work groups, these companies report 30 to 50 percent lower turnover. In fact, engagement scores show that people who feel part of a solidly committed team are routinely safer, better with customers, less likely to quit, and more productive. When workers feel more secure about their employment, there is a higher level of trust and commitment. Increased turnover often causes management to have an inexperienced and under-trained workforce, resulting in an increase in safety incidents (Kincaid, 1996).
Wagner and Harter (2006) further identify that “having a friend at work” averages 20% fewer accidents than a team with less cohesiveness. It is important to note that many employees work in teams and, therefore, often need to respond to hazards collectively rather than as individuals. Another factor that effect engagement, which also reduces accidents, is when companies focus on the progress of the individuals. In Gallup’s global database, business units that report “someone talked with them about their progress in the last six months” report 10 to 15% higher productivity and 20 to 40% fewer accidents (Wagner & Harter, 2006, p. 161). Numerous studies

(Tomàs, Melià and Oliver, 1999; Zohar, 2000a, 2000b) reveal that, when supervisors are actively engaged and monitor and reward safety performance, their subordinates engage in more safety-related behavior and experience safer overall performance than when they are not actively engaged. Tomàs, et al. (1999) find that the supervisor's attitude towards safety played a critical role in explaining co-workers' responses to safety (i.e. attitudes, behavior, risk and accidents). The studies indicate that when supervisors discuss, reward and encourage safe work habits, employees model similar behavior. This behavior results in higher safety performance levels and also shows effective financial performance (Komaki, Zlotnick and Jensen, 1986).

Change at the Leadership Level

The degree to which the leader embraces safety can predict the level to which the entire organization values safety. Studies reveal that when leaders monitor and reward safe performance, employees follow suit (Hofman & Stetzer 1996; Hofman et al., 2003; Zohar, 2000a). According to senior management at LCM Real Estate, safety was not a primary focus of the company at that time, nor is it part of the company culture. Further, the service technicians were not focused on safe work practices and did not follow proper procedures. In order to shift the company's focus to safe work practices, the company founder made strategic leadership changes and appointed a new Chief Executive Officer, with the charge of ensuring safety as a top priority. His primary objective is to reduce loss and change the company's attitude toward safety and its processes. Simply stated, his strategy involves implementing change at all levels within the organization by involving all employees and making safety a "mission focus" throughout the company (B.D., personal communication, November 16, 2006). In order for safety to become a core value, it is integrated at every business unit and throughout all divisions.

Despite the uniqueness of people, when placed in the same system, people tend to produce similar results (Senge, 1990). Senior management then shifts its focus to making and integrating transformational changes, such as values and beliefs, particularly with regard to safety in the workplace. One senior executive states: "Before we can reduce the number of accidents, we must first change how people think about safety in order to affect the behavior that is associated with these practices" (B.D., personal communication, November 16, 2006). A total paradigm shift is required that goes beyond assessing the "root cause" and making changes. From a top-down perspective, the entire way safety is viewed has to change, including developing an executive position to oversee safety policies and procedures. As a result, for the first time in the history of the company, safety is not reported in terms of losses, but is now being reported in terms of successes.

Solutions

LCM Real Estate executives center their strategic plan on the idea that "most people tend to support that which they help to create." As a result, they solicit the help of on-site employees in creating the central theme in which all employees would be reminded of safe work practices. The employees are asked to submit a theme for the campaign, and the majority of LCM's nearly 900 employees participate and submit ideas. Based on their input, one central message is selected: "*Safety's Intention is Accident Prevention.*"

Once the theme is established, the message is made visible. Posters are placed at every site and every maintenance employee is given a red cap to wear on Thursdays as a reminder to all employees, as well as residents, that the company embraces safe work practices. The vice president of safety also schedules a conference call with all field supervisors on Thursdays to review the week's safety performance and reiterate any necessary procedures. These initiatives lead to fully integrating safety in the on-site systems. The VP of Safety reports that until safety became a core value, the only thing that is measured is the injuries and the dollars that are lost due to an accident (H.B., personal communication, October 24, 2006).

In order to further define better systems, he and fellow executives look to other industries to find strategies for reducing loss, which are incorporated into LCM Real Estate's new initiatives. Others include:

Safety as a core value: It is important for everyone in the organization to embrace safety. A company's culture forms the basis for everything that is valued in the company, including its attitudes towards safety. Neal & Griffin (2006) define a safety climate "as a process model that draws important distinctions regarding the key dimensions of safety behavior: determinants of safety performance (i.e. safety knowledge) and safety motivation, safety performance (i.e. following safety protocols) and safety outcomes (i.e. occurrence and non-occurrence of injuries)" (p.17).

Values are manifested in actions and behavior: They are reflected in what management does, pays attention to, and what is ignored, measured and controlled. It is through management's actions and behavior that employees become aware of the organization's meanings and learn what is expected of them and how to behave. Through a reward and punishment system, the culture in an organization is maintained. Behaviors that are rewarded will be repeated. As behaviors are rewarded and repeated, they become unconscious (Erickson, 2000). LCM Real Estate's vice president of safety reports that, if the injury investigation reveals that the injury is due to policy violation or negligence, a performance interview or counseling is performed, which can include termination. If a supervisor is present during the injury and allowed the policy violation they too receive a performance interview or counseling. A full review of the procedure that can prevent the accident is reviewed with the entire staff during the investigation period.

Training is ongoing and occurs at all levels: Safety professionals attend many seminars and conferences to make their workplaces safer. However, knowing is different from doing, and being able to execute this new knowledge is a separate issue. LCM Real Estate recognizes its associates when this knowledge is put into action. Each month an issue of "Safe Times," a safety newsletter, is distributed to each employee both in Spanish and English.

Communication is open and circulates: Management acts on the recommendations and suggestions from the field. Communication is only effective when it is heard and actions are taken immediately to affect change. Senior management encourages involvement and solicits suggestions from every level of management. A prime example is when the majority of all LCM employees sent suggestions for the marketing campaign slogan.

Innovation and integration are strongly encouraged: LCM Real Estate's new way of thinking encourages many of the "veteran employees" to develop new systems of reporting and more efficient ways of integrating these changes at the site level.

Safety is respected: LCM Real Estate recognizes that it not only provides shelter, but also provides intangible benefits that its residents have come to appreciate. By focusing on safety and treating it with respect, the employees, as well as the residents, can be proud of a safer environment in which to live, work and play.

Measurable Results

As a result of these changes, LCM Real Estate reports 4.88 recordable injuries per 100 employees in 2005, and, in 2006, improves to 2.59 recordable injuries per 100 employees. A recordable injury is defined by OSHA as a work injury in which medical treatment is sought. According to the vice president of risk services at Wachovia Insurance Services, the national average is 4.11; LCM Real Estate went from average to better than average in one year's time (E.D., personal communication, December 11, 2006). Incidentally, the average company size for residential apartment management is 417 employees and LCM Real Estate is nearly twice that size. In most cases, the increase in the number of employees actually complicates safety and controlling hazards.

Another measurement is experience modification rate (an insurance rating tool). Officials report that top management companies have a rate that ranges between 0.80 and 1.00. A company with the greatest success in minimizing the number of claims typically has the lowest rating; a company with a 1.00 rating has an average number of injury claims. Based on this rating system, LCM Real Estate is 15% better than the average company operating in the State of Georgia. The Wachovia representative states: "In summary, I can say they are safer than the majority of companies in this industry and definitely have a better recordable rate than the industry. It is clear that companies that focus on safety are going to be better than those not emphasizing safety on a regular basis" (E.D., personal communication, November 28 2006). LCM Real Estate is now averaging $3.27 per $1,000 of payroll as of March 2007, with an average claim cost of $3,625.00, as shown in Figure 1 (E.D, personal communication, February 15, 2006, July 12, 2007). The low claim rate in the period between March 2005 and March 2006 is a reflection of a reduced number of accidents, and lower number of serious injuries.

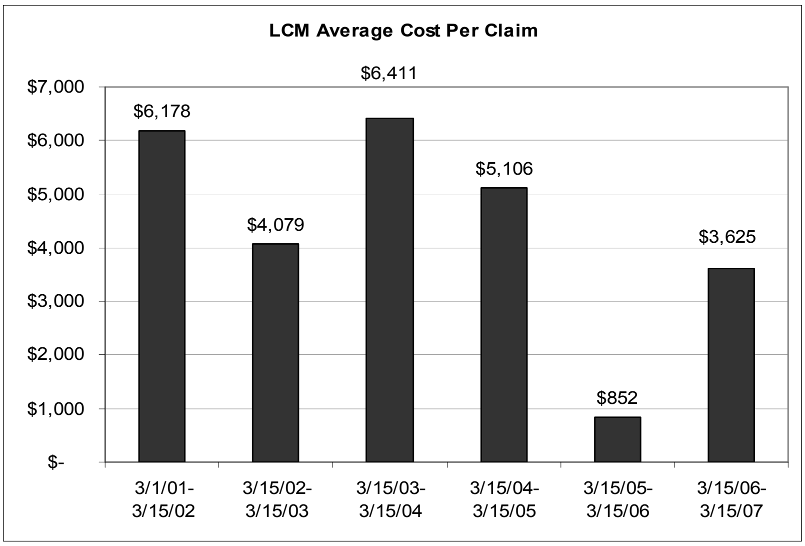


Figure 1: LCM Real Estate Average Cost Per Claim (LCM Real Estate, 2006)

Further, only 22 percent of report claims since March 2006 result in lost time from work. The reduced number of claims and reported absences represent a significant financial savings, as well as an improvement over the company's ability to successfully manage day-to-day operations, as shown in Figures 2 and 3 (LCM Real Estate, 2006).

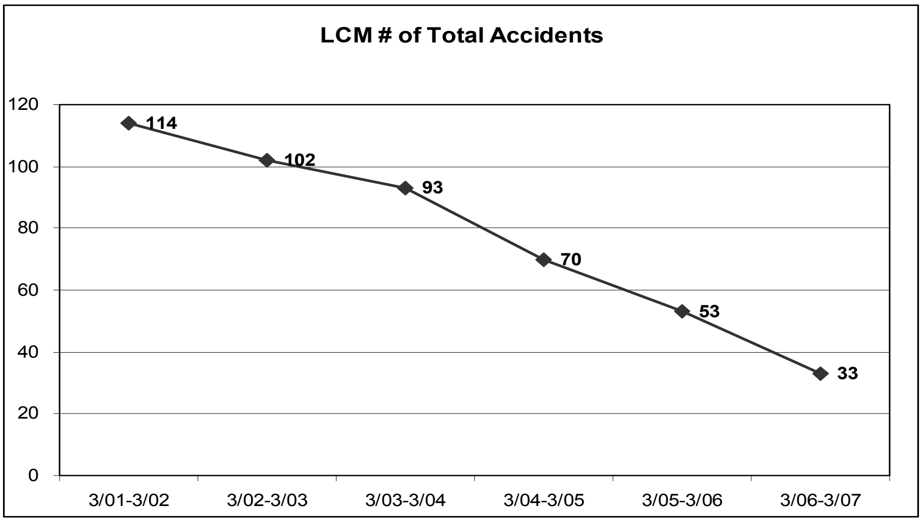


Figure 2: LCM Real Estate Total # of Accidents (LCM Real Estate, 2006)

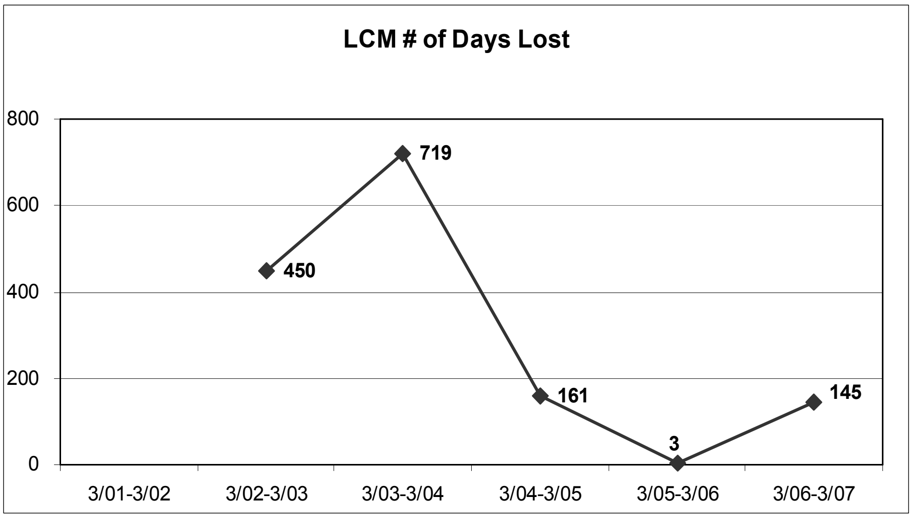


Figure 3: LCM Real Estate Total # of Days Lost (LCM Real Estate, 2006)

This dramatic reduction represents a significant improvement over national statistics on report claims. According to the 2005 National Multi Housing Council Survey, the national average cost per claim for similar properties is $4,293, as compared to LCM Real Estate's average claim of $3,391. Though the results are not achieved overnight, the company attributes their success to "everyone taking an active role and embracing a safety culture in each and every action."

CONCLUSIONS

Workplace accidents and injuries continue to create a financial burden for companies, both in direct and indirect costs. The paper presents a case study of one multi-family housing management company's efforts to successfully reduce the number and cost of employee injuries. These efforts require a paradigm shift in the company's attitude toward safety and its processes, beginning at the executive level. Through solicitation of employee input and development of innovative marketing, communication and education strategies, company executives are able to implement a strategic plan that emphasizes safety as a core value at the corporate level. The case study demonstrates that efforts to engage employees can result in a work environment in which there is a shared commitment and responsibility to safety, leading to positive financial outcomes.

The study concludes that, in order for these types of changes to occur in other organizations, it is necessary to take into account the organization's culture, as well as the systems and processes that are currently in place. Although there are numerous studies on ways to improve workplace safety, there is limited research that focuses specifically on the multi-family housing industry. In the past, the multi-family industry has been extremely focused on revenue maximization and value enhancement. Until recently, issues such as talent management and increased operating costs (payroll, worker's compensation insurance) have forced owners and operators to explore practices that extend beyond the traditional models. Corporate culture, leadership styles, team dynamics and individual employee behavior will become more closely scrutinized as organizations create their own safety climate.

Further research and development must be undertaken in the areas of training and development of safety programs that are effective in a high-turnover environment. In addition, further research is needed to understand the root causes of accidents and the level of engagement that is required to provide a safer work environment, particularly over time, rather than the immediate reductions following changes in safety procedures. While positive team dynamics can increase employee engagement, further study is needed on the extent to which each member assumes responsibility for working safer and takes an active role in accident prevention.

REFERENCES

Ayers, P.A. & Kleiner, B.H (2000) New developments concerning managing human factors for safety. Management Research News, (7/8), 18-23.

Barling, J. & Frone, M.R (Eds.) (2004) The psychology of workplace safety. Washington, D.C.: American Psychological Association.

Blumberg, K (2006) Reducing employee absenteeism – It's more than a matter of time. SPHR, Compliance Officer, IEC Group.

Bureau of Labor Statistics (2006) "Nonfatal occupational injuries and illnesses requiring days away from work, 2005", available at: http://www.bls.gov/news.release/osh2.nr0.htm

CCH, Inc. (2005) "Costly problem of unscheduled absenteeism continues to perplex employers", available at: http://hr.cch.com/press/releases/absenteeism/default.asp

CEL & Associates, Inc. (2006) "Where's the talent?", available at: http://www.apartmentprofessional.com/print/php?AID=21

Erickson, J (2000) Corporate culture: The key to safety performance. Occupational Hazards, 62, (4), 45-50.

Hansen, L (2000) The architecture of safety excellence. Professional Safety, May, 45, (5), 26-29.

Hansen, L. (2006) What safety excellence managers do. Occupational Hazards, May, 38-44.

Harter, J.K., Schmidt, F.L., & Keyes, C.L (2002) Well-being in the workplace and its relationship to business outcomes: A review of the Gallup studies. In C.L. Keyes & J. Haidt (Eds.), Flourishing: The Positive Person and the Good Life. Washington, D.C: American Psychological Association, 205-224.

Hoffman, D.A., Morgenson, F.P. & Gerras, S.J (2003) Climate as a moderator of the relationship between LMX and content specific citizenship behavior: Safety climate as an exemplar. Journal of Applied Psychology, 88, 170-178.

Hofmann, D.A., & Stetzer, A (1996) A cross-level investigation of factors influencing unsafe behaviors and accidents. Personnel Psychology, 49, 307-339.

Kincaid, W.H. (1996) Safety in the high-turnover environment. Occupational Health and Safety, August, 65, 22, 24-25.

Komaki, J.L., Zlotnick, S., & Jensen, M (1986) Development of an operant based taxonomy and observational index of supervisory behavior. Journal of Applied Psychology, 71, 260-269.

LaBar (1996) Can ergonomics cure "human error"? Occupational Hazards, 58, (4), 48-51.

LCM Real Estate (2006) Data on workplace accidents.

Liberty Mutual (2003) "Businesses pay $1 billion per week for workplace injuries: New study reveals financial burden of workplace", available at http://www.eh.doe.gov/

Liberty Mutual (2006) "American workplace changes, but top reasons for injuries don't", available at http://www.libertmutual.com

Mitchell, R (2001) Employers taking steps to reduce costs of absenteeism. National Underwriter, 105, (15), 57.

National Multi Housing Council (2004) "American community survey", available at http://nmhc.org

Neal & Griffin (2006) Safety climate and safety at work. In Psychology of Workplace Safety (Eds. Barling, J. & Frone, M.R.). Washington, D.C.: American Psychological Association, 17-34.

Senge, P.M. (1990) The fifth discipline: The art & practice of the learning organization. Doubleday: New York, N.Y.

Sheehan, R.J., & Freeman, R (2006) National Apartment Association 2006 income and expense survey. Alexandria, VA: National Apartment Association.

Sheehan, R.J., Freeman, R., Culkin, O.S., & Vassallo, B.A. (2005) National Apartment Association 2005 income and expense survey. Alexandria, VA: National Apartment Association.

Tomàs, J.M., Melià, J.L. & Oliver, A (1999) A cross-validation of a structural equation model of accidents: Organizational and psychological variables as predictors of work safety. Work & Stress, 13, 49-58.

Wagner, R & Harter, J(2006) The 12 elements of great managing. Princeton, NJ: Gallup Press.

Zohar, D (2000a) A group-level model of safety climate: Test the effects of group climate on microaccidents in manufacturing jobs. Journal of Applied Psychology, August, 85, 587-596.

Zohar, D. (2000b) Safety climate and leadership factors as predictors of injury records in work groups. (Paper presented at the Academy of Management Meeting, Toronto, August).

TRAINING FOR PERFORMANCE IMPROVEMENT IN CONSTRUCTION SECTOR IN TURKEY

Sema Ergonul
Mimar Sinan Fine Arts University, Istanbul, Turkey
ergonul@msgsu.edu.tr

Organisations learn in order to increase their capacity to produce required results. Training is widely accepted by companies as a learning tool for the reasons of improving employee morale, the complexity of the work environment, the rapid pace of organisational and technological change, and the growing number of jobs in fields that constantly generate new knowledge. The importance of training cannot be ignored in construction industry, which is large and diverse. This paper investigates the approach of Turkish construction companies to training, as a part of organizational learning, provided for their technical and administrative staff. A questionnaire is conducted and the results show that 66.67 percent of the companies provide training programs and also they agree on the satisfying outcomes of training in performance improvement. There is a significant relation between training and ISO 9001 quality assurance system certification.

KEYWORDS: construction industry, performance improvement, organizational learning, training

INTRODUCTION

Organizations are where people continually expand their capacity to create the results they truly desire, where new and expansive patterns of thinking are nurtured, where collective aspiration is set free, and where people are continually learning to learn together (Senge, 1990). As stated by Balasubramanian (2005), organizational learning is increasingly becoming popular among organizations which are interested in increasing competitive advantage, innovativeness and effectiveness. Dodgson (1993) describes organizational learning as “the way firms build, supplement and organize knowledge and routines around their activities and within their cultures and adapt and develop organizational efficiency by improving the use of the broad skills of their workforces. McChristy (2002) says that creating a learning environment in the workplace is not only vital to keeping employees up to date on rapidly changing technology, but can also help to bring revenues to the company.

Motwani (2001) feels that implementing Total Quality Management (TQM) is a major change that requires a transformation in the culture, process, strategic priorities, beliefs, etc. of an organization. Ideas of continuous learning allied to concepts such as empowerment and partnership, which are facets of TQM, also imply that a change in behaviour and culture is required if construction firms are to become learning organizations (Love et al, 2000). The process of organizational learning as part of organization’s core competence is the essence of all continuous improvement schemes. As such, construction organizations must recognize the need to improve their organizational learning capability in order to meet the ever-increasing challenges of the evolving business environment. This is one of the reasons why organizational learning has become an important feature of performance improvement (Kululanga et al, 2002).

Learning is a dynamic concept and it emphasizes the continually changing nature of organizations. The focus is gradually shifting from individual learning to organizational learning. Just as learning is essential for the growth of individuals, it is equally important for organizations. Since the individuals form the bulk of the organization, they must establish the necessary forms and processes to enable organizational learning in order to facilitate change. Organizational learning is more than the sum of the parts of individual learning (Dodgson 1993, Fiol and Lyless 1985). According to Weick (1991), "a more radical approach would take the position that individual learning occurs when people give a different response to the same stimulus but organizational learning occurs when groups of people give the same response to different stimuli.

Locke and Jain (1995) also reveals that all learning is individual learning, and there is no such thing as organizational learning except metaphorically. All learning takes place inside human heads and an organization can learn only by learning from its members or by ingesting new members who have new knowledge that the organization did not already possess. Gephart et al says that (1996) learning is more then the sum of employees mental capacity and ability to learn. It occurs when organizations merge and then institutionalise employee's intellectual capital and learning that are stored in their memories and their core competencies. Chan et al (2005) state that the development of individual skills and competencies exemplifies a core learning benefit. Kululanga et al (2002) establish that the majority of construction contractors focused their learning on continuous learning by individual employees. Lipshitz et al (2002) posits that learning by organizations occurs when individual learning occurs within the context of organizational learning mechanism that ensure that people get the information they need and that the products of their reflections are stored and disseminated throughout an organization.

A learning organization is not about 'more training', while training does help develop certain types of skill, a learning organization involves the development of higher levels of knowledge and skill (Senge, 1990). Training does not disappear in a learning organization; it becomes one of several modes of learning. Training is a tool for learning; learning and, ultimately, performance are the desired outcomes of training (Anonymous, 1996). The purpose of training in the modern dynamic business environment is to bring about a learning culture within an organisation – a systematic learning environment where knowledge is captured and transferred for the benefit of an organisation, its employees, its customers and other stakeholders (Loosemore et al, 2003). Beardwell and Holden's (1997) reasons for investing in training and development point to a close relationship between employee training and wider development activities. In effect, training programs offer a vehicle for individual and organisational learning. Managed effectively, they should create and maintain a healthy, motivated and adaptable core workforce that can respond to a changing demand of the modern business environment.

Many organisations are searching for effective ways to improve and maximise their performance. During the past several years there has been a global trend in business and industry to move from training to performance improvement. That points out the importance of how effectively a training program is accomplished. Instead of dealing with program results such as increased skill, increased knowledge and increased awareness, the concern on business result such as improved work performance, improved quality of service, increased revenue, reduced cost of sales has become more important.

In recent years, construction sector in Turkey has started to grow rapidly both in Turkey and abroad. This growth leads to the competition between companies and they are to strengthen their competency to stand in the sector. The company's main concern becomes increasing performance effectiveness, in other words, increasing the quality and standard while decreasing the costs. Construction companies in Turkey have recently given importance to individual learning as a initial part of organisational learning. They adopt training as a method of individual learning and they develop training programs for their employees to gain required skill at job in order to increase performance of their organizations. The aim of this study is to analyse the approach of Turkish construction companies to training as individual learning and also to find out if there is any relation between ISO 9001 Quality Assurance System Certification and training.

Methodology of Study

The study was conducted between January 2004 and May 2004. A structured questionnaire was designed to get information about training provided by construction companies in Turkey for their technical and administrative staff. Data were analysed using Stata Statistical Software, version 8.0 (Stata Corporation Texas, USA). Proportion comparisons for categorical variables were done using chi-square tests, although Fisher's exact test was used when data were scarce. Test results smaller than 0.05 was set as significant for 95 per cent significance.

According to the research carried out by DIE (2006) in Turkey there are 13,129 construction companies with a total staff of 222,111. The size of companies and their employment is presented in Table 1. Turkish Contractors Association represents main companies in Turkish construction sector. These companies have a volume of work which covers 70 percent of projects realized in Turkey and 90 percent of projects realized abroad. The companies of Turkish contractors association have realized almost 4300 projects in 69 countries since the beginning of 1970's and their total worth is more than US$ 105 billion (TMB, 2006).

Table 1: Size of Turkish Construction Companies

Size of Companies (Number of Employees)	Number of Companies	Percentage Number of Companies	Total Number of Employees	Percentage Number of Employees
0-9	11,830	71.3	35,319	15.6
10-19	2,183	13.2	30,917	13.7
20-99	2,284	13.8	89,062	39.4
100-199	229	1.4	31,746	14.1
200-499	37	0.2	12,181	5.4
500+	20	0.1	26,553	11.8
TOPLAM	16,583	100	225,778	100

The study covers the companies of Turkish Contractors Association. Each company has carried out at least US$ 100 trillion amount of work at home and US$ 150 trillion abroad in construction for last 10 years. Questionnaires were sent out to general directors of 142 construction companies.

The questionnaire includes three parts. The first part inquires about general profile of companies and whether training programs have been conducted. The second part inquires about the requirement of training programs, by whom and to whom these programs are addressed and also performance measurement of training programs. Part three is for respondents that do not conduct training programs and inquires the reason for that.

Results

Out of the 142 questionnaires mailed, 51 were returned, giving a response rate of 35.92%. The response rate could be attributed to two main reasons:

1- Training is not widely practised in construction companies.
2- Participants are unwilling to share their experiences with others.

General profile of companies

Table 2 presents the type of projects that respondents undertaken to construct. The survey results show that 66.67 percent of the respondents undertake industrial and public structures and 64.71 percent undertake heavy engineering structures. Airports, seaports, refineries and soil improvements are some of the other projects that companies carry out.

In the inquiry of the location of the projects, 64.71 percent of the respondents undertake projects both at home and abroad while 29.41 only at home. In order to analyse the size of the construction companies in relation with the number of their staff, 62.75 percent of the companies have less than 250 technicians and qualified workers and 70.59 percent have less than 75 technical and administrative staff. The results also show that 50.98 percent have 4-10 construction sites at the same time, 27.45 percent have 10-25 and 21.57 percent less than 4 construction sites.

This study is focused on the training of technical and administrative staff of construction companies rather than workers on site since they are expected to be effective on company's performance (quality, time and cost). The answers to the questionnaire indicated that 66.67 percent of the respondents conduct training programs for their technical and administrative staff. In addition, 74.51 percent of the respondents have ISO 9001 quality assurance system certification.

Companies conducting training programs

As mentioned above survey results show that 66.67 percent of the respondents conduct training programs for their technical and administrative staff. Within these respondents, 88.24 percent have ISO 9001 quality assurance system certification. Time period that respondents have provided training programs varies between 1 month and 372 months. However, 21.74 percent of the respondents provide training programs for 24 months, while 17.39 percent 60 months and 13.04 percent 48 months. 67.65 percent of the respondents have human resources management department in their companies and 61.76 percent use a method to measure their company's performance. Table 3 shows that in the construction companies training is mainly given by experienced staff in the company and by specialists. Training programs are for new employees and technical line-staff. Technical development is the main consideration in providing training programs. Performance of the trained staff is the main criteria to assess the performance of the training. Increase in performance is measured by the client satisfaction and increase in the volume of work.

Table 2: Project Types undertaken by Respondents

Types of Projects	Respondents, %
Houses	62.70
Industrial Structures	66.67
Offices and Shopping Centres	60.78
Public Buildings such as schools and hospitals	66.67
Cultural and Art Buildings	33.33
Sport Buildings	33.33
Heavy Engineering Structures such as dam, bridge motorway and highway	64.71
Infrastructure and landscaping	62.75
Installation	15.69
Others (Tourism Buildings, Hotels, Natural Gas Pipe Lines, Ports)	23.53

Companies not conducting training programs

The answers to the questionnaires indicated that 33.33 percent of the respondents do not conduct training programs for their technical and administrative staff. 94.12 percent of them believe in the necessity of training programs in performance improvement of both staff and company. 88.24 percent don't give any reason for not conducting training programs. The rest think that conducting training programs are costly and the staff attending these programs is looking for any other job. However, 93.75 percent are willing to conduct training programs in near future.

Analysis

The results of the questionnaires show that there is a significant relation between training and ISO 9001 quality assurance system certification. As shown in Table 4, 58.82 percent of the respondents, which provide training programs, have ISO 9001 certification. It could be because of that, companies conduct training programs as a part of quality management system in order to contribute to business success by improving efficiency, reducing cost etc. Another relation is between training and the number of technical and administrative staff in companies. Table 5 shows that having technical and administrative staff between 25 and 75 provides 25.49 percent of companies conducting training programs. Statistical results provided by DIE (2006) also show that the total number of employees in Turkish construction companies has the highest value within this range.

There is also a direct relation between training and the number of construction site. As seen in Table 6, with a 0.006 significant, 25.49 percent of the companies that conduct training programs have 10 to 25 construction sites at the same time. 47.06 percent of the respondents conducting training have undertaken projects at home and abroad (Table 7). This could be because that the companies carrying out international projects attach more importance to the training of their employees.

Table 3: Training conducted by respondents

Questions about training	Respondents, %
Who gives training?	
Experienced staff in the company	79.41
Chambers of professions	26.47
Specialists	76.47
Universities	20.59
To whom training is given?	
New employees	70.59
Staff at management level	58.82
Technical line-staff	70.59
Others (all staff)	11.76
For what reason training is conducted?	
Lack of knowledge	50.00
Lack of experience	47.06
Technological development	82.35
Others (about company procedures and occupational safety & health)	17.65
How do you assess the performance of training?	
Performance of the staff attending training	73.53
Satisfaction of staff attending training	26.47
Successful completion of the training program	17.65
General performance of the company	50.00
Do you think that training increase your company's performance?	100
How do you assess the increase in performance?	
Reduction in cost	44.12
Increase in the volume of work	58.82
Satisfaction of client	58.82
Others (satisfaction of employees and gaining speed in job duration)	8.82
Who demands training?	
Company's management	88.24
Employees	61.76
Trade Unions	0

Table 4: Relation between Training and ISO 9001 certification

ISO 9001 certification	Training		Chi-square
	Conducted	not conducted	
Available	58.82	15.69	0.001
Not available	7.85	17.64	

Table 5: Relation between Training and Number of Technical and Administrative Staff

Number of technical and administrative staff	Training		Chi-square
	Conducted	Not conducted	
<10	3.92	5.88	
10-25	11.76	9.80	
25-75	25.49	13.72	0.253
75-200	5.88	0.00	
>200	19.61	3.92	

Table 6: Relation between Training and Construction Sites

Construction Site	Training		Chi-square
	Conducted	not conducted	
<4	17.65	3.92	
4-10	23.53	27.45	0.006
10-25	25.49	1.96	

Table 7: Relation between Training and Location

Location	Training		Chi-square
	Conducted	not conducted	
Home	19.61	9.80	
Abroad	0	5.88	0.038
Home and Abroad	47.06	17.65	

CONCLUSIONS

Learning organisations requires a change in behaviour and culture. If companies are to become learning organisations they must learn to be able to respond to changes in environment. Learning occurs through individuals and training has recently become a management tool in order to improve the performance of an organization. It may be highly effective if it is designed and conducted in relation to the organisational objectives and if the effect of training on job performance after a worker has completed training and returned to work is measured properly.

This study is carried out to investigate the current approach of Turkish construction companies to training as individual learning. The results of questionnaires show that the companies within the framework of this study emphasise the importance of training as it increases the performance by satisfying client, decreasing cost and increasing the volume of work. Technological development seems to be the main reason to provide training for technical and administrative staff. There is a significant relation between ISO 9001 and training, i.e. companies holding ISO 9001 quality assurance system certification are more sensitive to conduct training programs than others. Respondents agree that training provides a decrease in cost and increases the volume of work. However, performance measurement remains at individual level rather than overall company.

REFERENCES

Anonymous (1996) Training and trainers in learning organization. Training & Development. Alexandria. 50 (12), 43-45.

Balasubramain, V. (2006) Organizational learning and information systems. Training and Staff Development (http://www.e-papyrus.com/personal/orglrn.html).

Beardwell, I. and Holden, L. (1997) Human resource management: A contemporary perspective, Pitman Publishing, London.

Chan, P., Cooper, R. and Tzortzopoulos, P. (2005) Organizational learning: conceptual challenges from a project perspective. Construction Management and Economics. 23, 747-756.

DIE (2006) State Institute of Statistics. Construction Statistics, http://www.die.gov.tr/statistics.

Dodgson, M. (1993) Organizational learning: a review of some literatures. Organization Studies, 14(3), 375-394.

Fiol, C.M. and Lyless, M. (1985) Organizational learning. Academy of Management Review.19(4), 803-813.

Gephart, M.A., Marsick, V.J., Van Buren, M.E. and Spiro, M.S. (1996) Learning organizations come alive. Training and Development. 50(12), 35-45.

Kululanga, G. K., Price, A.D.F. and McCaffer, R. (2002) Empirical investigation of construction contractors' organizational learning. Journal of Construction Engineering and Managemen. 128(5), 385-391.

Lipshitz, R., Popper, M. and Friedman, V.J. (2002) A multifacet model of organizational learning. Journal of Applied Behavioural Science. 38(1), 78-98.

Locke, E.A. and Jain, V.K. (1995) Organizational learning and continuous improvement. International Journal of Organizational Analysis. 3, 45-68.

Loosemore, M., Dainty, A. and Lingard, H. (2003) Human resource management in construction projects: strategy and operational approaches, London.

Love et al (2000) Love, P.E.D., Li, H, Irani, Z, Faniran, O.O (2000) Total quality management and the learning organization – a dialogue for change in construction, Construction Management and Economics, 18(3),321-3.

McChristy, N. (2002) Creating a learning organization. Office Solutions. Mt. Airy. 19(2), 26-29.

Motwani, J. (2001) Critical factors and performance measures of total quality management. The TQM Magazine. 13(4), 292-300.

Senge, P.M. (1990) The fifth discipline: the art and practice of learning organization, Doubleday Dell, New York.

Weick, K.E. (1991) The non-traditional quality of organizational learning. Organization Science. 2(1), 116-124.

TMB (2006) Turkish Contractors Association, http://www.tmb.org.tr

sASSESSMENT OF PROJECT VULNERABILITY AS A PART OF RISK MANAGEMENT IN CONSTRUCTION

Irem Dikmen
Middle East Technical University, Civil Engineering Department, Turkey
idikmen@metu.edu.tr

M. Talat Birgonul
Middle East Technical University, Civil Engineering Department, Turkey
birgonul@metu.edu.tr

Gulsah Fidan
Middle East Technical University, Civil Engineering Department, Turkey
gulsahf@gmail.com

The main purpose of risk management is to identify risks, quantify their impacts and develop strategies to mitigate them to succeed in project objectives. Project risk assessment is usually about quantification of the statistical link between the risk events and their consequences. However, this approach has a limitation as the influence of the "system" is neglected during modeling the relation between risk sources and consequences. The word "vulnerability" is used to describe internal characteristics of a system which influence this relationship. In this study, it is proposed that risk management should cover assessment of project vulnerabilities as well as risk factors. A case based methodology is used to investigate the relationships between risk events, project vulnerabilities and project performance. By referring to two international construction projects, the impact of project vulnerability on performance is demonstrated and a list of factors that can be used for vulnerability assessment is presented. Case study findings point out that an integrated structure that takes into account of cause-effect relations between risk and vulnerability factors must be developed and an integrated procedure should be used for risk and vulnerability assessment rather than individual risk and vulnerability ratings.

KEYWORDS: Risk, vulnerability, international construction.

INTRODUCTION

Risk is the probability of occurrence of a risk event, which triggers undesirable outcomes. Magnitude of risk depends on its probability and potential consequences (Brooks, 2003). Risk management process mainly comprises of identification of risk events, assessment of their influence on project outcomes and developing response strategies to mitigate them. Within this process, the consequences are determined only by considering likelihood of risk events. However, as emphasized by Zhang (2007), giving more importance to the statistical link between risk events and risk consequences neglects the effect of project system on the process.

The rules, structures, actions, behaviors, cultures within the project system have influence on the risk process. Barber (2005) considers these types of risks as internally generated and mentions the fact that imperfect organizations or systems generate new risks. Dikmen et al. (2007) describe the factors that determine the relationship between risk source and consequence as factors about manageability. In this paper, the term "vulnerability" will be used to characterize the influence of project system on risk consequences as suggested by Zhang (2007) and Lewis (1999). The traditional risk management process should be enhanced to cover vulnerability management, which deals with the fragility of a system to probable risk events.

VULNERABILITY AND RISK

Crichton (1999) defines risk as the probability of a loss, which depends on three elements: hazard, vulnerability and exposure. Changing any one of these three elements changes the risk consequence. According to Agarwal and Blockley (2007), risk is the production of hazard and vulnerability. To illustrate, hazard is the earthquake, exposure is the facility on earthquake zone and vulnerability changes due to the design, construction and maintenance of the facility. It is clear that the combination of a hazard with a vulnerable system results in disasters.

The term "vulnerability" is used to explain inborn characteristics of a system. Project vulnerabilities create the potential for harm but are independent from the probability of occurrence of a risk event (Sarewitz et al., 2003). Vulnerability indicates the degree to which a project is susceptible to adverse effects of change (Brooks, 2003). It exists within systems independently of external hazards and depends on organization's capability to manage risks, and can be internally created by organizational, social and economic factors.

The social, political and economic conditions of nations, regions and systems have been investigated considering the concept of vulnerability. Focusing on different types of risks and their outcomes leads to the emergence of different definitions of vulnerability (Alwang et al., 2002). Table 1 presents some of the different definitions of vulnerability within the literature.

Table 1: Definitions of Vulnerability in the Literature

Author(s)	**Definitions**
Agarwal and Blockley (2007)	**"Vulnerability is a particular form of hazard- a hazard which is internal to the system."**
Allen (2003)	**Vulnerability refers to "the set of socio-economic factors that determine people's ability to cope with stress or change."**
Blaikie et al. (1994)	**Vulnerability is "the combination of characteristics of a person or group in terms of their capacity to anticipate, cope with, resist, and recover from hazard impacts that threaten their life, well-being and livelihood."**
Buchanan (1991)	**"Vulnerability refers to the scale and complexity of the problems facing the project manager, the degree of uncertainty and risk involved, and to the anticipated degree of contention and resistance which the change is likely to generate."**

Buckle et al. (2001)	**“Vulnerability is a measure of the exposure of a person to a hazard and indicates the type and severity of the damage that is possible.”**

Table 1: Vulnerability Definitions in the Literature (continued)

Author(s)	**Definitions**
Council for International Organizations of Medical Sciences cited in Levine (2004)	**“Vulnerable persons are those who are relatively or (absolutely) incapable of protecting their own interests because they may have insufficient power, intelligence, education, resources, strength, or other needed attributes”.**
Nicholls et al. (1999)	**“The likelihood of occurrence and impacts of weather and climate related events.”**
Oksuz (2003)	**Vulnerability assessment is for the prediction and identification of the seismic performance and safety level of the building, which might be exposed to severe damage during an expected earthquake.**
Winslow (1998) cited in Levine (2004)	**Vulnerable populations are the “social groups who experience limited resources and consequent high relative risk of morbidity and premature mortality.”**
Zhang (2007)	**“A system’s vulnerability represents the extent or the capacity of this system to respond to or cope with a risk event.”**

Vulnerability is often confused with risk (Ezell, 2007). However, vulnerability concept has several distinctions from risk and management of vulnerability is based on a different perspective than the traditional risk management. Vulnerability is the concept of being susceptible to a risky situation, whereas risk is used for defining the severity of consequences within a scenario. While risk management is applied to estimate the likelihood and consequences of risks, vulnerability management is used to define the characteristics of a system that will change the possibility for harm. (Ezell, 2007; Brooks, 2003; Adger, 1999). Project vulnerabilities exist before the occurrence of risk events (Zhang, 2007), but they will not become significant until the risk event occurs. For instance, the existence of an escalation clause will not become momentous until there is a change in inflation. Reducing vulnerability is an important way of managing risk, but any reduction in the impact of a risk is not related with reducing the vulnerability of system (Agarwal and Blockley, 2007; Sarewitz et al., 2003). For example, theft of materials at site will cause both time and money loss. Insurance, as a risk response strategy, will prevent cost overrun. However, insurance will not change the vulnerability of system. Vulnerability can only be reduced by improving site conditions, such as building secure storages at site. A vulnerability parameter cannot generate a risk consequence without a risk event; however, a risk event may lead to a risk consequence on its own (Zhang, 2007). Vulnerability is the condition or inherent characteristic of a system, which influences the amount of damage. For example, project size will not cause any risk. However, in case of any change in quality of a material, project size will change the degree of cost overrun.

If a system has enough strength to handle a risk (low vulnerability), the occurrence of risk may not cause any deviation from pre-defined objectives. As Buckle et al. (2001) mentioned, “the higher the resistance, the less likely damage may be, and the faster and more effective recovery is likely to be. Conversely, the higher the vulnerability, the more exposure there is to loss and damage." This reveals out that vulnerability is not related with the probability and severity of the risk event. Vulnerability is a function of internal properties of a system. In spite of not being a function of severity and probability of occurrence of a risk event, some characteristics of a system will make it more vulnerable to certain risks (Brooks, 2003). For example, if the project's construction technology is complex and if the company does not have enough experience than the risk of project failure will be high.

Determination of vulnerabilities and managing them is important for increasing the capability to deal with risks and improving adaptation capabilities (Prowse, 2003). Through vulnerability management, the weakness of a project system can be identified and the project may be adapted to probable risks to minimize their impact on project outcomes.

According to Brooks (2003), "adaptation is the adjustments in a system's characteristics that improve its ability to cope with risks and adaptive capacity of a system is the ability of a system to modify or change its characteristics so as to cope better with existing external stresses." Vulnerability will be reduced through adaptation. For example, if a company is not familiar with the construction technology used in the project, then an experienced partner may be found to perform the construction. Then the company may reduce the vulnerability generated from the lack of experience and decrease the probability of project failure.

Managing vulnerability shows the ways of limiting uncertainty through achieving enough capacity to deal with risk and vulnerability (Prowse, 2003). Effective planning for risk consequences requires that the vulnerability associated with specific processes be understood in parallel with understandings of probabilities of risk, so that decisions can be taken by achieving the appropriate balance between risk and vulnerability management (Sarewitz et al., 2003). Integrated vulnerability management into risk management process may help companies to better understand threats, determine acceptable levels of risk, and take action to mitigate identified vulnerabilities.

In this paper, it is suggested that the level of vulnerability should be assessed so that it can effectively be managed. Thus, a framework that consists of vulnerability parameters applicable to construction business should be developed.

Vulnerability Parameters

As Twigg (2001) mentioned, in order to understand the factors that increase a system's vulnerability, one should diverge from the risk event itself and consider a set of influences. For international construction projects the factors related with the contract, company, project and project participants come together to create the influencing factors. Table 2 summarizes the vulnerability factors, which were identified as a part of this study.

According to Katz (2004), "the contract is the contractor's first line of defense in dealing with risks", because responsibility and risk allocation between project parties are defined through contractual clauses. Ineffective risk sharing or the misunderstanding of risk distribution between project parties generally leads to a dispute after the occurrence of a risk event (Hartman and Snelgrove, 1996). Unfair or poorly defined contract clauses may lead severe risk consequences. Table 2 shows the most significant contract clauses that will make the projects more or less vulnerable to risk events.

Project characteristics basically include project requirements, restrictions, standards, project size, duration, site and country conditions (Table 2). Fan et al. (2008) mention that project characteristics could change the impact of risk event by affecting the risk handling strategy. As discussed by Han et al. (2007), many risks of international construction projects are closely related with fairness of construction laws and regulations of host country, local material supplies, the cultural issues and the attitude of government.

Table 2: Vulnerability Parameters

Category	Sub-category	Factors
Contract	Clauses	Rights and obligation of parties, payment method, escalation, taxation, warranty, default of owner, force majeure, cost compensation, time extension, liquidated damages, change orders, variation of work, valuation of variations, disputes, codes and standards, etc.
Project	Project-requirements	Technical, technological, managerial, quality, health and safety, environmental impact
	Project-conditions	Design maturity, constructability, geotechnical conditions, location, site conditions, contract clarity, scope clarity, size, duration, payment type, project delivery system
	Country-market conditions	Labor, material, equipment, local supplier, local subcontractor, infrastructure
	Country-requirements	Import-export rules, customs procedures, social security law, requirements from foreign firms
	Country-conditions	Political and economic stability, legal system maturity, socio-cultural differences, international relations, bureaucracy, significance of the project for the country, geography and climate conditions, government attitude toward foreign investors.
Company	Company-resources	Financial and technical resources, staff, managerial capability, experience, relations (with client,etc.)
	Company-conditions	Objectives, management capability (such as planning, organization, documentation, control and monitoring, leadership etc.), risk response strategy, workload, business style, management style, top management support, location of management (headquarter vs. regional branch)
Project parties	Client-resources	Financial strength, staff, experience
	Client-conditions	Significance of the project, clarity of objectives, management capability, risk response strategy, relations with contractor
	Other parties (Partner, designer, engineer, supplier etc.) -resources	Financial strength, experience, staff, cultural differences, Management capability, risk response strategy, relations with the client and government

Company characteristics such as project management system's maturity, project managers and team's abilities, experience and strength have also influence on the risk consequences.

Chan et al. (2004) mention that the project managers should be able to plan and execute their construction projects to maximize the project's chances of success. They should use management tools effectively, which include adequate communication, control mechanisms, feedback capabilities, monitoring, project organization structure, plan and schedule followed, etc.
Key project participants include client, partner, subcontractor, supplier, designer and engineer. As Chan et al. (2004) state, "a construction project requires team spirit; therefore team building is important among different parties." Thus, the abilities, workload, financial strength of each party and the relations between these parties will influence project outcomes.
Table 2 presents a set of factors and a categorical structure for vulnerability assessment. Although it is based on an extensive literature survey, it has to be validated by referring to real cases. In this paper, two interviews carried out to test the validity of vulnerability parameters are discussed.

CASE STUDIES

This research is built on cases to demonstrate the relationships between risk events, project vulnerabilities and project performance. The initial cases are chosen so that they are carried out in the same country and the projects are technically very similar. This enables the investigation of impacts of contract and country conditions as well as the parties involved in the project.

The Company that carried out both of the projects has been designing, manufacturing and undertaking the construction works of steel structures for energy and telecommunication industries since 1955. The Company employs around 1 000 personnel and exports to more than 100 countries in five continents. In 2007, the total sales of the Company were around 180 million USD and the Company exported nearly 70 000 metric tons of towers. The projects investigated for this research were technically very similar and performed in different regions of the same country in the same year.

Information about the projects was collected through interviews. Managers taking part in both of the projects were interviewed, each lasting for 1-1.5 hours. They were asked to give information about the project progress and their experiences. Project failures, their causes and actions taken were discussed. Some information about the projects and findings are as follows:

1. Project A – The Company was responsible for design and manufacturing of the steel structure for the energy transmission line constructed in the south region of the country. The construction phase of the project was under the responsibility of a local firm who is the JV Partner of the Company. As a part of their competitive strategy, the Company managers did not want to introduce an experienced firm to the Owner to sustain their competitive advantage in the market and therefore, they chose an inexperienced partner. However, because of the technical complexity, Partner could not complete the construction. The Company had to undertake the responsibility of the Partner and performed the construction themselves due to its significance for them. This caused several revisions in organizational structure of the Company and allocation of required resources to project took more time than expected and caused delays. In addition to technical issues, the quality requirements of the

project were also heavy. The chosen local suppliers and subcontractors were not capable enough to maintain these requirements. Low quality of materials resulted in repetitive tests and reworks. Heavy constraint in quality also required several suppliers from different countries, which made the communication and coordination a critical issue for the Company. In the south side of the country where the project was performed, there was a conflict between different ethnic groups. Because of the social instability, the Company faced with obstacles in finding personnel who is willing to work there. Finally, they had to employ a site manager who does not have enough experience in similar works. Site manager's insufficient technical competence resulted in a new crisis due to improper selection of suppliers. Project required a detailed geotechnical investigation, but at tendering stage, the Company made several assumptions about soil data instead of a detailed site survey. Being inexperienced in the region, not having a detailed geotechnical report and wrong quantity estimation at the tendering stage resulted in significant deviations from the initially assumed quantities regarding the pile foundations. Large-scale of the project and contract type (lump sum) influenced the severity of this event and resulted in severe financial losses. The company tried to overcome this issue by making a claim. However, the frequent change of project managers and team members slowed down the claim preparation progress. Complex managerial requirements of the project and unfamiliarity with contract requirements also caused some financial problems. According to the contract, progress payments were not made unless all the reporting was done according to the format defined in the contract. The owner assigned a consulting firm to examine the submitted documents to accelerate the approval process. The project was delivered with two months delay and with a lower profit than expected.

2. Project B – It has very similar technical characteristics with Project A. This time, the Company was responsible for design, manufacturing and construction. The Company did not have any partner. The Company had previously completed several projects for the same client and chose subcontractors and suppliers that they worked together before. The project manager, who was an expert in this type of projects, controlled the project at site, which eliminate the communication problems with parties and accelerate the approval process. The project was performed in the North side of the same country, where there was more stability in social life. The company performed several projects in this region and did not face with any unexpected conditions affecting the project execution. The managerial complexity of the project was lower when compared with Project A. Team turnover rate in the project was very low, and there were no changes in the organizational structure. The most critical issue was the consulting company who assigned only one engineer to the project. The engineer did not have enough technical capacity; therefore, he slowed down the process. The project was delivered on time and within budget.

It is clear that although the company is the same, different strategies were utilized in the projects. Different parties involved in the projects and contract clauses significantly affected the level of vulnerability. Some examples of project vulnerabilities identified through case studies are summarized in Table 3.

Table 3: Examples of Risks and Project Vulnerabilities from the Case Studies

Case	Risk Event	Project Vulnerability

Project A	Poor Performance of Partner	Partner could not fulfill his responsibilities because of his insufficient capacity and lack of enough experience.
Project B	-	The Company performed the project on his own. It had enough experience and resources to complete project successfully.
Project A	Poor competency of staff	Because of the social instability in South region, the Company could not find an experienced manager willing to work there and had to choose an inexperienced site manager.
Project B	-	In Northern side, there were not any security problems; so the Company could easily find a very qualified manager.
Project A	Delay in approvals	Project is directed from the headquarter; communication through e-mails on critical issues took much time.
Project B	-	Project was directed at site, there were not any communication problems. In addition since they worked together before, relations between parties were good.

Table 3: Examples of Risks and Project Vulnerabilities from the Case Studies (continued)

Case	Risk Event	Project Vulnerability
Project A	Delay in progress payments	Owner made payments when progress reports were completely submitted. Because of the unfamiliarity with this system, company could not submit the required documents on time.
Project B	-	The managerial requirements were very low. Submitting photos proofing the progress at site was enough for Owner.
Project A	Delay in logistics	Due to heavy quality requirements, several suppliers from different countries were selected which result in coordination problems.
Project B	-	The chosen suppliers were all in the host country, and the relations with suppliers were good.

It is clear from the case study projects that vulnerability factors may affect different stages of the risk emergence process. Some vulnerability parameters affect the probability of occurrence of risk. For example, in Project A, heavy technical requirements of the project caused an unexpected change in partner's performance, which is considered as a low probability risk at the first stages. Thus, "technical complexity" is a potential vulnerability factor that may increase the risk of poor performance. Another vulnerability factor mentioned in the case studies was "unfamiliarity with FIDIC type of contract" which resulted in "conflict between project participants". Some vulnerability factors may affect manageability of risk. For instance, in Project B, an experienced site manager controlled the project at site, which minimized delay risk for the company. Vulnerabilities may also influence the impact of risk events on project success. In other words, those are the factors, which affect the magnitude of risk consequences. For instance, wrong quantity estimation during tendering stage caused severe financial losses for company because the contract/payment type was lump sum.

CONCLUSION

In this paper, the concept of vulnerability as a part of risk assessment was introduced and factors that can be used for vulnerability assessment were presented. A hierarchical structure that comprises of factors related with the contract, company, project and parties involved in the project were developed. Validity of these factors was discussed by referring to findings of two case studies. The major conclusions derived as a result of case studies are as follows:

1. The vulnerability factors affect project success by interfering with the risk events in different ways. Some vulnerability parameters affect the probability of occurrence of risk, some of them affect manageability of risk and some vulnerability factors may influence the impact of risk events on project success.

2. Vulnerability should be assessed within the context of risk scenarios. Vulnerability assessment should be done simultaneously with risk assessment. Risks should be examined through paths (risk source- risk event- risk consequence paths) and vulnerabilities should be added to those paths for estimation of risk impacts on project success. A hierarchical vulnerability structure that excludes risk factors and a multi-criteria vulnerability assessment process that does not consider risk paths may give unreliable results if used for quantification of level of vulnerability in a project. Thus, an integrated risk-vulnerability assessment procedure has to be developed.

This paper presents the initial findings of an ongoing research. It is evident that only two case studies are not enough to understand the risk-vulnerability relations and validate the identified vulnerability factors. In the forthcoming stages of this research, more case studies will be carried out to finalize the vulnerability parameters and define generic risk-vulnerability paths that can be used for risk modeling of international construction projects.

ACKNOWLEDGEMENT

This paper presents the preliminary findings of a three year research project entitled "Development of a Multi-Agent System for Risk Management of International Construction Projects" sponsored by TUBITAK (Scientific and Technological Research Council) under the grant number 107M334.

REFERENCES

Adger, W. N. (1999) Social vulnerability to climate change and extremes in Coastal Vietnam. World Development, 27(2), 249–269.

Agarwal J., and Blockley D. I. (2007) Structural integrity: hazard, vulnerability and risk. International Journal of Materials and Structural Integrity, 1(1/2/3), 117–127.

Allen, K. (2003) Vulnerability reduction and the community-based approach. In Pelling (ed.), Natural Disasters and Development in a Globalising World, 170–184.

Alwang, J., Siegel, P. B., and Jorgensen, S. L. (2002) Vulnerability as viewed from different disciplines. International Symposium: Sustaining Food Security and Managing Natural Resources in Southeast Asia- Challenges for the 21st Century-, Thailand.

Barber, R. B. (2005) Understanding internally generated risks in projects. International Journal of Project Management, 23, 584–590.

Blaikie, P., Cannon, T., Davis, I., and Wisner, B. (1994) At risk: natural hazards, people's vulnerability, and disasters. London, UK: Routledge.

Brooks, N. (2003) Vulnerability, risk and adaptation: a conceptual framework. Tyndall Centre for Climate Change Research, Working Paper 38.

Buchanan, D. A. (1991) Vulnerability and agenda: context and process in project management. British Journal of Management, 2(3), 121-132.

Buckle, P., Marsh, G., and Smale, S. (2001), "Assessing resilience and vulnerability: principles, strategies & actions guidelines" available at: http://www.proventionconsortium.org/themes/default/pdfs/CRA/EMA2001meth.pdf
Chan, A. P. C., Scott, D., and Chan, A. P. L (2004) Factors affecting the success of a construction project. ASCE Journal of Construction Engineering and Management, 153-155.

Crichton, D. (1999) The risk triangle. In Ingleton, J.(ed.), Natural Disaster Management, Tudor Rose, 102-103.

Dikmen, I., Birgonul, M. T., Tah, J. H. M., and Aouad, G. (2007) A learning based approach for risk management. 1st Symposium on Towards the Foundation of Theory for the Built Environment, Salford, United Kingdom, 21-35.

Ezell, B. C. (2007) Infrastructure vulnerability assessment model (I-VAM). Risk Analysis, 27(3), 571-583.

Fan, M., Linb, N. P., and Sheu, C. (2008) Choosing a project risk-handling strategy: an analytical model. International Journal of Production Economics, 112, 700–713.

Han, S. H., Park S. H., Kim, D. Y., Kim, H., and Kang, Y. W. (2007) Causes of bad profit in overseas construction projects. ASCE Journal of Construction Engineering and Management, 932-943.

Hartman, F., and Snelgrove, P. (1996) Risk allocation in lump-sum contracts-concept of latent dispute. Journal of Construction Engineering and Management, 291-296.

Katz, G. (2004) Analyzing and avoiding contract risks. International Risk Management Institute, Workshop Q.

Levine, C. (2004) The concept of vulnerability in disaster research. Journal of Traumatic Stress, 17(5), 395–402.

Lewis, J. (1999) Development in disaster-prone places: studies of vulnerability. London: Intermediate Technology Publications.

Nicholls, R. J., Hoozemans, F. M. J., and Marchand, M. (1999) Increasing flood risk and wetland losses due to global sea-level rise: regional and global analyses. Global Environmental Change, 9, 69-87.

Oksuz, A. (2003) Software development for R/C building vulnerability index and member importance calculation. M.Sc. Thesis, Middle East Technical University, Ankara.

Prowse, M. (2003) Towards a clearer understanding of ‘vulnerability’ in relation to chronic poverty. CPRC Working Paper 24.

Sarewitz, D., Pielke, R., and Keykhah, M. (2003) Vulnerability and risk: some thoughts from a political and policy perspective. Risk Analysis, 23(4), 805-810.

Twigg, J. (2001) Sustainable livelihoods and vulnerability to disasters. Benfield Greig Hazard Research Centre, Disaster Management Working Paper 2.

Zhang, H. (2007) A redefinition of the project risk process: using vulnerability to open up the event-consequence link. International Journal of Project Management, 25, 694–701.

Key Performance Indicators (KPIs) and priority setting in using the multi- attribute approach for intelligent buildings (IBs)

H. AL WAER
The University of Dundee, School of Architecture
Matthew Building, 13 Perth Road, Dundee DD1 4HT, UK
Tel: +44(0) 1382348805, Fax: +44 (0) 1382203631, Email: h.alwaer@dundee.ac.uk

D.J. Clements-Croome
School of Construction Management & Engineering
The University of Reading, Whiteknights, PO Box 219, Reading RG6 6AW, UK
Email:d.j.clements-croome@reading.ac.uk

Abstract

The objectives of this paper are to identify key performance indicators (KPIs) for intelligent buildings (IBs) and model the building performance. The authors studied various types of building to develop key performance indicators (KPIs) that could be readily used by architects, clients, producers and end- users to better understand and promote value through design. The tool includes key elements covering Environmental, Socio-cultural and Economic sustainability issues. The value of intelligent buildings is assessed in relation to their design for different uses and their ability to meet a variety of needs including sustainability, whole life value, health and emotional needs of occupants and users. The process raises a lack of consensus on what constitutes a good design indicator for intelligent buildings due to the difficulties in the broad description and application of sustainability indicators.

Sustainability performance of intelligent buildings is not easy to measure particularly when trying to quantify qualitative data. This paper uses a consensus-based model (*Comprehensive Assessment System for Intelligent Buildings*- CASIB) which is analysed using the analytical hierarchical process (AHP) for multi-criteria decision-making. The use of the multi- attribute model for priority setting in sustainability assessment of intelligent buildings is introduced. Issues related to the proper use of the model, such as selection criteria, priority levels, hierarchy structure and allocation of weightings to these criteria are discussed. Other potential applications of the proposed model and methodology are discussed. It is argued that the benefit of the new proposed model (CASIBs) is a 'tool' for 'comparative' rather than an absolute measurement, because it has the potential to provide useful lessons from current sustainability assessment methods for strategic future of intelligent buildings in order to improve a building's performance and to deliver objective outcomes. It is concluded that the priority levels for selected criteria is largely dependent on the integrated design team which includes the client, architects, engineers and facilities manager.

Keywords: Key performance indicators (KPIs), intelligent buildings, sustainability assessment, priority levels, CASIBs.

Introduction

An intelligent building is understood as a complex system of inter-related three basic elements- ***People*** (owners; occupants, users, etc.); ***Products*** (materials; fabric; structure; facilities; equipments; services); and ***Processes*** (automation; control; systems; maintenance; performance evaluation) and the inter-relationships between them. These goals include the entire phases of a buildings life span, the environmentally friendly built environment with substantial safety, security, well-being and convenience, a lower life cycle cost and long term flexibility, controllability and marketability, leading to achieve a building that has the highest environmental, social and economic values (Chen, *et al* 2006, p. 394; Clements-Croome, 2004). The differing emphasis of these and other definitions communicates technological capacity, design value, and culturally perceived needs in the design of buildings. So, *et al*., (2001) suggest, "*intelligent buildings are not intelligent by themselves, but they can furnish the occupants with more intelligence and enable them to work more efficiently*". From the definitions, technological advanced was not considered as the main driver in the system selection. This finding reinforced the argument by Clements-Croome that a true intelligent building is not a building with purely advanced technologies; instead it should be one of high values. Thus, intelligent buildings should be sustainable, healthy, and technologically aware, meeting the needs of the occupants and business, and should be flexible and adaptable to deal with change.

When aiming to reduce environmental impacts, a yardstick for measuring environmental performance was needed (Crawley and Aho, 1999). The term" *Building Performance*" is complex, since different criteria in the building sector have differing interests and requirements (Cole, 1998). A problem has emerged associated with the scope to find objective or universal quality standards. The issue here is the lack of consensus on what constitutes excellence in building assessment performance, covering the overlapping dimensions of social, economic, environment and technological factors. Thus, sustainable assessment methods have emerged in recent years as a means to evaluate the performance of buildings across a broad range of sustainable considerations. The importance of such methods can be regarded firstly in terms of helping architects, engineers, planners and decision makers in what is defined as the principles of "*Selective Sustainable Design*" (Hawkes et al., 2001) in which there is a strong relationship between *climate*, *comfort* and *Technology*. These issues are leading to pressures on industry to demonstrate how well (or how poorly) they are currently performing vis-à-vis "sustainability." In addition, the construction industry, are being confronted with a new set of regulatory practices and priorities, largely generated by the push for sustainability. However, the success of intelligent building is measured, in part, by how well it supports the management at these issues at all stages of its existence, from the inception of the design process to the recycling of its materials at the end of its useful life (Kroner, 1997, p. 387). Thus, a wide range of existing issues are available in terms of intelligent buildings, and can be used for the aim of developing a new model called Comprehensive Assessment System for Intelligent Buildings analysed using analytical hierarchical process (AHP) for multi-criteria decision-making, in which "*multiple methods*" that involve quantitative and qualitative approaches are employed (Lee, et al, 2006, p.1832). The main objective of the new model in this paper is to make it accessible to the developers, designers, occupiers and decision makers by providing practical benefits on how they can insight their own sustainability indicators selection, priority levels, benchmarking and building performance. The new tool explains how to analyse and interpret various range of data ad feedback, and how to share results so that any lessons learnt can be put into practice. The paper will end with a discussion of the difficulties the proposed analytical framework would face in practice.

Objective of the study

Since the field of key performance indicators is vast, the aim of this study is to clarify that field by undertaken the following specific objectives, to:

1- Evaluate the trends in the development of intelligent buildings

2- Identify key issues related to intelligent buildings (Environmental, social, economic and technological factors).

3- Develop a new model for measuring the level of sustainability for intelligent buildings.

4- Evaluate stakeholder's perceptions and values of selected SIs intelligent buildings

Methodology

In order to achieve the goal of this paper, the methodology is broken into 3 phases:

Phase 1; *To develop general conceptual models that highlight the* ***critical selection factors and indicators****;*

Before choosing a methodology, however, it is essential to decide how the data will be used. It is essential to design data management systems to the correct format in order to ensure the system performance is monitored properly, that reliability data is collected and that the relevant people are trained to analyze it for use by decision makers, architects and facilities management (Clements-Croome, et al, 2007). It is advisable to think ahead so that data collected as part of a sustainability assessment can be reported as Key Performance Indicators (KPIs) (British Council for Offices, 2007, p. 19). The use of (KPIs) and benchmarking is fundamental to any improvement strategy. "*An indicator system should provide a measure of current performance, a clear statement of what might be achieved in terms of future performance targets and yardstick for measurement of progress along the way*" (Jefferson, et al., 2007, p. 58). The challenge in this case is to find effective indicators, requiring a clear conceptual basis. Hence, the selection of indicators will recognize the available data, resources and time, in addition to the interests and needs of the particular group involved in the selection of indicators (Becker, 2004). Hence, it is important for the selected indicators to meet the following criteria (adapted from Brandon & Lombardi, 2005, p. 39; Gann, Salter, & Whyte, 2003, P. 323; Bell and Morse, 2003, p. 31) and be:

1- Specific and must directly relate to outcomes.

2- Easily understood by the general public.

3- Measurable. Implying that indicators must be either quantitative, or, if qualitative, must be interpreted into quantitative values.

4- Useable at different phases in a building's life cycle: conception, design, construction and operation. This is essential, as the criteria and indicators are not applicable at all times or for the same stage during the life cycle of a building.

5- Able to reflect changes over a period of time. Time scale is one of the most important factors in selecting sustainability indicators due to the changing nature of the performance criteria and the appearance of new ones over a period of time. Also, some indicators are ideally looked at over even longer time frames presenting valuable information about tendencies of overall development (i.e. energy and water consumption in buildings). Additionally, considering a time scale offers the possibility of reading the level of sustainability for any building in the time dimension (Alwaer & Sibley 2005; Alwaer, 2006; Dalman, 2002, p. 1).

6- Sensitive, i.e they must readily change as circumstances change.

7- Able to reflect the multi-faceted nature of indicators (Composite indicators), which combine two or more individual indicators, can also be useful as integrative indicators. For instance, the cost of recycling per ton of waste recycled is a simple composite indicator that integrates economic and environment considerations (Maclaren 1996 in Wheeler and Beatley, 2004, p. 206). Also, natural lighting for example in shopping centres can have a functional quality, such as providing a safe, pleasing environment for customers, but it can also have an impact on energy saving. Unfortunately, the problem we could be face in constructing more complex composite indicators, including such issues as deciding how to weight the individual indicators and how to standardised different measurement unites (Maclaren 1996 in Wheeler and Beatley, 2004, p. 206).

8- Available, i.e. it must be relatively straightforward to collect the necessary data for the indicator.

9- Cost effective. It should not be a very expensive task to access the necessary data, *"a clear concern that data availability should not be a constraint in selecting relevant indicators"* (Meter, 1999, in Bell and Morse, 2003, p.32).

10- Able to reflect the multi-spatial scale of sustainability indicators: Consideration of the individual building is itself useful in the "green" building debate; however, it is not always valid as an appropriate scale to define and discuss optimal performance within broad sustainability models. Therefore, a special scale is essential in order to read the level of sustainability of a building design in different contexts. The objective behind this is to show the scale in which indicator is applied.

The initial step is to choose the most appropriate criteria to formulate an '*indicators set*', for a project which relates to the building's performance in relation to the local environment, culture and economy, in addition to business goals (Roaf, 2005, p. 100). However, since the intelligent building industry is new and developing, large samples of professionals are not always available.

Only a very limited number of experts could be identified for the surveys described here but does include design consultants and facilities managers. 20 stakeholders were presented with the proposed selection criteria, and a survey was carried out with stakeholders from different fields in practice and academia. The selected stakeholders were invited to review the relevance, coherence and clarity of approximately 115 individual indicators identified as having a major influence on the overall perceived and operational quality of a building. They were also invited to add and refine new attributes to the indicators. The selected indicators were derived from reformulated sustainability assessment methods used within the UK (*Building Research Environmental Assessment Method* 'BREEAM' , *Design Quality Indicator* 'DQI'…), supplemented with additional ideas taken from sustainability indicators used in other countries, such as, (*Leadership in Environmental and Energy Design* 'LEED', *Comprehensive Assessment System for Building Environmental Efficiency* 'CASBEE', *Asian Institute of Intelligent Buildings* 'AIIB', *Green Star, Sustainable Building Challenge* 'SBC' and *Hong Kong Building Environmental Assessment Method* 'HK-BEAM'... The additional indicators related to health and well being and their effects on productivity and well being of users... Automation, intelligence and user control of the indoor environmental quality, temperature, daylighting and sound in buildings were considered. The CASIBs system is designed is designed to include consideration of regional conditions and values, but the calibration to local conditions does not destroy the value of a common structure and terminology. The system is therefore a very useful international benchmarking tool, one that provides signals to local industry on the state of performance in the region, while also providing absolute data for international comparisons (Larsson, 2007).

Although most of the indicators are directly transferable from UK to elsewhere, it should be noted that depending on the context some indicators may require reformulation or new indicators may be needed to take into consideration the specificity of the context in which they are applied. However, there should be a limited number of indicators, which can be compared to targets, benchmarks or other standards as appropriate. "*There is no limit on the number of indicators that can be used, although a greater number can limit comprehension and the relative importance of each indicator*" (Becker, 2004, p. 204). The selected stakeholders were invited to attach new attributes to the indicators and select related ones based on their *relative importance* and potential *value* of each indicator on various projects size and functions (shopping centres, offices, schools, etc…).. In order to facilitate the selection process and make it transparent and easy to follow, four hierarchical categories of indicators were introduced as follows (adapted from Design Quality Indicator framework- see http://www.dqi.org.uk):

1- **Required (prerequisite) Indicators or Mandatory** (*as a*rticulated by demand side): Compliance with standards, regulations and quantified minimum targets.
2- **Desired Indicators**: Setting ideal targets for building performance beyond the minimum required by guides and codes of practice to include the *users vision*.
3- **Inspired Indicators**: Inspiring goals and vision set by client: refers to long term mission and values.
4- **Non- applicable indicators** or *non- active indicators*: The scope of the project does not require these, or they cannot be achieved.

The table 1 (See Table 1) reveals the stakeholder's (in this case an architect) response to this survey, with reference to energy and natural resources sustainability indicators. The stakeholder's contribution in this study therefore is a response to the question "*Which sustainability issues are required (mandatory) or desired more than other issues (non applicable or non active indicators)*?" based on their intensive knowledge, experience and preferences. For instance, it may not possible to answer this question with absolute certainty by creating a credible and robust process to arrive at a consensus as to what are currently the most important issues for sustainable buildings (Aizlewood, Edwards, Hamilton, Shiers & Steele, 2007, p. 1). It is notable that the stakeholder selected 6 out of 9 main indicators in terms of required and desired categories. Thus, the inspired and non applicable criteria could be marginalised at this stage. This may be the case if the indicator needs to be addressed, but is not relevant in the region or case study. Or it requires client vision and statement or the relevant raw data has not been provided, or the importance of the indicator or sub indicator is not applicable at this stage but might be over a period of time (i.e. five years). This might be considered as a wide approach, but conversely highlights one significant issue in customising a general assessment scale to regional application.

Table 1: An example of a stakeholder (one of the architects) perceptions selection process for proposed energy indicators based on relative impact and importance on the buildings.

Proposed Sustainability Indicators			**Minimum Request and the Compliance Requirements**	**Indicators Classification**				**Life Cycle Stage (Spatial Scale)**			
Category	**Credit No.**	**Indicator (SI)**		**Required** Mandatory	**Desired**	**Inspired**	**Non Applicable**	**D & P**	**M & OP**	**POE**	**R**
Energy and natural resources	E1	Total life cycle primary non-renewable energy	To predict non-renewable primary energy used for building operations and greenhouse gas emissions	●	○	○	○	✓	✓	✓	
	E2	Lot orientation to maximise passive solar energy	To ensure that the project site plans provide for the location and orientation of building that will maximise passive solar potential	○	◉	○	○	✓	✓		
	E3	Total life cycle primary from renewable energy (renewable energy implications)	To encourage the use of sources that generates power by renewable energy means, e.g. 'green power'.	○	○	◍	○	✓	✓		
	E4	Use of Daylight in the primary areas (Daylight absorbability)	To ensure an adequate level of daylighting in all primary occupied spaces.	●	○	○	○	✓	✓		
	E5	Peak Energy Demand Reduction for building operations	To encourage and recognise projects that implement systems to reduce peak demand on energy supply infra-structure	○	◉	○	○	✓	✓		
	E6	Passive solar gain and cooling	To encourage using the natural movement of heat and air to maintain comfortable temperatures, operating with little or mechanical assistance	○	○	◍	○	✓			
	E7	Annual electrical energy conservation	To minimize the peak monthly electrical demand for building operations, especially where the grid is near peak capacity	○	○	◍	○	✓	✓		
	E8	Design features to maximise effectiveness of ventilation in naturally ventilated occupancies	To encourage and recognise the provision of natural ventilation system from the early design stage considering building orientation and wind directions	●	○	○	○	✓	✓	✓	
	E9 … … En	Maximize the effectiveness of operable windows (Glass structure encourage effectively natural air flow)	To ensure that the number, placement and type of windows or other openings in a naturally-ventilated building are capable of providing a high level of air quality and ventilation	○	◉	○	○	✓	✓		

Key: (the degree of importance)	**Key: (Life Cycle Stages)**
Highly Important and Required ■	Design and Post Construction (**D&P**)
Desired and Important issue ●	Management and Operation (**M&OP**)
Inspired issue with less important than other issues ◉	Post Occupancy Evaluation (**POE**)
Non applicable or they can not be achieved ◍	Recycle, Reassemble and Reuse (**R**)

At the end of the survey, 11 complete answered questionnaires were received from (4 architects, 4 engineers, 3 sustainability assessors). The stakeholders identified 18 main key categories relevant to intelligent buildings based on their influence on the whole life cycle of intelligent buildings, and categories under the four headings of *Environmental* (e.g. energy, CO_2 emissions, transport, land use, waste reduction….), *Socio-cultural* (user satisfaction, quality of space, safety at work, quality of services…), *Economic factors* (predictability, maintenances, life cycle costs…) and *Technological Factors* (Intelligence, communications, Controllability….). Within these categories, 57 indicators and sub indicators were identified within the scope of required and desired indicators.

1- Environmental Indicators group (En-SIs):
- Energy and Natural Resources (E)
- Water and Water Conservation (W)
- Materials used, Durability and Waste (M)
- Land use and Site selection (L)
- Transport and Accessibility (T)
- Greenhouse Gas Emissions (Pollution) (GHG)

2- Socio- Cultural Indicators group, (So-SIs):
- Functionality, Form, and Aesthetic aspects (F)
- Indoor Environmental Quality (IEQ) - Health and Wellbeing 1-
- Daylighting and Illumination (D) - Health and Wellbeing 2-
- Architectural considerations – cultural heritage integration and the compatibility with local heritage value (A)
- Users trends and aspirations (Us)
- Innovation and design process (ID)

3- Economic Indicators group (Ec- SIs):
- Flexibility & Adaptability(FA)
- Economic performance and affordability (EP)
- Building Manageability (BM)
- Whole Life Value (V)

4- Technological Indicators group (Tc- SIs):
- Intelligence and controllability (IC)
- Communications and mobility (C)

The importance of the selected indicators can be considered in relation to the implementation of various aspects, from building issues at the "***micro scale***" (water, energy, maintenance, and so on), to urban and regional planning on the "***meso scale***" (such as land use and site selection, planning considerations,…), to national issues on the "***macro scale***" (such as greenhouse gas emissions from all energy used for building operations, transport, and infrastructure) and cross country issues on the ***global scale*** (climate change). The selection of sustainability indicators are based on a through life model focusing on ***People***, ***Products*** and ***Processes*** based on design, construction, commissioning, operation, maintenance, post-occupancy evaluation, recycling and disposal (see Clements-Croome, *et al* 2004; Clements-Croome, *et al* 2007). However, due to the time constraints of this research dealing with a large set of sustainability indicators- and in order to make the selected indicators relevant to intelligent buildings, only those indicators located within building scale are chosen in this paper as follows:

Environmental SI (Ecological and Natural resource) group (En-SIs):
- Energy and natural resources (E)
- Material used, Durability and Waste (M)

SOCIO- Cultural Indicators group, (So-SIs):
- Functionality, Form, and aesthetic aspects (F)
- Indoor Environmental Quality (IEQ) - Health and Wellbeing 1-
- Daylighting and Illumination (D) - Health and Wellbeing 2-
- Innovation and design process (ID)

Economic Sustainability Indicators group (Ec- SIs):
- Flexibility & Adaptability(FA)
- Economic performance and affordability (EP)

Technological Indicators group (Tc- SIs):
- Intelligence and controllability (IC)

Phase 2; To **test and refine the general conceptual models developed in phase 1** by testing the level of importance of the selection criteria and indicators;

There are no hard and fast rules about which techniques embodied in sustainability assessment should be used, because each study will be unique to the building location or prevailing situation. However, it is clear that adopting well-known and widely used techniques ensures that results are meaningful; that they can be repeated and therefore compared; and that the information can be benchmarked against other tools that have used the same methodology. With the possibility of not having scientifically derived weights, it is possible to use 'consensus-based' weighting for the different categories of indicators. In the CASIBs, the 11 selected stakeholders (from sample of 20) ranked various factors, such as environmental issues, in terms of their relative importance or assigned weights to the process of design, construction and operation of offices. Since people have different views and different levels of understanding about sustainability issues, a standardised production for assigning relative importance to different sustainability impacts is required if there is to be a consistent basis for decision-making. The relative importance has been derived using the analytical tool called the *Analytical Hierarchy Process* (AHP) (Saaty, 2001), which uses a 9 point scale. In brief, the AHP approach can help to improve the decision-making process, and has been applied to numerous multi-criteria problems in the last few decades (Chang, et al, 2007; Wong, 2007; Clements-Croome and Li, 2001; Saaty, 2001).

The AHP approach consists of several levels of hierarchies, but in this case five have been selected beginning with goals followed by dimensions, categories, indicators, interrelationship between indicators, and inter-relationship between categories. AHP enables the users to make *effective decisions* on complex issues by helping to order their natural decision-making processes. In addition, AHP helps to establish decision models through a process that contains both qualitative and quantitative components. *Qualitatively*, it helps to *decompose a decision problem* from the overall goal to a set of manageable categories, indicators and sub-indicators. *Quantitatively*, it uses *pair-wise comparison* to assign weights to the elements at the indicator and sub indicator levels, and finally calculates "score" weights for assessment taking place at the bottom level (Wong, 2007; Chung and Li, 2007, p. 279).

Intelligent buildings can be treated as a complex system and can best be understood by breaking the system down into their constituent elements and then structuring the elements hierarchically (See Figure 1); composing judgments on the relative importance of the elements at each level of the hierarchy into a set of overall priorities (Saaty, 2001). Each level in the hierarchy corresponds to the common characteristic of the elements in that level. For example, the aim of the stakeholder's contribution in this study therefore is to ask the question "*Which sustainability issues are of greatest importance*? That is, is transportation and accessibility more important than say, energy and natural resources or water consumption and if it is, then *how much more important*?" The nominal-ratio scale of the priority levels among the categories was represented as the score from a 1 to 10 point scale, with participants asked to judge the relative importance of one issue compared with another (pair-wise comparisons).

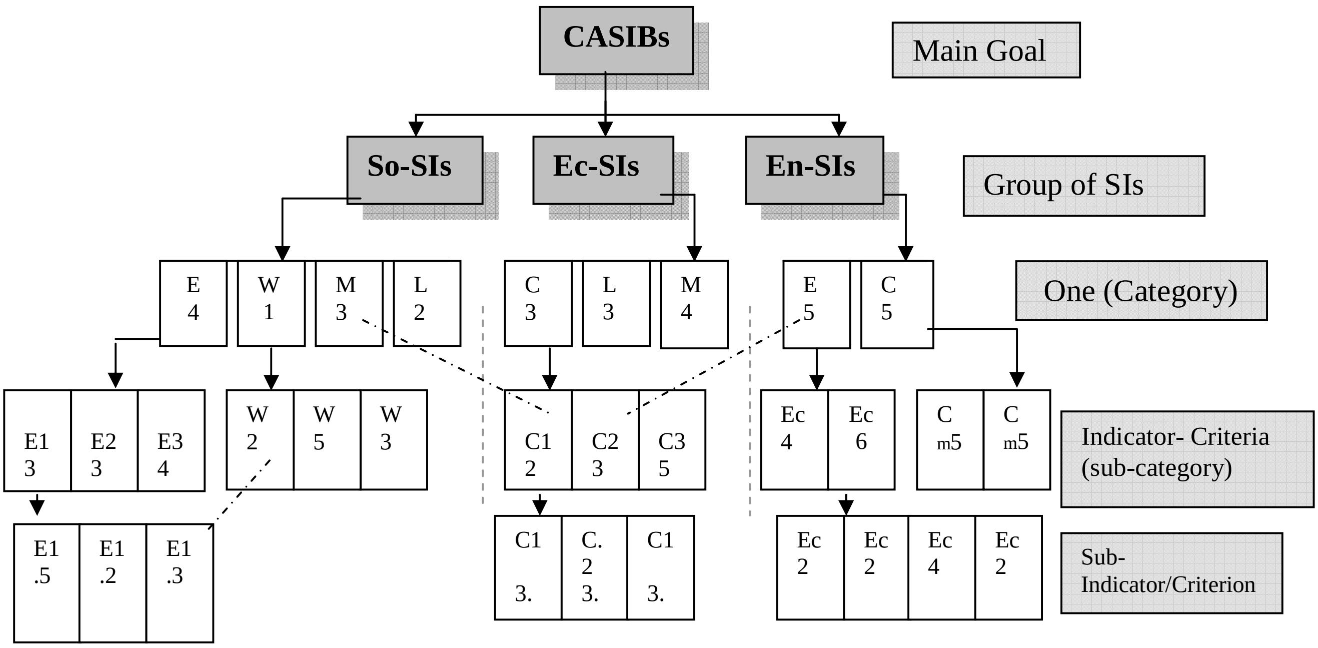


Figure 1: The principles and the priority values used in CASIBs: Hierarchy order (interactive hierarchies).

For instance, taking Environmental sustainability indicators (En, SIs) as one group illustrates two main categories. In this case, the evaluators, sustainability assessor, the architect and the building engineer, determine the priority level attributed to each one taking into account that each value for a category in one group will be granted a value out of 10 (See Figures 2 and 3).

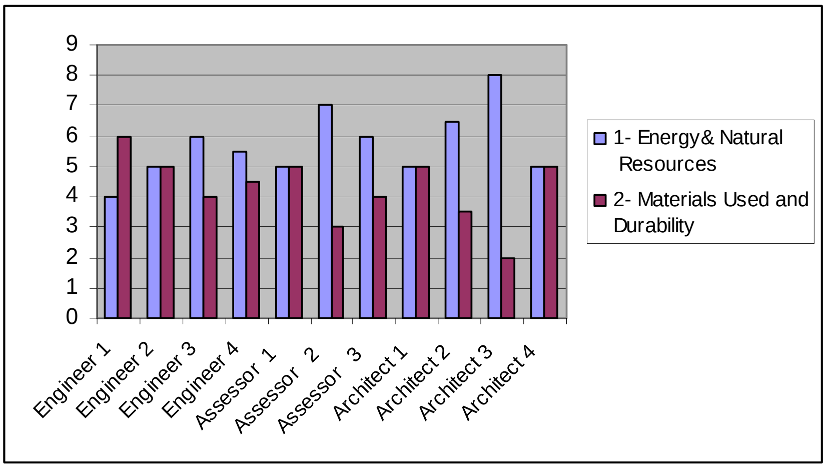


Figure 2: The priority levels attributed for selected Environmental categories by different stakeholders.

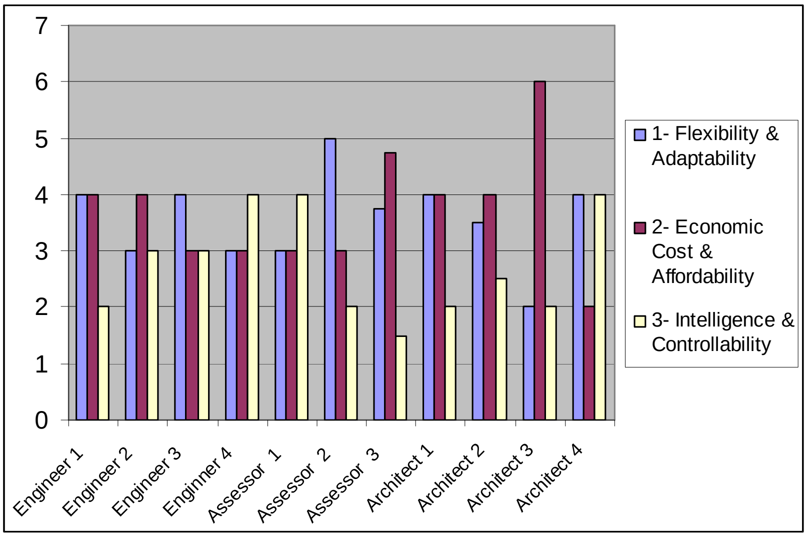


Figure 4: The priority levels attributed for selected Economic categories by different stakeholders.

It is noted from the previous tables that, although each multiplier (Priority level) is identified on a scale of 1 to 10, the process of assessment is complex. The differing views of the assessor, the building architect and the building engineer on multiplier level lead to subjective results. When this method is applied in different regions, the reference building types, climatic conditions and geographical locations are different. Additionally, the differences in priority levels between stakeholders could result in major differences in sustainability assessment results. Also, according to the survey, the aggregated results illustrate that the different individuals of the same skill group (i.e. architects) have given different weightings scores based on their preferences and experiences of buildings. Even by making the average between the architects, the building managers and the assessors, the aggregated results have given different weightings which could skew the final assessment results. Also, it is clear from the aggregated results that, the priority levels expressed qualitatively and quantitatively are open to wide interpretation by the 11 assessors and therefore the assigning of scores can vary considerably depending on those making the assessment- even within the same system. These can also be very subjective leading to a distorted evaluation, as there has been no consensus in various sustainability indicators.

Phase 3; To **develop practical model** of intelligent building systems assessment and performance;

A sustainability assessment methodology and tool has been developed called- the *Comprehensive Assessment System for Intelligent Buildings* (CASIBs). The aim of developing the system is to deliver the most objective measurement possible, by considering a range of vital issues. The CASIBs have been developed to deliver the best objective measurement possible. Such improvements rely on the accurate translation of an indicator value into a sustainability measure. The CASIBs was designed to comply with the following principles:

- The system is a rating framework or toolbox and only becomes a rating tool after a third party (a range of stakeholders) calibrate it for their region and meet local area considerations by defining selective criteria, priority levels and setting weights, context and performance benchmarks.

- Negative implications are as valuable as positive ones, particularly for assessing existing buildings. Furthermore, a survey carried out by Lee & Burnett (2006) revealed that 70% of the stakeholders agreed with the use of 'negative scoring'. The supporters of negative scoring considered that this would give more incentive to building owners, developers and decision makers for achieving higher sustainability scores. Hence, in the CASIBs, a negative scoring system should be adopted to downgrade non-performing buildings.

- In this model a linear ranking scale for the level of each criterion has been used. '*Priority level*' and the value for each indicator can be translated into a numerical score. Moreover, the importance of this indicator is further modified by a weighting to represent its priority within the criteria group. To summarise, the value of the multipliers are based on the importance of each criterion which is weighted according its importance in each case;

- Apart from weighting issues, the arrangement of data has been categorized using the following equation to reflect the application of indicator performance in terms of positive and negative applications. Adapting the approach of SBC (Larsson, 2007) as follows:

Sustainability Score = (Level of Performance (L) × (Priority Level) relative importance (PL)
Scn = L × PL (by Stakeholders)

L= -2 to +5, PL ≤10

Each category is further sub-divided into individual indicators and these are weighted according to their relative importance (Becker, 2004). The actual value of each indicator is translated into a sustainability measure value in the range: from +5 to -2 (Level of performance) as below:

- +5 (demanding performance) represent best practice (Excellent performance)

- +1 to +5 represents good practice reflecting stable conditions in terms of sustainability, (+3 Good Performance)

- 0 represents current standard (Minimum acceptable performance) or typical practice for the particular building type and region, or also due to the difficulty in obtaining data.

- -1 to -2 represents unsatisfactory performance (Deficient) which is not likely to meet the accepted regulations, design criteria and industry norms, or the indicator performance gives a negative impact on the environment in social, economic and environmental terms.

One could ask why the level of performance of each indicator is allocated a value between -2 to +5 instead of -5 to +5? The main justification for this by the evaluators is to provide a scale where the focus in sustainability assessment is based on more positive than negative attributes. This is why the researchers did not use “0” as a middle terms in their assessment tool. This scale is designed to encourage those involved in sustainability projects to achieve better design results.

Each criterion is allocated a score after the data analysis. The score for a criterion is multiplied by the priority level for that area. The score for an indicator is, therefore, the total of the criteria’s scores under each category. Afterwards this value is multiplied by the multiplier (priority level) provided beside each indicator or sub-indicator, and the resulting number from such a multiplication represents the weighted score for the indicator or sub indicator.

The authors found it may be easy to achieve a consensus between stakeholders in most building performance on the CASIBs scale (-2 to +5). For instance, if there is no evidence for renewable energy applications in buildings the performance level could be given the score -2. However, it seems more difficult to obtain this consensus when it is related to the relative important and priority level of each indicator. For instance, the four selected architects (from sample of 11 selected stakeholders in this study) have revealed different priority levels with reference to Renewable energy implication (1, 2, 3, and 2 respectively). The difference in priority level between stakeholders could have a much bigger impact on the final “Score” or outcome than all performance inputs into the system from “measured data” (See Table 2). Thus, weighting and expert weightings can skew results dependent on who is carrying out the evaluation, and thus results in a subjective assessment even when the same indicators are applied.

Table 2: Weighting process for renewable energy for four individuals (Architects) of the same skill group

Energy and Natural Resources (E)	**Weighting L1 × PL 1 = Scn**	**Weighting L2 × PL 2 = Scn**	**Weighting L3 × PL 3 = Scn**	**Weighting L4 × PL4 = Scn**
E1: Use Renewable Energy Systems	**-2** ×1 = -2	**-2** ×2 = -4	**-2** ×3 = -6	**-2** ×2= -4

L= -2 to +5 (Performance Level for applied indicators)

Priority Level attributed by Architect 1	PL1
Priority Level attributed by Architect 2	PL2
Priority Level attributed by Architect 3	PL3
Priority Level attributed by Architect 4	PL4

The overall results show remarkable differences in the level of sustainability despite the similarities in the performance value for the applied indicators between stakeholders

(Architects). For instance, in the three figures, the non implication of renewable energy systems have greatly different levels of sustainability, equalling respectively -2 for Architect 1, -4 for Architect 2, -6 for Architect 3 and -4 for Architect 4. In other words, the aggregated results can vary from expert to expert and sometimes can be skewed which are not reliable in terms of the accuracy of the tool itself and make the results open to interpretation .The problem in fact, understanding requirements and transforming them into high quality indicators is a universal one that many stakeholders have struggled with (Gann, et al, 2003, p. 321; Alwaer, et al, 2008). It raises questions about the nature of good sustainable indicators in terms of priority levels and benchmarking. It is typically the case that different individuals or groups are responsible for different levels within building sectors, and they will have their own take on the narrative and its implications. For example, some architects might be concerned that the functionality and quality of internal spaces are relegated to a secondary issue in comparison with the external shape of their buildings. Meanwhile for the managers their main concerns may be for the indoor environmental quality and energy consumption of their buildings rather than with the external aesthetics. Their stories are their experiences of these interactions, and others may (or may not) have quite different perspectives (Bell and Mores, 2007). However, given different weightings and scores by each stakeholder, it would be really meaningful to take their averages in real practice. For instance by making the average between the four selected architects, it is possible to read the overall trends for each selected indicators from their judgments. Thus, by recognizing KPIs as a tool to reach consensus among stakeholders, it seems useful to discuss a procedure to do so as a future topic.

Discussions

Although the research has generally achieved the specific objectives stated in the introduction, this research was limited to the following points:

- Determine the relative significance of different sustainability impacts is a problematic and complex process but one that is necessary if we are to identify sustainability priorities and make an informed decision toward better building performance and assessment;

- The AHP (pair-wise) comparisons of indicators can only be subjectively performed, and thus their accuracies always depend on the knowledge and experience of the raters on the issues and its field (Yurdakul, 2003). In fact, preference modeling of the human decision makers is often uncertain in many cases, and it is also relatively difficult for the decision maker to provide exact numerical values for the comparison ratios;

- New sustainability indicators might be added when new innovative features and properties developed. Complexity increases exponentially with the number of indicators or criteria and their interdependence (Wolfslehner et al., 2005). This requires more calculations and the formation of additional comparison matrices, and eventually requires significant time resources and efforts for completion from an application perspective (Wong, 2007);

- The research methodology adopted in this paper also imposed its own limitation. First, the size of the sample of this research was limited. Since the intelligent building industry is new and developing, a large sample of professionals was not available. Only a very limited number of experts could be identified for the surveys. The major group of experts were the design consultants together with engineers and facility managers;

- The key point is that we believe that the developed framework and key criteria identified in this study will improve the understanding of industry practitioners, but in a way that allows comparison, discussion and learning. Also, the developed framework is able to consider different levels of information and structure all relevant issues in an ordered manner, helping decision makers to handle the multiplicity of the issues embodied in the concept of sustainability.

Conclusions

The paper revealed that although the participation of all decision makers and stakeholders in the establishment of proper levels and weighting could facilitate the process of recognition and incorporation of regional diversities. The problem in this regard is in understanding the different stakeholder perspectives on what constitutes good performance in buildings in order to reach consensus about shared indicators and priorities and relationships. Also, weighting and expert weightings can skew results dependent on who is carrying out the evaluation, and thus results in a subjective assessment. The main difficulties associated with benchmarks include the definition of typical, good and advanced (outstanding) practice in intelligent buildings. In addition, subjectivity in sustainability is unavoidable and consensus needs to be reached by a wide variety of stakeholders. This should be facilitated by whoever is carrying out a sustainability assessment. Additionally, participation of stakeholders and decision makers in the establishment of benchmarks and weightings could significantly facilitate the process of recognition and incorporation of regional diversities (Alwaer, Sibley and Lewis, 2008).

The AHP approach was chosen since it was essential to collect data from experts who were highly experienced in the whole life span of intelligent building and thereby make a positive contribution to the identification of optimum design solutions and facility operation. Also, the AHP provides a means of structuring the decision maker’s mind by providing a systematic prioritisation of sustainability indicators. However, a large sample size seemed inappropriate in this paper as the intelligent building is a new form of building development which is yet to mature (Wong, 2007). The AHP is an analytical method which permits a small group of survey population. Thus, the AHP is helpful in collecting and analysing data from a small group of experienced experts. It is generally believed that feeding more information to the model (or experts) would lead to better decisions. It is meaningful to discuss accuracy of assessment of each weight. In this problem, however, it seems that further discussion about the consistency of each rater’s assessment and reliability of overall assessment should be carried out. In addition, reliable sustainability assessment is a difficult task; the CASIBs system was particularly intended to give guidance on which categories (indicators) are likely to have greatest sustainability impact in order to prioritize effort. This approach has led to a very large and complex system, which requires large quantities of detailed information to be assembled and input, causing further difficulties and frustration. However, it is essential to emphasise that the new proposed framework for selecting sustainability indicators is a starting point for discussion rather than any pretence at a finished, tried and tested, end product (Bell and Morse, 2003, p. 108).

Finally, based on continually changing and evolving character of information technology and due to appearance of new features intelligent buildings, new innovative features and criteria mean that new key performance indicators might be added (Wong, 2007). This implies that the models developed in this paper can be validated at least to a yearly time span, but it is subjected to the nature of changes in the environment including technological advancement and changes of user's values. Also, the models effectiveness in other countries will be ascertained when they have been claimed as broadly received. Thus, significant work remains to be carried out in order to make the measurement less complex, less subjective, more reliable and the process of calculation more flexible and easier to follow. Also, greater integration across various stakeholders, urban policy makers, planners and architects needs to generate a consensus in various sustainable buildings issues. The researchers contend that the CASIBs in its current form is most useful as a starting point for discussion. It cannot provide an absolute measure of the design quality of an intelligent building but can be used to articulate the subjective qualities felt by different stakeholders in the design process and thereafter in the use of a building.

REFERENCES

Aizlewood, C., Edwards, S., Hamilton, L., Shiers, D., & Steele, K. (2007) Environmental Weightings: Their Use in the Environmental Assessment of Construction Products' Results of a Study. Bracknell, England: HIS BRE Press, BRE IP 4/07.

Alwaer, H., Sibley, M., & Lewis, J. (2008). Different Stakeholder Perceptions of Sustainability Assessment. Architectural Science Review (ASR), 51 (1), 47-58.

Al Waer, H. (2006). Regional Shopping Centres in the UK: Sustainability Indicators and application of an assessment model. Unpublished PhD thesis, Liverpool: The University of Liverpool, School of Architecture.

AlWaer, H., & Sibley, M. (2005). Sustainability Indicators: Complexity of Measurements and New Trends. Proceedings of 11th Annual International Sustainable Development Research Conference. University of Tampere, Helsinki: Inderscience Publishers, 1-10.

BCSC. (2007) Future of Retail Property: Future shopping places. London: British Council of Shopping Centres.

Becker, J. (2004) Making sustainable development evaluations work. Sustainable Development (12), 200-211.

Bell, S., & Morse, S. (2003). Measuring Sustainability: Learning by Doing. London: Earthscan.

Bell, S., & Morse, S. (2007). Storey telling in sustainable development projects. Sustainable Development (15), 97-110.

Brandon, P.S., and Lombardi, P. (2005) Evaluating Sustainable Development in the built environment. Oxford: Blackwell.

British Council for Offices. (2007) Guide to Post- occupancy Evaluation. London: British Council for Offices.

Chang, K. F. Chiang, C. and Chou, P. (2007) Adapting aspects of GBTool 2005- searching for sustainability in Taiwan, Building and Environment (42), 310-316

Chen, Z., Clements-Croome, D.J., Hong, J., Li, H., & Xu, Q. (2006) A multicriteria lifespan energy efficiency approach to intelligent building assessment. Energy and Buildings (38), 393-409.

Chung, E. W. L. & Li, H. (2007) Application of ANP in process models: An example of strategic partnering. Building Environment, 42(1), 278-287.

Clements-Croome, D.J, Wu, S., & John, G. (2007) High-Quality Building Services based on Whole-Life Value. Reading: The University of Reading.

Clements-Croome, D.J. (2004) Intelligent Buildings: design, management and operation. London: Thomas Telford.

Clements-Croome, D.J, & Baizhan, L. (2001) Productivity and indoor Environment. Proceedings of Healthy Buildings (1),629-634.

Cole, R.J. (1998) Emerging trends in building environmental assessment methods. Building Research & Information. 26(1), 3-16

Crawley, D., & Aho, I. (1999) Building Environmental Assessment Methods: Applications and Development Trends. Building Research & Information. 27(4/5), 300-308.

Dalman, E. (2002). Key factors and indicators: How do we use them? Proceedings of Sustainable Building SB2002, IISBE, Oslo, available at http://www.sbis.info/database/dbsearch/details/docsdetails.jsp?index=6 accessed on 14 July 2004.

Design Quality Indicator Framework (DQI), available at: http://www.dqi.org.uk accessed on 14 February 2008

Hawkes, D., McDonald, J., Steemers, K. (2001) The selective environment: An approach to environmentally responsive architecture. London; New York: Spon Press,

Gann, D.M., Salter A.J., & Whyte J.K. (2003) The Design Quality Indicator as a tool for thinking. Building Research & Information. 31(5), 318-333.

Jefferson, I., Hunt, D.V.L., Birchall, C.A., & Rogers, C. D. F. (2007) Sustainability indicators for environmental geotechnics. Proceedings of the Institution of Civil Engineers. 160(ES2), 57-78.

Kroner, W. M. (1997) An intelligent and responsive architecture. Automation in Construction(6), 381-393

Larsson, N. (2007). “Rating System and SBTool” available at: http://www.iisbe.org/iisbe/sbc2k8/sbc2k8-download_f.htm accessed on 15 March 2008

Lee, W. L. Burnett, J. (2006). Customization of GBTool in Hong Kong. Building and Environment (41), 1831-1846.

Maclaren, V. W. (2004) ‘Urban Sustainability reporting’. in Wheeler, S. M. and Beatley, T. (Eds). The Sustainable Urban Development Reader, Oxon; New York: Routledge, 203- 210.

Roaf, S. (2005) ‘Benchmarking the ‘sustainability’ of a building project’. in Preiser, W. F.E. and Vischer, J. C. (Eds). Assessing Building Performance, Oxford: Elsevier, 93- 103.

Saaty, T.L. (2001) Decision Making for Leaders: The Analytic Hierarchy Process for Decisions in a Complex World. Pittsburgh, USA: RWS Publications.

Seo, S., Tucker, S., Ambrose, M., Mitchell, P., & Wang, C.H. (2006), “Technical Evaluation of Environmental Assessment Rating Tools”. Forest and Wood Products Research and Development Corporation, Australia, Project No PN05.1019, available at: www.fwprdc.org.au/content/pdfs/PN05.1019.pdf

Wolfslehner, B., Vacik, H. & Lexer, M.J. (2005) Application of the analytic network process in multi-criteria analysis of sustainable forest management, Forest Ecology and Management 207 (1-2), 157-159.

Wong, J. K. W H. (2007) Development of Selection Evaluation and System Intelligent Analytic Models for the Intelligent Building Control Systems. Unpublished PhD thesis, Hong Kong: The Hong Kong Polytechnic University Department and Real Estate.

Yurdakul, M. (2003) Measuring Long Term Performance of a manufacturing firm using the Analytical Network Process (ANP) approach. International Journal of Production Research 41 (11), 2501-2529.

ROLE OF PSYCHOLOGICAL CAPITAL (PSYCAP) IN LEADERSHIP EFFECTIVENESS

Shamas-ur-Rehman Toor
National University of Singapore
shamas@nus.edu.sg

George Ofori
National University of Singapore
bdgofori@nus.edu.sg

Psychological Capital or PsyCap has gained prominence as an important construct in leadership research. Comprising four factors (self-efficacy, hope, optimism, and resiliency), PsyCap is considered to be a vital factor for both leadership development and influence. The current study reports the results of a questionnaire survey that was conducted in the construction industry of Singapore. The survey explored the correlations of PsyCap with various form of leadership and leadership outcomes. The results show that PsyCap significantly correlates with transformational leadership and leadership effectiveness. The discussion in the paper also considers the implications of PsyCap for leadership development and effectiveness.

KEYWORDS: Psychological Capital, Leadership, Effectiveness, Construction Industry, Singapore

INTRODUCTION

Authors have placed much emphasis on human capital (O'Leary et al., 2002) and social capital (Adler and Kwon, 2002) as viable sources of competitive advantage for organizational success. However, rooted in the movement of positive psychology and positive organizational behaviour (POB), recent developments in organizational studies have focused on "positively oriented human resource strengths and psychological capacities that can be measured, developed and managed for performance improvement in today's workplace" (Luthans and Youssef, 2004, p. 152). These psychological capacities are termed as "Psychological Capital" or in short, "PsyCap" (Luthans et al., 2007a). Proponents of PsyCap argue that its development at all levels of the organizations has a high potential to be play a key role as a strategy of human resources management (HRM),helping the firms to capitalize on their existing and prospective human resources.

The latest literary developments support the notion that to develop and sustain competitive advantage, the enterprises' human resource strategies should emphasize the factors that are highly unique and valuable, context-specific, cumulative, renewable, hard to imitate, and non-substitutable (Luthans et al., 2007a; De Saa-Perez and Garcia-Falcon, 2002). Therefore, in addition to providing better monetary compensations, the firms need to invest in human resources in more a innovative manner. They should manage their talent and train them to be better leaders and followers who are inspired to think innovatively, possess positive psychological capacities, and have the highest sense of authenticity to contribute to the achievement of the organizational objectives. For this purpose, firms need to develop PsyCap among their employees, both folloswers and leaders. PsyCap is a fresh but theoretically robust and well researched notion. There is substantial support in the literature that PsyCap is potentially an important human resource asset for any business organization.

Given the growing body of knowledge on the subject, it is pertinent to undertake more research on it, as well as performing real-time testing to explore the practical implications of the construct for organizations. The focus of this paper is to examine how PsyCap relates to various forms of leadership (transformational leadership, transactional leadership, and laissez faire leadership) and how it influences various leadership outcomes, such as effectiveness, extra effort, and satisfaction.

PSYCHOLOGICAL CAPITAL

The foundations of PsyCap lie in positive organizational behaviour or POB (Luthans, 2003; Luthans and Youssef, 2004; Youssef and Luthans, 2007). Drawing from POB, Luthans et al. (2007) define PsyCap as the "individual's positive psychological state of development and is characterized by: (1) having confidence (self-efficacy) to take on and put in the necessary effort to succeed at challenging tasks; (2) making a positive attribution (optimism) about succeeding now and in the future; (3) persevering toward goals and, when necessary, redirecting paths to goals (hope) in order to succeed; and (4) when beset by problems and adversity, sustaining and bouncing back and even beyond (resiliency) to attain success" (p. 3). Thus, PsyCap has four main components that are self-efficacy, optimism, hope, and resiliency.

Luthans et al. (2007a) argue that for any positive psychological capacity to become a part of the PsyCap, the following criteria must be met:

1. It should be positive and relatively unique to the field of organizational behavior
2. It should fulfil the scientific criteria of being theory- and research-based (that means it should have substantial theoretical and research background)
3. It should be measurable (with the help of some tool such as a questionnaire)
4. It should be state-like (that means the capacity is not hard-wired—or trait-like—or static in nature) and therefore can be developed with certain interventions.
5. It should be related to work performance outcomes (it should have some positive influence on sustainable work performance)

Luthans et al. (2007a) discuss some other candidate social capacities (such as gratitude, forgiveness, emotional intelligence, and spirituality) as well as some higher order strengths (such as authenticity and courage). Luthans et al. (2006a) note that PsyCap is a core construct that predicts performance and satisfaction better than any of the individual strengths that make it up. In their study of Chinese workers, Luthans et al. (2005) ascertain significant correlation of positive psychological capital with their performance that was rated by their supervisors. Luthans et al. (2006b) also claim that a relatively short intervention—or what they call micro-intervention—can lead to increase in PsyCap. Similar results were found when a 2-hour long intervention was conducted on practicing managers. The next section discusses the potential of PsyCap to provide sustainable competitive advantage.

COMPETITIVE ADVANTAGE OF PSYCHOLOGICAL CAPITAL

Earlier research has shown strong support for human capital—that emphasizes developing personal capacities and skills ("what you know). Researchers have argued that successful organizations attract, engage, develop, and retain the best and brightest employees (O'Leary et al., 2002; Wright et al., 1998). Others argue that social capital—that emphasizes social relations, networks, and connections ("who you know"—is important for organizations as it helps to leverage more information, results in more influence, control power, and organizational solidarity (Adler and Kwon, 2002). It has also been argued that social capital contributes to the creation of human capital and is important for creating sustainable competitive advantage (Luhans and Youssef, 2004). Snell (2002) shares a relatively balanced perspective. He argues that human resource function should treat human capital and social capital equally, saying: "Human capital is, of course, very important for building a foundation for effectiveness, but it may only be the raw material of competitive advantage. The finished product may depend on effective management of social capital" (Snell, 2002, p-64).

PsyCap has several advantages at all levels including employees, leaders and organizations at large. Its proponents argue that it challenges the individuals to explore the question of "who you are" (Luthans and Youssef, 2004) and therefore results in better self-awareness that is fundamental to the development of leadership (George et al., 2007). Luthans et al. (2005) argue that developing PsyCap in employees is not only beneficial for organizations, but also difficult for other enterprises in the business sector to imitate or replicate. PsyCap management possesses the capability of effectively channelling and growing employees' talents, strengths, and potential and helping the organizations to achieve a long-term competitive edge. A positive psychological state can energize employees' cognitive processes and their perceptions of what they can achieve (Luthans et al., 2007a). Hopeful employees tend to be independent in their thought processes and possess an internal locus of control that helps them to be motivated by the accomplishment of enriched tasks. Moreover, hopeful leaders and managers are crucial for organizational growth. Such leaders stimulate the followers to determine their own goals and inspire them to reach their maximum potential. Research has also shown a positive relationship between higher level of 'hope' among employees and organizational outcomes (Luthans et al., 2007a; Luthans et al., 2005). Empirical evidence has also shown that PsyCap is positively correlated to performance and satisfaction of employees (Luthans et al., 2007b).

Luthans and Youseff (2004) argue that optimism allows individuals to take credit for favorable events in their lives and therefore results in enhanced self-esteem and morale. They also claim that optimism shields them from depression, guilt, self-blame, and despair. Finally, resilience enhances the positive abilities and reduces the fear factors within individuals and/or within their environment. Therefore, resilient individuals are in a better position to bounce back from crises or difficult circumstances. Luthans et al (2007a) also argue that PsyCap emphasizes a new approach to organizational management that inspires a unique and long-term competitive advantage. PsyCap does not contest the widely established need for human capital and social capital. PsyCap is, rather, a new dimension which builds positive psychological capacities and takes the culture of the whole organization to new heights where human potential is valued the most.

Researchers consider PsyCap as a fundamental asset of authentic leadership (Luthans and Avolio, 2003; Walumbwa et al., 2008) which is unique and vital for contemporary businesses (George, et al., 2007) as well as the construction industry (Toor, 2008). Authentic leaders possess a great deal of self-efficacy, hope, optimism and resilience (Jensen and Luthans, 2006). With these attributes, authentic leaders are well equipped to face the challenges of business ventures by: understanding their followers and realizing the full potential of their vision (Jensen and Luthans, 2006); establishing organizational trust (Norman, 2006); and appreciating the complexity of the situation (Avey, 2007). They are also able to develop their followers into authentic leaders themselves (Luthans and Avolio, 2003; George and Sims, 2007) through role modelling (Avolio and Gardner, 2005), monitoring, teaching, and coaching (Bass and Steidlmeier, 1999). They are committed to building the highest level of organizational capacity through individual performance (Gardner and Schermerhorn, 2004), intra- and inter-individual impact, group-level impact, and organizational-level impact (Avolio and Luthans, 2006). With a high level of PsyCap as their primary quality, authentic leaders turn their organizations into sustainably high performing and profitable ventures and highly desirable places to work.

Therefore, if developed and well-managed, PsyCap can provide enormous potential benefits for construction organizations. Investment and leveraging of PsyCap can help enterprises to develop a strong workforce with the capacity to build large and complex ventures. With the increasing trend of strategic alliances, having better PsyCap at all levels of the organization can help enterprises to deal with the challenges which organizations normally face when they work in various forms of alliances. PsyCap can also help businesses to realise desirable attitudinal outcomes which include job satisfaction, commitment to the organization, organizational citizenship, and perceived organizational effectiveness (Luthans and Youssef, 2004). Finally, recent publications (see: Luthans et al., 2006b) have also shown that investment in PsyCap development generates high return on investment (ROI). They claim that a mere increase of 2% in PsyCap of organizational leaders can lead to a high return on investment. Luthans et al. (2007) use the approach developed by Skarlicki et al. (1996) to calculate ROI on PsyCap development in a study of 74 managers who went through a micro-intervention for PsyCap development. The results of these initial studies are promising and show high impact of PsyCap development on business performance (see: GLI Briefings Report, 2006). Apparently, PsyCap has a twofold impact; first, in terms of organizational culture and environment, and second, in terms of economic and financial performance.

METHOD

In order to measure PsyCap, a self-report 24-item scale proposed by Luthans et al. (2007) was used. This questionnaire consists of items adapted from Parker, (1998); Snyder et al. (1996); Wagnild and Young (1993); and Scheier and Carver (1985). Luthans et al. (2007) have not only proposed a composite questionnaire to measure PsyCap, they have successfully used and validated this questionnaire in some recent studies (Luthans et al., 2006b; Luthans et al., 2007a). Self-report responses on this scale were sought on a 5-point scale from 1 ("strongly disagree") to 5 ("strongly agree"). To measure various forms of leadership, a self-report 45-item Multi-factor Leadership Questionnaire Form 5X (Avolio and Bass, 2004) was used. Responses were sought on a 5-point scale from 0 ("not at all") to 4 ("frequently, if not always").

Questionnaires were sent to 90 managers across various professional backgrounds of the construction industry. These managers had been nominated by their immediate bosses who were interviewed in an earlier part of the larger study as 'authentic leaders' in their organisations – who have a sense of purpose, practice solid values; who lead with heart and soul, and who demonstrate self-discipline. After these managers were nominated by their bosses, short briefing sessions with held with them to explain the nature of the study and the research objectives, and to seek their consent to participate in the study. After the briefing sessions, questionnaires were distributed among these managers. Follow-up e-mail messages and telephone calls were made in an attempt to enhance the response rate to the questionnaire survey. However, due to the busy schedule of the managers in the prevailing massive boom in construction activity in Singapore, only 32 completed questionnaires were returned, yielding a response rate of 35%.

ANALYSIS OF RESULTS

Cronbach Alpha values for PsyCap, leadership, and leadership outcomes – effectiveness, extra effort, and satisfaction – were calculated and appear along the diagonals in Tables 1, 2, and 3. Satisfactory results of internal reliabilities for PsyCap (24-items, α = 0.88), PsyCap-Self-Efficacy (4-items, α = 0.85), PsyCap Hope (4-items, α = 0. 73), PsyCap Resiliency (4-items, α = 0.56), PsyCap Optimism (4-items, α = 0.51), transformational leadership (20-items, α = 0.91), transactional leadership (12-items, α = 0.78), and leadership outcomes – effectiveness (4-items, α = 0.61), extra effort (3-items, α = 0.74), satisfaction (2-items, α = 0.56) – led to correlation analysis of responses that are shown in Tables 1 and 2.

The results in Table 1 show that PsyCap is significantly and positively correlated to transformational leadership (0.45*) as well as leadership effectiveness (0.49**). Correlations of PsyCap with transactional leadership (0.29) and extra effort (0.24) are positive although not significant. Transformational leadership is positively and significantly correlated with all three leadership outcomes. Whereas transactional leadership significantly correlates with effectiveness and extra effort; it bears positive but insignificant correlations with satisfaction. Laissez-faire leadership is negatively correlated with PsyCap (-0.38), transformational leadership (-0.25), transactional leadership (-0.01), effectiveness (-0.41*), extra effort (-0.14), and satisfaction (-0.22).

Table 1. Means, Standard Deviations, Reliabilities, and Correlations for Psychological Capital, Leadership, and Leadership Outcomes

Variables	**Mean**	**SD**	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**
(1) Psychological Capital	3.90	0.39	0.88^						
(2) Transformational Leadership	2.95	0.52	0.45*	0.91^					
(3) Transactional Leadership	1.92	0.54	0.29	0.38	0.78^				
(4) Laissez Faire Leadership	0.46	0.42	-0.38	-0.25	-0.01	0.53^			
(5) Effectiveness	3.02	0.41	0.49**	0.69**	0.52**	-0.41*	0.61^		
(7) Extra Effort	2.80	0.60	0.24	0.68**	0.55**	-0.14	0.59**	0.74^	
(7) Satisfaction	3.05	0.51	0.04	0.55**	0.35	-0.22	0.68**	0.56**	0.56^

** Correlation is significant at the 0.01 level (2-tailed); * Correlation is significant at the 0.05 level (2-tailed); ^ Cronbach Alpha for internal reliability

Table 2. Means, Standard Deviations, Reliabilities, and Correlations for components of Psychological Capital and Leadership Outcomes

Variables	**Mean**	**SD**	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**
(1) Psychological Capital (PsyCap)	3.90	0.39	0.88^							
(2) PsyCap Self-Efficacy	4.18	0.52	0.90**	0.85^						
(3) PsyCap Hope	3.99	0.43	0.91**	0.72**	0.73^					
(4) PsyCap Resiliency	3.77	0.37	0.88**	0.80**	0.77**	0.56^				
(5) PsyCap Optimism	3.63	0.43	0.83**	0.62**	0.77**	0.59**	0.51^			
(6) Effectiveness	3.02	0.41	0.49**	0.54**	0.34	0.40*	0.40*	0.61^		
(7) Extra Effort	2.80	0.60	0.24	0.35	0.14	0.06	0.26	0.59**	0.74^	
(8) Satisfaction	3.05	0.51	0.04	0.16	-0.12	-0.10	0.17	0.68**	0.56**	0.56^

** Correlation is significant at the 0.01 level (2-tailed); * Correlation is significant at the 0.05 level (2-tailed); ^ Cronbach Alpha for internal reliability

Table 3. Means, Standard Deviations, Reliabilities, and Correlations for Leadership and Leadership Outcomes

Variables	**Mean**	**SD**	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**	**(9)**	**(10)**
(1) Psychological Capital (PsyCap)	3.90	0.39	0.88^									
(2) PsyCap Self-Efficacy	4.18	0.52	0.90**	0.85^								
(3) PsyCap Hope	3.99	0.43	0.91**	0.72**	0.73^							
(4) PsyCap Resiliency	3.77	0.37	0.88**	0.80**	0.77**	0.56^						
(5) PsyCap Optimism	3.63	0.43	0.83**	0.62**	0.77**	0.59**	0.51^					
(6) Transformational Leadership (TL)	2.95	0.52	0.45*	0.58**	0.26	0.31	0.37*	0.91^				
(7) Idealized Influence (II)	2.93	0.54	0.41*	0.56**	0.27	0.30	0.29	0.91**	0.79^			
(8) Inspirational Motivation (IM)	2.93	0.67	0.46**	0.58**	0.34	0.27	0.38*	0.87**	0.75**	0.83^		
(9) Intellectual Stimulation (IS)	3.01	0.56	0.49**	0.59**	0.28	0.45*	0.37*	0.83**	0.66**	0.66**	0.74^	
(10) Individualized Consideration (IC)	2.95	0.65	0.18	0.29	0.00	0.05	0.26	0.82**	0.63**	0.62**	0.67**	0.64^

** Correlation is significant at the 0.01 level (2-tailed); * Correlation is significant at the 0.05 level (2-tailed); ^ Cronbach Alpha for internal reliability

The results in Table 2 show that three components of PsyCap are significantly and positively correlated to effectiveness (PsyCap-Self-Efficacy = 0.54**; PsyCap-Resiliency = 0.40*; PsyCap-Optimism = 0.40*). PsyCap-Hope is positively correlated with ‘effectiveness’ but this correlation is not significant (0.34). Table 2 also illustrates that PsyCap and its components do not bear any significant correlations with ‘extra effort’ and ‘satisfaction’ of leaders. PsyCap-Hope and PsyCap-Resiliency are, in fact, negatively correlated with satisfaction. This finding is ironical because effectiveness is significantly and positively correlated with both ‘extra effort’ and ‘satisfaction’ as shown in Table 2. Another notable finding in Table 2 is that all components of PsyCap are positively, strongly, and significantly correlated with each other and with overall PsyCap.

Some important findings in Table 3 show that PsyCap is positively and significantly correlated with idealized influence (0.41*), inspirational motivation (0.46**) and intellectual stimulation (0.49**). PsyCap-Self-Efficacy also bears positive and significant correlations with idealized influence (0.56**), inspirational motivation (0.58**) and intellectual stimulation (0.59**). PsyCap-Hope does not bear any significant correlations with components of transformational leadership. However, PsyCap-Resiliency is positively and significantly correlated with intellectual stimulation (0.45*) whereas PsyCap Optimism is positively and significantly correlated with inspirational motivation (0.38*) and intellectual stimulation (0.37*). Table 3 also shows that transformational leadership is positively correlated to all components of PsyCap, although correlations with PsyCap-Hope (0.26) and PsyCap-Resiliency (0.31) are not significant. It is notable that individualized consideration is not significantly correlated with either PsyCap or any of its components.

Tables 1, 2 and 3 also show that PsyCap and transformational leadership are not only positively correlated with each other, but also, they bear positive correlations with leadership outcomes – effectiveness, extra effort, and satisfaction. Given the strong empirical support for transformational leadership in the literature, and the current evidence that it is positively correlated to PsyCap, it is plausible to claim that transformational leaders possess relatively higher levels of psychological capital which leads to positive outcomes of the functioning of leadership within organizations. It is also evident from the data that ‘authentic leaders’ in the current study possess relatively more attributes and behaviours of transformational leadership rather than transactional or laissez-faire leadership.

IMPLICATIONS FOR CONSTRUCTION ORGANIZATIONS

Construction businesses are engaged in an industry that is mostly project based, and in which activities are dynamic, complex, and prone to high risks as its environment is turbulent. As Raiden and Dainty (2006) note, the changing requirements of construction work demands the formation of new teams depending upon the volume and complexity of work. Consequently, many jobs in construction are also project based, resulting in higher performance pressure, lack of organizational citizenship, high turnover, and lack of commitment to the job. High socio-political pressure on construction projects also exacerbates the work pressure. These factors cause discontinuity in organizational learning, growth, and veritable performance.

In the current knowledge age, human resources are indispensable assets which an organization can truly capitalize on, but only if they are properly managed (Luthans and Youssef, 2004). In order to make the most of their human resources, construction organizations need to adopt strategic measures to retain their existing employees and attract new talent. To achieve this, they need to invest in developing the PsyCap of their employees through long- and short-term interventions. Given an established theoretical and research base of PsyCap, the present authors argue that it possesses the potential for improving organizational outcomes in construction businesses. It is plausible to posit that construction organizations with better psychological health are likely to provide superior conditions for their employees, both leaders and followers, to grow and contribute to the achievement of the organizations' objectives. Moreover, it is likely that the employees would feel stronger psychological contracts with their employers which will result in higher motivation, job satisfaction, commitment to the organization, and reduced turnover (Dainty et al., 2000). Such organizations can also be expected to attain self-responsibility and continuous improvement among their employees through organizational learning (Raiden and Dainty, 2006).

High PsyCap construction organizations are also likely to attain greater success in their strategic alliances and other business relationships. Employees with high PsyCap will have better capacity to adjust to new conditions, work in cooperation with their counterparts from other organizations to pursue the project goals. Moreover, as many projects involve players from various cultural backgrounds, employees with high PsyCap will be in a better position to adjust in a cross cultural environment. High PsyCap construction organizations are also expected to face challenges with confidence in their self-efficacy and optimism to realize better outcomes. These organizations will be capable of making a rebound from failure as they would take such failure as a learning rather than constraining factor. Construction organizations with better PsyCap will also develop authentic leaders and followers who, together, will create a positive organizational culture (Toor and Ofori, 2008). Such an atmosphere is ideal for work, and would improve the employees' performance

CONCLUSIONS

Recent developments in the literature on organizations and their behaviour and development support the concept of psychological capital. The current study provides evidence that PsyCap is positively correlated with transformational leadership and leadership outcomes, especially leadership effectiveness. With the increasing complexity of the business world, uncertainty in markets, as well as in employees' attitudes, it is timely for employers to invest in PsyCap development of their leaders so that the impact can be transferred down throughout the organizations' membership. Once organizational leaders are able to master and exhibit positive psychological capacities, it will be easier for lower-level organizational members to follow suit. Future research can, focus on PsyCap development and return on investment in PsyCap development. Also worth exploring is how PsyCap is related to authentic leadership (that is purported in the literature to be at the root of all forms of positive leadership), ethical leadership, organizational well-being, organizational culture, and organizational citizenship behaviour.

REFERENCES

Adler, P. S. and Kwon, S. (2002) Social capital: Prospects for a new concept. Academy of Management Review, 27(1), 17-40.

Avey, J. B. (2007) The performance impact of leader positive psychological capital and situational complexity. Unpublished PhD Dissertation. The Graduate College at the University of Nebraska, Lincoln, NE.

Avolio, B. J., and Bass, B. M. (2004) Multifactor leadership questionnaire. Manual and sampler set, 3rd Ed. Redwood City: Mind Garden, Inc.

Avolio, B. J., and Gardner, W. L. (2005) Authentic leadership development: Getting to the root of positive forms of leadership. Leadership Quarterly, 16, 315-338.

Avolio, B. J. and Luthans, F. (2006) High impact leader: Moments matter in authentic leadership development. New York: McGraw-Hill.

Bass, B. M. and Steidlmeier, P. (1999) Ethics, character, and authentic transformational leadership behaviour. The Leadership Quarterly 199, 10(2), 181-217.

De Saa-Perez, P. and Garcia-Falcon, J. M. (2002) A resource-based view of human resource management and organizational capabilities development. International Journal of Human Resource Management, 13(1), 123–40.

Gallup Leadership Institute (GLI) (2006) Psychological capital (PsyCap): Measurement, development, and performance impact. Briefing Report 2006-01.

Gardner W. L. Schermerhorn J. R. (2004) Unleashing individual potential: performance gains through positive organizational behaviour and authentic leadership. Organizational Dynamics, 33, 270-281.

George B. Sims P. (2007) True North: Discover your authentic leadership. J-B Warren Bennis Series, San Francisco: Wiley.

George B. Sims P. McLean A. N. and Mayer, D. (2007) Discovering Your Authentic Leadership. Harvard Business Review, 85 (2), 129-138.

Jensen, S. M. and Luthans, F. (2006) Relationship between entrepreneurs' psychological capital and their authentic leadership. Journal of Managerial Issues, 53(2), 254- 273.

Luthans, F. (2003) Positive organizational behaviour: Implications for leadership and HR development and motivation. In L. W. Porter, G. A. Bigley, and R. M. Steers (Eds.), Motivation and work behaviour (178–195). New York: McGraw-Hill/Irwin.

Luthans, F., and Avolio B. J. (2003) Authentic leadership development. In: Cameron, K. S., Dutton, J. E., Quinn, R. E. (Eds.) Positive organizational scholarship: foundations of a new discipline. San Francisco (CA): Berrett-Koehlerr (241–58)

Luthans, F., and Youssef, C. (2004) Human, social, and now positive psychological capital management: Investing in people for competitive advantage. Organizational Dynamics, 33(2), 1-22.

Luthans, F., Avolio, B. J., Walumbwa, F. O., Li, W. (2005) The psychological capital of Chinese workers: Exploring the relationship with performance. Management and Organization Review, 1, 249-271.

Luthans, F., Avolio, B. J., Norman, S. M., and Avey, J. B. (2006a) Psychological capital: Measurement and relationship with performance and satisfaction. Gallup Leadership Institute Working Paper. Lincoln, NE: University of Nebraska.

Luthans, F., Avey, J. B., Avolio, B. J., Norman, S. M. and Combs, G. M. (2006b) Psychological capital development: Toward a micro-intervention. Journal of Organizational Behaviour, 27, 387–393.

Luthans, F., Youssef, C. and Avolio, B. J. (2007a) Psychological Capital: Developing the Human Capital Edge. Oxford, England: Oxford University Press.

Luthans, F., Avolio, B.J., Avey, J.B., and Norman, S.M. (2007b) Positive psychological capital: Measurement and relationship with performance and satisfaction. Personnel Psychology, 60, 541-572.

O'Leary, B. S., Lindholm, M. L., Whitford, R. A., and Freeman, S. E. (2002) Selecting the best and brightest: Leveraging human capital. Human Resource Management, 41(3), 325-340.

Norman, S. M. (2006) The role of trust: implications for psychological capital and authentic leadership. Unpublished PhD Dissertation. The Graduate College at the University of Nebraska, Lincoln, NE.

Raidén, A. B. and Dainty, A. R. J. (2006) Human resource development (HRD) in construction organisations: An example of a 'chaordic' learning organisation? The Learning Organization, 13(1), 63-79.

Skarlicki, D. P., Latham, G.P., and Whyte, G. (1996) Utility analysis: Its evolution and tenuous role in human resource management decision making. Revue Canadienne des Sciences de l'Administration, 13(1), 13-21.

Snell, S.A. (2002) Social capital and strategic HRM: It's who you know. Human Resource Planning, 22(1), 62-65.

Toor, S. R., and Ofori, G. (2008) Leadership in the construction industry: Agenda for authentic leadership development. International Journal of Project Management. doi:10.1016/j.ijproman.2007.09.010.

Walumbwa, F. O., Avolio, B.J., Gardner, W.L., Wernsing, T.S., Peterson, S.J. (2008) Authentic leadership: Development and validation of a theory-based measure. Journal of Management, 34(1), 89-126.

Wright, P. M., and McMahan, G. C. (1992) Theoretical perspectives for strategic human resource management. Journal of Management, 18(2), 295-320.

Youssef, C. M., and Luthans, F. (2007) Positive organizational behavior. In: S. Lopez, and& A. Beauchamp (Eds.), Encyclopedia of Positive Psychology. Oxford, UK: Blackwell.

LEADING THE DEVELOPMENT OF SUSTAINABLE ORGANIZATIONS

George Ofori
National University of Singapore
bdgofori@nus.edu.sg

Shamas-ur-Rehman Toor
National University of Singapore
shamas@nus.edu.sg

The term "sustainability" has become popular over the last two decades and will continue to feature in both the academic and common vocabulary for decades to come. It refers to a process or state that can be maintained at a certain level indefinitely. In the organizational context, sustainability refers to an organization that can develop and grow over time while benefiting its stakeholders, and society, without causing any adverse impacts on the natural environment. To ascertain the key principles for developing sustainable organizations, an in-depth analysis of interviews with 45 senior executives in the construction industry in Singapore was undertaken. This resulted in a framework which presents 10 such principles. These principles related to: organizational culture and values, business strategizing, business growth and success, client service, company's leadership of the industry, product/service differentiation, geographical diversification, overall corporate management system, human resource management, and knowledge management. The analysis showed that organizations that follow these principles are able to achieve sustainability for their people, stakeholders and society as a whole. Moreover, their activities tend to be in harmony with the natural environment. They are ecologically sustainable systems that are both economically successful and socially responsible.

KEYWORDS: sustainable organizations, construction industry, Singapore

INTRODUCTION

In most countries, the construction industry is experiencing significant growth in demand and activity. This growth is putting considerable pressure on the resources required by the industry. Thus, organizations in the construction industry are now finding it increasingly difficult to deliver their projects. The firms face parallel project deadlines. Indeed, in some cases, there is even a shortage of construction firms which are able and willing to undertake the projects which clients wish to invest in. On the other hand, the situation is the reverse during times of economic downturn when most organizations are forced to take measures to reduce their activity and their sizes. This vicious cycle of "boom and bust" has largely resulted in construction as an unattractive business in which turbulence is part of the system. Failures in construction businesses, including large ones are quite common. Toor and Ogunlana (2008) observe that scarcity of construction materials and human resources has intertwined with existing socioeconomic and political problems resulting in added pressure on construction firms.

Construction is a key sector in the pursuit of sustainable development. The environmental impact of construction activity is seen in terms of the depletion of the natural resources from which it obtains its materials, and the various emissions during the construction process and the use of the buildings. The objective of this article is to present findings from a field study of organizations that have survived difficult times – such as many economic recessions, and planned or forced organizational change. The policies they adopted, the active response they made to the environmental changes, their preparedness for crises, and effective organizational leadership enabled them to endure the challenges and grow over time.

BUSINESS FAILURES IN CONSTRUCTION

Many studies show that business failures are common in construction (see: Kangari, 1988; Russell, 1991; Abidali and Harris, 1995; Kale and Arditi, 1999; Arditi et al., 2000; Schaufelberger, 2003; Koksal and Arditi, 2004). Although majority of these studies were undertaken in the US, construction business failures are reported in other parts of the world (see: Singh and Tiong, 2006; Jannadi, 1997; Enshassi et al., 2006). In the construction industry, business failure can be generally categorized into failure of a project or failure of an organization. Problems causing project failures have been extensively studied. Recently, Toor and Ogunlana (2008) observed that major problems which construction projects typically face include: inadequate procurement system, lack of resources, discrepancies between design and construction, lack of project management practices, variation orders, communication lapses, cultural issues, and different interests of the participants

With reference to organizational failures, Koksal and Arditi (2004) have noted various reasons including insufficient capital, lack of business knowledge, fraud, lack of managerial experience, lack of line experience, lack of commitment, poor working habits, over expansion – and environmental problems such as weaknesses in the industry, the impact of various disasters, poor growth prospects, and high interest rates. Dun and Bradstreet noted that construction businesses failed at a higher rate between 1988 and 1997 as compared to all other businesses. Similar reports have been published by Business Information Tracking Series (BITS) and BizMiner which show that business failures are significantly higher in construction than in other industries. Studies have shown that economic cycles and political environment (Enshassi et al., 2006) and lack of effective business plan (Schaufelberger, 2003) are the key reasons of business failure in construction. Davidson and Maguire (2003) found the top ten reasons for contractor failure to include: growing too fast, obtaining work in a new geographic region, increase in the sizes of single jobs, obtaining new types of work, high employee turnover, inadequate capitalization, poor estimating, poor accounting systems, and poor cash flow

SUSTAINABLE ORGANIZATIONS

Humans are social species and are driven to make alliances so that they can exist in a social environment where they can fulfil their personal needs. Despite this, some individuals engage in. Lozano (2008) observes that the tendency towards individualistic and self-serving behaviors has gained deeper roots during the last century which he describes as “The Century of Self”. He explains that individualistic behaviors of humans or organizations lead to conflicts, detrimental competition, selfish attitudes, and a culture in which "the quest for profit maximization is reciprocally transferred from individuals to groups to organizations to societies, in complex simultaneous and sequential cybernetic behavioural loops" (p. 500). In such a culture, individuals and organizations start working around the agenda of "survival" at the expense of others, leading to a vicious circle of unhealthy competition in which "self" is more important than anything else. When organizations are caught up in the vicious circle of self-service, they engage in actions that lead to adversarial relationships with other stakeholders in the society. How can a society become sustainable if smaller units – individuals, teams, groups, and organizations – continue to engage in behaviors leading to centered around "survival" rather than "sustainability".

Starik and Rands (1995) suggest that an ecologically sustainable world would comprise ecologically sustainable societies, cultures, political and economic systems, organizations, and individuals. They argue that sustainability can be achieved by simultaneously recognizing and addressing the actions and resulting interactions of each of the entities influencing its attainment. They further suggest that "…ecological sustainability is the ability of one or more entities, either individually or collectively, to exist and flourish (either unchanged or in evolved forms) /or lengthy timeframes, in such a manner that the existence and flourishing of other collectivities of entities is permitted at related levels and in related systems" (p. 909). Ecosystems are essentially the places where the interests of people, organizations, and natural environments are interdependent and interlinked (Bradbury, 2003; Manring, 2007).

Understanding the need for a sustainable society, researchers and experts are increasingly stressing the need to develop organizations that are sustainable in terms of structure (Osborn, 1998; Kjellberg and Werneman, 2000); culture, activities, and attitudes (Lozano, 2008); values and strategies (Starik and Rands, 1995); networks and relationships (Osborn, 1998; Manring, 2007). In the context of structure, Osborn (1998) argues that sustainable organizations need to organize themselves around processes instead of hierarchies. They must overcome the paradox of "competitive agility". To be sustainable in a rapidly changing and global world, organizations must be flexible – so that they can respond to change – and stable – so that they can capitalize on their strengths (Osborn, 1998). Organizations working with temporary team structures must have sustainable structures and new team constellations (Kjellberg and Werneman, 2000). Alliances, partnerships, and joint ventures are likely solutions that can help organizations establish sustainable networks that have the resiliency to respond to crises and chaos (see: Osborn, 1998).

Bradbury (2003) asserts that sustainable organizations are able to maintain their financial, human, social, and environmental resources over the long term. By exercising a systems approach, they are able to view the whole picture in which they find themselves interdependent on, and interlinked with, other stakeholders in the society. Such organizations are likely to be led by authentic leaders (Ofori and Toor, 2008) who have the highest sense of ethics, morality and personal values. They build an environment of mutual trust, optimism, altruism and transparency in teams (Toor and Ofori, 2008). Such leaders treat the pursuit of sustainability as a cause, live it as a vision, and spread it as a mission. In the opinion of Starik and Rands (1995), such leaders are considerate and sensitive about ecological realities; they are effective analysts of various external environments and the contexts they operate in; they are astute observers of their own organizations; they effectively manage change and are able to reconcile multiple internal consistencies with external contingencies. Such leaders do not fall victims to Sternberg's (2007) fallacies of unrealistic-optimism, egocentrism, omniscience, omnipotence, invulnerability, and moral disengagement.

Lozano (2008) recognizes that the highest priority of organizations is economic survival; however, they must collaborate with other stakeholders to build a larger sustainable system. This is achieved through consistent organizational learning that encourages alignment – among individuals and groups across different levels of organization – and congruency – that refers to consistency in informational attitudes, emotional attitudes, and behavioural attitudes. In these regards, Lozano (2008) refers to the Japanese concept of "Kyosei" – which means the spirit of cooperation – that is achieved in five stages or layers of collaboration among labour, companies, customers, governments, and other stakeholders. Collaboration across different layers helps to achieve the desired results which are beneficial to both the organizations and the larger ecosystems they are part of.

STUDY APPROACH

The current study used a grounded theory methodology to examine authentic leadership development and influence in the construction industry of Singapore. A total of 49 senior practitioners in the industry were interviewed/observed (see: Table 1 for demographic details). These were nominated to be authentic leaders (see: Ofori and Toor, 2008) and successful professionals by their peers in their respective professions and the industry. The interviews mainly focused on the leaders' developmental experiences and strategies they used to influence their followers and organizations. The interviews were audio-recorded, transcribed and then analyzed using the principles of grounded theory methodology. Theoretical sampling was also carried out until the resulting categories reached the saturation stage. In addition to various other categories showing how authentic leaders influence their organizations, "building sustainable organizations" also emerged as a major approach that authentic leaders adopted to lead their organizations. Ten main issues which were highlighted by the interviewees under "building sustainable organizations" are described in the subsequent sections.

Table 1: Demographic details of subjects

Attribute	**Range/Properties**	**Cases**	**Attribute**	**Range/Properties**	**Cases**
Gender	Male	42	Experience in the Industry	5-10 Years	3
	Female	7		10-15 Years	4
Age Group	30-40	9		15-20 Years	6
	40-50	14		20-25 Years	12
	50-60	23		25-30 Years	10
	60-70	3		30-35 Years	12
Company Type	Architects	8		35-40 Years	2
	Consultants	9	Position in the Organization	GM/Deputy GM	2
	Contractors	7		Managers	7
	Developers	11		Directors	22
	Quantity Surveyors	7		CEO/Deputy CEO	10
	Architects + Engineers	4		Managing partner	2
	Others	3		President/Vice President/Chairman	6

FINDINGS

The leaders shared how they had gone through various difficult times and had take appropriate steps in order to build organizations that were sustainable. A clear message that emerged from the discussions was that authentic leaders were persistently involved in building sustainable organizations to which they belonged. One of their fundamental motivations was to take their respective organizations to further heights of achievement and success. The CEO of a developer's firm noted:

> …I have to do the best I can and build an organization better than what it is. We don't see our business as one for short-term gain. We don't see ourselves as getting the bottom line gains. I would like to see my organization becoming one people would be attracted to, where people share the same values. An organization which is easily understood, an organization with diversity of skills, and talent. It [our organization] has to be self ecosystem, and a microcosm of the society…a place for everybody.

The Chairman of a quantity surveying outlined a number of points that are imperatives for sustainable businesses. He reflected that: "…the recession of 1976 really taught me about what I should do to have a more sustainable business. Its one thing it taught me in that year was that the quality of service is very important. [Then] to build up the skill base and the domain knowledge, and then to diversify geographically; to look at the needs of the client because every organization has its own needs, and these also differ from one country t the next. So 1976, was I think, a year that taught me a lot about…" He went on talking about his desire to further sustain his organization:

> I would like to build a sustainable firm and a sustainable leadership, and for this leadership to do even better than what we have achieved in the decades ahead,... to build a better business and better people … great leaders build great companies, and they build people, they don't build themselves.

These excerpts from some of the interviews show that authentic leaders constantly endeavoured to achieve sustainability within their own organizations. As a result of further analysis of interviews of authentic leaders, sub-categories that emerged under the broader category of 'building sustainable organizations' are shown in Figure 1.

Positive organizational culture and values were underscored by several interviewees as key to developing sustainable organizations. The executive director of an architectural practice observed that:

> …what is unique so far as [our organization] is concerned…is that it is a very warm and cozy environment. It is a very family oriented firm; it is a very close staff oriented firm, in the sense that we even have our own social club…

The chairman of a quantity surveying firm emphasized the importance of shared values between the organization and its members. He observed:

> We come through with the same core values, the same vision. It is a very strong family business ... If you have a group of people with the same core values, same vision, and then when the leadership thinking is in this mould …I would use the word, "very generous leadership"…we can achieve a lot.

Some of the leaders noted the importance of strategic management in business development. The CEO of a consulting firm explained this:

> What we call a strategic talk, we do that every year. And that is important … we take all the directors away to Sentosa for one day every year ... Every director has to present a paper on what changes we need to make in the company, where should we go from here, what should be the focus or area of our next diversification, what should be our next move to survive in the face of competition. We do all these things every year because if your [business] model is five years old it cannot survive!

The Chairman of a quantity surveying firm also shared the importance of strategic management, saying: "…in our group, fortunately, we always do a 3-5 year forecast of our business, not only in financials, but how the business would shape up, what sort of services would be demanded, and how the services would be reshaped by events, by the changing requirements of the developers." He said that the firm's business partners were important in its quest to succeed in the market. He observed:

> …in every business, you need to collaborate with somebody. You need to find partners who have the skills you need to put into your team … In such partnerships, you have to safeguard the integrity of your firm. You must ensure that your reputation of high standards in terms of ethics is taken care of.

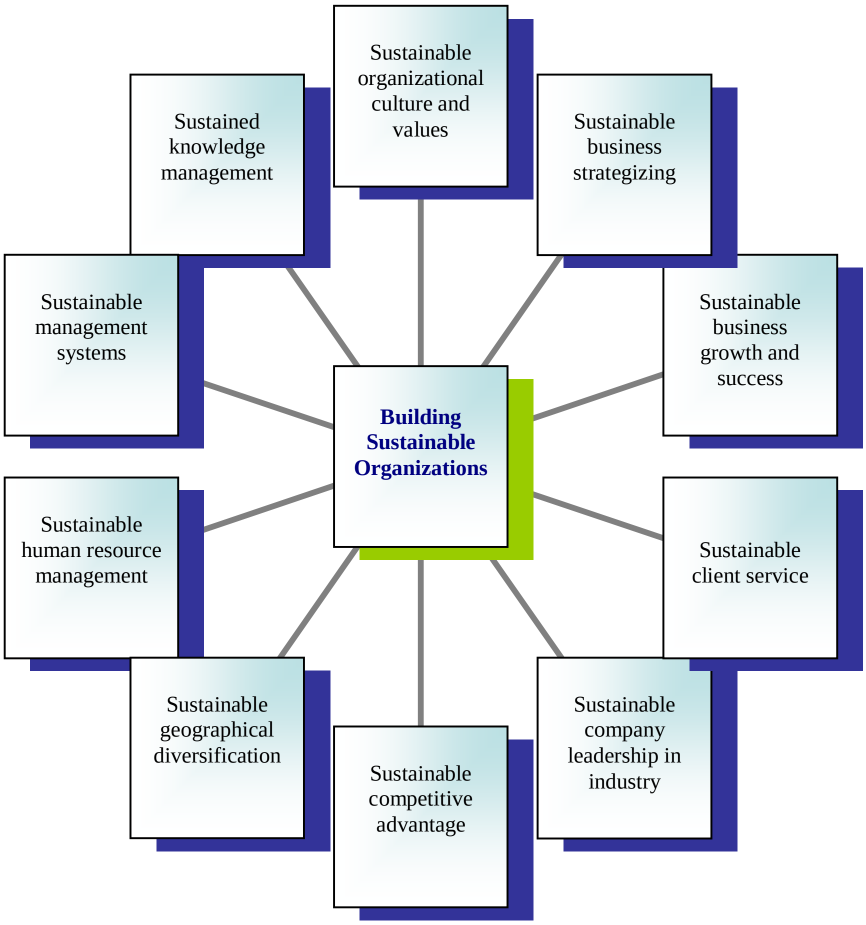


Figure 1. Characteristics of sustainable organizations

The leaders highlighted the significance of sustainable growth and success of their businesses. Many of them noted that their organizations were constantly striving to maintain the success they had achieved. The general manager of a developer's group observed: "…it is a never ending race. And if you stop and say 'I am very successful now', it means that you have stopped running. Then I think your competitors will catch up with you. Then you have become complacent. Therefore, I think the term here success, I don't think I have this success, because there are more things to do, more things to go."

A CEO underscored the importance of sustainable and controlled growth. "We don't want to stray too much, and then one day, suddenly realize that we are every where and we don't know how to manage. [To] focus on the areas where we have competency, we identify and define very clearly the areas where we are competent, and we use this competency", he noted. The leaders talked about sustaining their relationships with their clients. They emphasised that it was important to maintain the trust of the clients, by providing an excellent service. The CEO of a developer's firm observed:

> …we have to know what is it that the market and the customers want. If we don't start from that point, whatever we do, it is never really going to spot on and you need luck and randomness of luck to turn the failure into success.

A senior executive in a developer's firm also shared her viewpoint about client service: "…the philosophy is to give the best value for money. To make sure that …we give people the best investment in their homes."

The leaders noted the significance of company leadership within the industry. In the opinion of many of the interviewees, leadership is not just about developing personal leadership. It was also important to develop the company's leadership in the industry. The CEO of a quantity surveying firm explained:

> …my own thoughts about being a leader is not only establishing oneself in the office but also establishing oneself in the profession and in the industry. So, that has always been my target. And in so doing, to drive the firm not only for myself but drive the firm and all who work with me in the firm to be recognized as leaders in the industry.

The CEO also shared: "…the greatest challenge I think will always be to maintain the leadership role of the firm, not the individuals; and at the same time, to ensure that the firm continues to prosper and grow". To build a sustainable organization, leaders also stressed on the need for developing long-term competitive advantage to differentiate them from other firms in terms of products and services they offer. The CEO of an engineering consultancy firm noted:

> …we were able to differentiate ourselves from other firms. I have always believed that we are in the technology business. Therefore, we must be able to do unconventional things, difficult things that others would not do.

A senior director in an architect's firm also noted: "We are [a] multi-professional firm … There are clients who prefer firms like that. But there are clients who like firms which are specialized in their own disciplines. … We have an integrated service and we want to sell this advantage."

An executive director in an architectural practice observed the importance of innovation and creativity as competitive advantage:

> …I think the architectural profession is a unlike construction. We have to be innovative and creative in our products. I see this as a challenge because if you don't renew yourself, the outsider will look at you as a rather outdated and conservative company which doesn't do innovative design work.

The leaders highlighted the significance of sustainable geographical diversification as part of their efforts to develop competitive advantage of their firms. The CEO of a consulting group observed:

> …if we are operating in Singapore and the market here is going down, what are the options left to us? Do we downsize? Or do we find work somewhere else? Typical guides say that if business workload comes down from $25 billion per annum to $10 billion per annum and the [firm] size should be reduced from 100 people to 40 people. We say no, if we become 40 people we will never be able to pick up a big job again because everybody will say you are too small so we said we want to keep our 100 people. We will look for work overseas; we will extend our operations to China and set up offices there, in Beijing and Shanghai …We went to the Middle East, and we set up offices in Dubai, Abu Dhabi, and Qatar. As a result, our size has grown. From 200 people, we have become 350 people.

The CEO of a developers firm also observed the importance of autonomy of foreign offices:

> We adopted the philosophy from our first day … don't try to have a centralized policy when we come to diversify [geographically] … I trust the lieutenants that I employed … I let them have a very high level of autonomy. And because they are operating in India, in the Middle East, in China, in Southeast Asia, I cannot have too many things, too many central policies that are limiting them. They must have a lot of autonomy, to operate … so the important thing is to select the right people, then trust them, let them develop.

The leaders also emphasized the need to understand the local market, culture, and way of work wherever their firms operate. One senior executive noted: "…market research is important. You really need to know what is happening in the market. We can rely on the internet but we also need to network and talk to people. We invest a lot of time into market research. Market intelligence is the most important word I should use." Another interviewee pointed out the importance of understanding the local culture and working style, saying:

> You have to understand the culture and how things have to be done ... Wherever you go, you have to be patient. You are bound to have surprises. You are not so used to living in the other countries. In some countries, you have to make sure that you don't shake hands with ladies straight away. You can't shake hands everywhere.

Many of the leaders underscored the importance of corporate management systems, particularly in the case of overseas branches. The CEO of a consulting firm noted:

> …You must have a system of accountability … Leaders should not try to micro manage other people. You also can't let everybody loose … there must be, somehow, a system for accountability and corporate KPIs and you need to monitor them.

The chairman of another consulting group explained in length about some of the management systems his company had established to cooperate across the borders. He noted:

> …We have set up systems, where basically we have standard drawing templates, calculation spreadsheets, very rigorously monitored methodologies …. There was always a possibility of bringing in some of the knowledge and the institutional framework and systems … we built a stimulus-integrated platform to deliver work anywhere … we can take a job here [Singapore] … part of the design might be done here, part

> of it might be done in Auckland, in Wellington or in Christchurch. The drafting can be done in Myanmar, or in Jakarta, and then we pull it all together again here … We call it remote resourcing. People talk about outsourcing because they send it to other companies; we do remote resourcing because we are not outsourcing the work; it belongs to us …

The importance of human resources and human resource management was noted by all the leaders. The highlighted the need to attract, retain and develop talent. The director of an architectural consultancy firm noted:

> …We have to bring in new blood and new directors who are good in design. So we constantly keep track of staff who are good in design work and who have a broad outlook of the future. That's why we have recently recruited some directors who are fairly young, below the age of 40. So this is how we have to get the best people to be in the management team. This is very critical.

The director of an architects' firm also shared some of his firm's human resource management policies:

> … We want to impart our knowledge to the young people. We want to grow uniformly together in this firm. We want to create a path for each individual architect. Also, we have a growth path for everyone in the firm, down to the draughtsman. We want people to improve. If you are a draughtsman and you can come up as a construction manager, I believe we have a path for you, as we have for everyone.

Leaders talked at length about the importance of knowledge for leadership. They also expressed their desires to have knowledge management through various means. They were determined to share their knowledge with others so that their followers can also learn, grow and become leaders in their respective fields. For this reason, many of the leaders were consciously co-ordinating the building of knowledge management systems within their firms. One of them said:

> …I came up with knowledge management. Knowledge in the office should be retained. Previously, if a person went, his knowledge went with him. Now we retain the knowledge. I am conducting classes every Friday now. I find that when I conduct classes, it helps me; it reinforces my own learning and understanding.

These excerpts from the interviews show that authentic leaders are primarily driven to build sustainable organizations. Such organizations are not only sustainable with respect to their internal working – meaning that they are self-ecosystems – but they also function as part of the larger ecosystems – the societies in which they exist. Sustainable organizations are not only responsive to the needs of their stakeholders – employees, customers, product end-users, suppliers, partners, shareholders, and so on – but they also deal with social and natural environment in more responsible manner. These qualities of sustainable organizations earn them a long-term competitive advantage and sustainability through which they are better able to not only sustain but also grow and expand as compared to their competitors.

CONCLUSION

To build a sustainable future, efforts need to be integrated at individual, organizational, and societal level. This paper attempted to identify the main characteristics of sustainable organizations. It also makes proposals for future research in this emergent area of research. The approaches which the leaders interviewed adopted in their organizations included: business models that were responsive to change, encouraged diversification and competitiveness, strategically aligned the organizational vision and services, and focused on the development of a positive organizational culture. These organizations are termed as "sustainable organizations". By following these principles, organizations will not only be economically successful, they will be better able to realize their efforts to achieve sustainable development for society. By demonstrating that they are environmentally conscious, economically viable, socially equitable, professionally competent, and responsible and ethical, organizations can attract and retain high-calibre people who are driven by their desire to make a difference in the world. This, in turn, will make these firms further sustainable, as microcosms of the larger society.

REFERENCES

Abidali, A.F. and Harris, F. (1995) A methodology for predicting failure in the construction Industry. Construction Management and Economics, 13, 189–196.

Bradbury, H. (2003). Webs not Kevlar: Designing sustainable organizations. Reflections: The Society for Organizational Learning Journal, 4(4), 65-68.

Davidson, R.A. and Maguire, M. G. (2003) Ten most common causes of construction contractor failures. Journal of Construction Accounting and Taxation, January/February, 35-37.

Enshassi, A., Hallaq, K., and Mohamed, S. (2006) Causes of contractors' business failure in developing countries: The case of Palestine. Journal of Construction in Developing Countries, 11(2), 1–14.

Jannadi, M.O. (1997) Reasons for construction business failures in Saudi Arabia. Project Management Journal, 28(2), 32–36.

Kale, S. and Arditi, D. (1999) Age-dependent business failures in the U.S. construction industry. Construction Management and Economics, 17, 493-503.

Kjellberg, A. and Werneman, A. (2000) Business innovation - innovative teams, competence brokers and beehive structures - in a sustainable work organization. Annals of the ClRP, 49(1), 355-358.

Koksal, A. and Arditi, D. (2004) An input/output model for business failures in the construction industry. Journal of Construction Research, 5(1), 1-16.

Lozano, R. (2008) Developing collaborative and sustainable organizations. Journal of Cleaner Production, 16, 499-509.

Manring, S.L. (2007) Creating and Managing Interorganizational Learning Networks To Achieve Sustainable Ecosystem Management. Organization and Environment, 20(3), 325-346.

Ofori, G. and Toor, S.R (2008) Leadership in sustainability in construction. Presented at the CIOB International Construction Conference: "Regional Outlook and Sustainability", February 20, Singapore.

Osborn, C.S. (1998) Systems for sustainable organizations: emergent Strategies, interactive controls and semi-formal information. Journal of Management Studies, 35(4), 481-509.

Russell, J.S. and Jaselskis, E. J. (1992) Quantitative study of contractor evaluation programs and their impact. Journal of Construction Engineering and Management, 118, 612–624.

Starik, M. and Rands, G. P (1995) Weaving an integrated web: multilevel and multisystem perspectives of Ecologically sustainable organizations. Academy of Management Review, 20(4), 908-935.

Sternberg, R.J. (2007) A systems model of leadership – WICS. American Psychologist, 62(1), 34–42.

Seydel, A., Wilson, O. D., and Skitmore, R. M. (2002) Financial evaluation of waste management methods: a case study. Journal of Construction Research, 3(1), 167-179.

Toor, S. R. and Ogunlana, S. O. (2008) Problems causing delays in major construction projects in Thailand. Construction Management and Economics, 26(4), 395-408.

Toor, S. R. and Ofori, G. (2008) Leadership in the construction industry: Agenda for authentic leadership development. International Journal of Project Management. doi:10.1016/j.ijproman.2007.09.010.

CHANGE MANAGEMENT IN THE IMPLEMENTATION OF COLLABORATION ENVIRONMENTS

Bilge Erdogan
SCRI, School of Built Environment, University of Salford
B.Erdogan@salford.ac.uk

Chimay J. Anumba
Department of Architectural Engineering, Pennsylvania State University
anumba@engr.psu.edu

Yasemin Nielsen
Department of Civil Engineering, Middle East Technical University
ynielsen@metu.edu.tr

Dino Bouchlaghem
Department of Civil and Building Engineering, Loughborough University
N.M.Bouchlaghem@lboro.ac.uk

Although emerging technologies offer the construction industry many opportunities for IT-enabled collaboration environments, the companies adopting these technologies usually fail in achieving the full benefits from their implementations. The reason for this is found to be focusing too much on the technical factors and ignoring or underestimating the factors related to change, implementation, human and organizational factors, and the roles of the management and end-users. This paper summarizes the findings of a three-year research project aimed at finding out how to introduce collaboration environments to construction organizations and how to manage the changes required in order to obtain the full benefits from their implementation. Firstly, the theoretical concepts and previous work on collaboration environment implementations in construction industry, and change management (with a focus on organizational change management) are reviewed. Secondly, the results of case studies carried out in the UK construction industry are presented in order to show the perspectives and approaches of the construction organizations on the implementation of collaboration environments. Thirdly, the organizational change management framework developed to implement collaboration environments is introduced and the computer based prototype automating a part of the framework is explained. Fourthly, the evaluation of the framework and the prototype are presented. Finally, the conclusions drawn from the research are summarised and recommendations for further research are made.

KEYWORDS: Construction industry, collaboration, collaboration environment, organizational change management, human factors, framework

INTRODUCTION

In the construction sector, traditionally, a project is divided into a series of sequential and discrete operations undertaken by individual parties (Egan, 1998). The traditional separation of design from execution, the uniqueness of each project, and the temporary teams set up for each project are some of the aspects that result in a complicated and complex construction process. Emerging technologies offer the construction industry an opportunity to address this complexity. With the emergence of technological innovations, distance and spatial boundaries have been blurred to the point where any organization can theoretically participate in a design or construction project in any location (Chinowsky and Meredith, 2000).

Much of the recent work in construction has focused on the delivery of Web-based technological solutions, collaborative visualisation, virtual reality and CAD applications, and knowledge management systems and technologies. The rapid developments in Internet and Web-based technologies have led construction researchers to focus on the development of collaboration solutions for globally dispersed project team members. Many collaboration tools and systems are currently in use and the industry is constantly searching for new, more efficient and more effective IT-based collaboration methods. Analysing the adoption of collaboration technologies in terms of the traditional product lifecycle approach, Wilkinson (2005) argued that the construction industry had successfully passed the development and introduction phases and by the mid-2000s had gone on to the growth phase. Likewise, in a case study-based research conducted by Ruikar et. al (2005), the construction companies were found to be early adopters of extranet technology for collaboration. However, although there have been some successful examples, the benefits of collaboration tools are not yet proven industry wide (Allen et. al, 2005). The problem in the construction sector is not a lack of technology but more a lack of awareness of how to fully exploit it and how important cultural changes are in order to allow this to happen (Betts and Smith, 1999).

According to a research project that gathered information on the experience of 45 leading experts (researchers and consultants) in the UK, 80-90% of IT investments do not meet their performance objectives (Clegg et. al., 1997). The reason for this is found to be rarely technical but related to change, implementation, human and organizational factors, and the roles of the management and end-users, whereas the major failure reason can be defined as the lack of attention to the human and organizational aspects of IT adoption. Focusing too much on technical factors may result in technically excellent systems which are incompatible with the organization’s structure, culture and goals (Laudon and Laudon, 2000) since it neglects to consider how the new technology interacts with working practices, work organization design, job design, and work processes (Clegg et. al, 2001). While introducing a new technology, it should be kept in mind that the construction industry is a conservative industry that does not welcome change very easily. There have been several research efforts that discuss the link between the IT adoptions and the accompanying change (Kuruppuarachchi et. al, 2002;. Maguire, 2000; Gardner and Ash, 2003; Bartoli and Hermel, 2004; Cheng et. al, 2001). However, very little research has been done on how these changes should be carried out.

RESEARCH PROJECT AND METHODOLOGY

The-research project on which this paper is based was aimed at investigating how to introduce collaboration environments to construction organizations and how to manage the changes required in order to obtain the full benefits from their implementation. The research project consisted of stages:

- **Stage 1** aimed at reviewing the theoretical concepts and previous work on collaboration environment implementation in construction and on change management with a focus on organizational change management. Therefore, the research methodology adopted for this stage was literature review.

- **Stage 2** aimed at investigating the current collaborative working approaches in construction organizations and how collaboration environments are implemented. This investigation is carried out through case studies conducted in UK construction industry. The findings are further analysed through a systems thinking approach and causal relations were obtained for the factors affecting the success of collaboration environment implementations.

- **Stage 3** aimed at finding a way to implement collaboration environments on construction projects and to carry out the organizational changes required for their effective implementation. An organizational change management framework was developed for the implementation of collaboration environments.

- **Stage 4** aimed at automating the project organization level of the framework. The methodology adopted was rapid prototyping.

- **Stage 5** was the final stage of the research which aimed at evaluating the framework and the prototype developed in stages 3 and 4. Evaluation research was adopted as the research methodology.

The following sections explain these work packages in detail and summarise the methodologies adopted and the findings obtained in each.

REVIEW OF THEORETICAL CONCEPTS AND PREVIOUS WORK IN THE RESEARCH AREA

Reviewing previous studies in the research area and seeking any potentially relevant theories form an essential early part of every research (Blumberg et. al, 2003; Fellows and Liu, 2003). The research process started with the review of previous research on collaboration environment implementation in construction. From this review, the failure of collaboration environments to achieve the full benefits expected was found to be related to the underestimation of organizational and people issues. Seven key issues were revealed for the success of collaboration environment implementations (Erdogan et. al, 2008):

1. User requirements capture;
2. Overcoming user resistance to change;
3. User involvement;

4. Proper planning/ project management;
5. Strategic IT implementation;
6. Buy-in;
7. Trust.

The results of the review showed that there is potential to benefit from organizational change management concepts in order to address these key issues. Therefore, another review on change management with a particular focus on organizational change management was carried out.

The second review provided a huge amount of previous research in the organizational change management area, especially in the social sciences. Theoretical approaches, techniques and models for organizational change management were studied. The enablers and barriers were identified. It was found that very little research had focused on how to manage the change resulting due to a collaboration environment implementation. A summary of the findings of the second review can be seen at Erdogan et. al (2005). The specific aim and objectives of the research were determined when two reviews were analysed together. The research process in WP1 is represented in Figure 1.

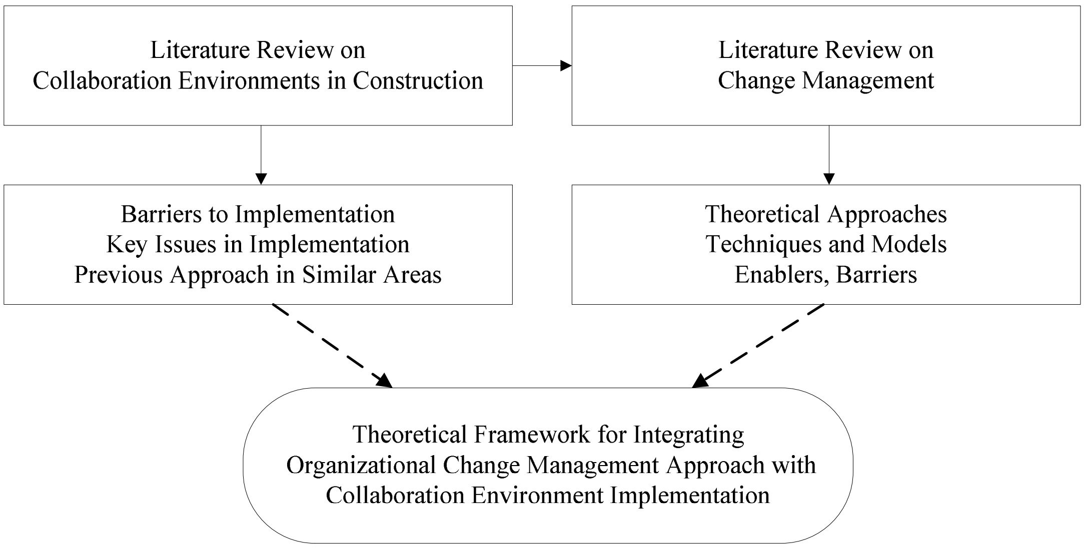


Figure 1: The Literature Review Process for the Research (Erdogan, 2008)

INVESTIGATE THE CURRENT COLLABORATIVE WORKING AND IMPLEMENTATION APPROACHES IN CONSTRUCTION ORGANIZATIONS

From the literature review, it was established that the main problem in the implementation of collaboration environments is not related to technical issues but people and organizational issues. In order to review the current collaboration environment (CE) implementation and collaborative working approaches in construction companies, nine case studies were carried out. Semi-structured face-to-face interviews were arranged with senior level managers in two engineering consultancy, three contracting, two architecture and two technology providing organizations. Each interview lasted approximately one hour. The data collected was grouped under five headings: 1) Background information; 2) Collaboration environment implementations in the company; 3) Success level and success criteria of collaboration environment implementations, 4) User involvement during collaboration environment implementation stages; and 5) How the collaboration environments were implemented and the factors affecting their success.

The interviews were recorded using a digital recorder and then fully transcribed. These transcripts were analyzed using a combination of qualitative coding, interpretation and cross-case analysis whereas the responses to closed questions were analyzed quantitatively. Following the coding principles, the textual data in each transcript was broken into main subject categories. For some categories containing very complex and complicated data, Nvivo (a software for qualitative data analysis) was used for coding while other parts were coded manually. The analysis of the interview data was completed by the interpretation of the results.

From the results, the success of collaboration and collaboration environment implementations was found to be affected by thirteen factors related to organizational, people or technical issues. It was also found out that these factors are linked to each other. The interdependency of some of these factors was mentioned directly by the interviewees. Further relationships were revealed after the analysis and interpretation of the case study results which was later combined with a systems thinking approach to create a causal loop diagram (CLD) reflecting the organizational issues in implementing a CE for construction projects. CLDs provide a significant level of assistance to thinking by introducing circular causality and providing a medium by which people can externalize mental models and assumptions and enrich these by sharing them (Wolstenholme, 1999). The causal loop diagram in Figure 2 shows the thirteen main organizational issues affecting the success of CE implementation and how these issues are related to each other.

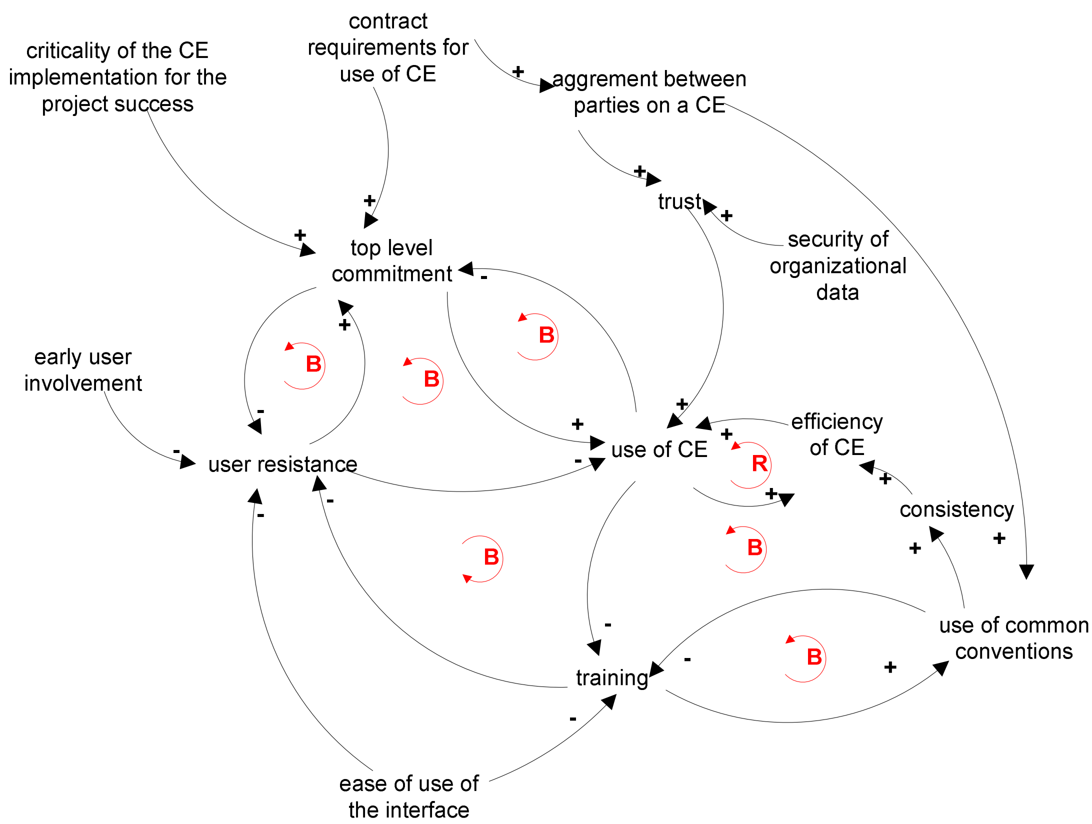


Figure 2: Organizational Issues in Collaboration Environment Implementation: Causal Loop Diagram (Erdogan et. al, 2008)

In order to develop this CLD, each of the links was assigned focusing on the relationship between two parameters only and ignoring the interaction of all other parameters. Positive and negative links indicate whether the change in one parameter affects the other parameter in the same direction or in the opposite direction. If the links are investigated, it can be seen that some of the parameters and their links form a loop relationship. The red circles in the diagram are placed to show these loop relationships. Positive/Reinforcing Loops start with an increase and end with an increase (or vice versa) whereas Negative/Balancing Loops start with an increase but end with a decrease (or vice versa). R and B signs are used to indicate whether the loops are reinforcing or balancing. Circular arrows are used to show the direction of the loop flow.

FRAMEWORK DEVELOPMENT

Both the literature review and case study results revealed that the success of collaboration environments does not only depend on "what is introduced to the organization" but is also related to "how it is introduced". ICEMOCHA (Implementation of Collaboration Environments and Management of Organizational Changes) was developed to respond to the need for a methodology which can manage how collaboration environments are introduced to construction organizations and to increase the focus on the key issues affecting their success.

In order to manage the factors affecting the success of a CE implementation, ICEMOCHA was designed as a combination of two interlinked process models: Implementation of Collaboration Environments (ICE) Model at project organization level, and Management of Organizational Changes (MOCHA) at the organizational level. An overview of the ICEMOCHA framework is shown in Figure 3.

At the project organization level, the framework guides organizations in the planning and implementation of collaboration environments on construction projects. The project organization level decisions for the project are made in the presence of representatives from each organization, and the agreed collaboration solution and related decisions are binding for all organizations. Therefore, these procedures should be adopted by each organization, and it should be ensured that the common decisions are followed by all of their employees.

At the organizational level, the framework guides each organization to manage the organizational changes introduced by the new collaboration environment. Since the required changes will vary in each organization due to the different organizational cultures and varying organizational procedures and processes, MOCHA provides a methodology which will enable each organization to come up with an organization-specific organizational change management approach.

Both ICE and MOCHA follow a scientific problem solving approach that involves five stages. These steps are used for collaboration management at the project organizational level and for change management at the organizational level. The first stage is called the initiation stage where the need for collaboration and for organizational change is defined. The second stage focuses on defining vision. In the ICE model, a shared collaboration vision is developed whereas in the MOCHA model, a change vision is developed. At the third stage, the focus is on developing a collaboration solution in ICE and an organizational change management plan in MOCHA. The fourth stage focuses on implementing the solutions defined at the third stage while the last stage focuses on evaluating the performance of the implementation. Each of these five stages is further broken down into sub-processes using an IDEF0 modelling approach. The selection of IDEF0 technique as the modelling approach was mainly because of the technique’s potential to allow representing different levels of details through the processes and sub-processes presented in parent and child diagrams. The second reason was the familiarity of construction industry professionals with the technique.

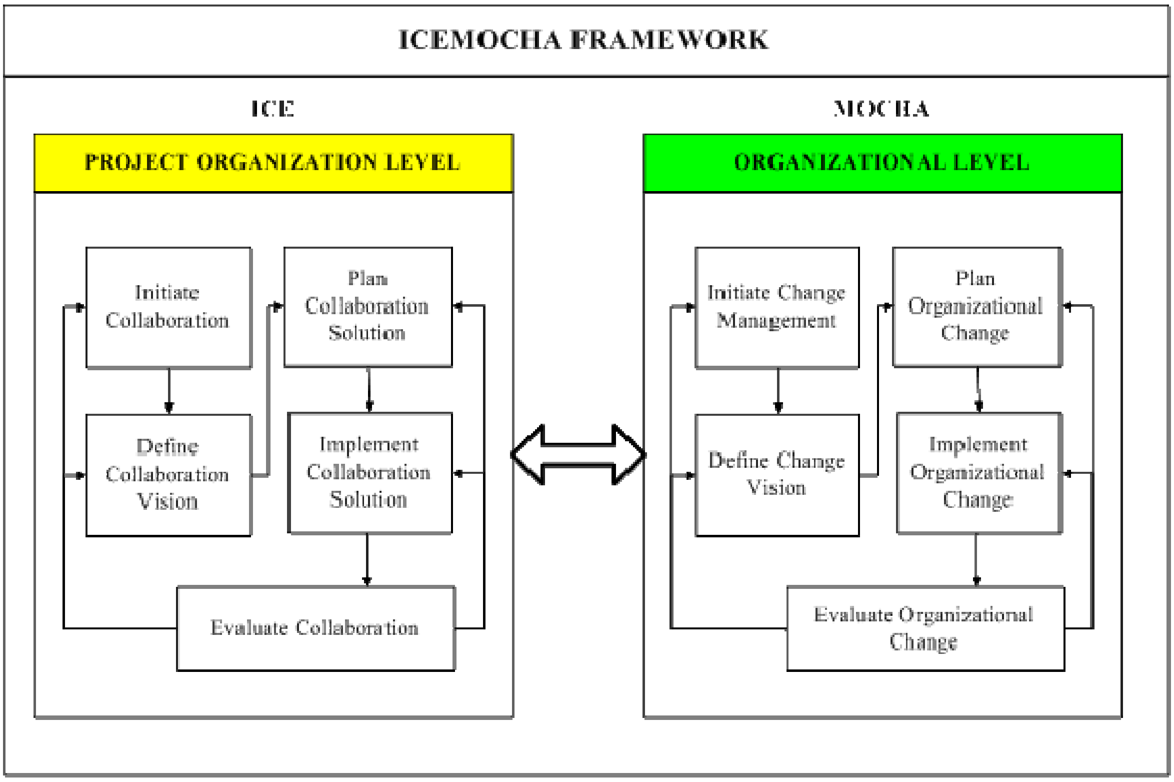


Figure 3: ICEMOCHA Framework Overview (Erdogan, 2008)

AUTOMATION OF THE FRAMEWORK

Prototyping is a process of building an experimental system quickly and at a low cost for demonstrating to the users so that they can evaluate the system and determine further information requirements (Laudon and Laudon, 2000). The prototype developed for this research aimed at automating the project organization level processes of the ICEMOCHA framework. It was intended that the ICE prototype would guide the collaboration management team members in planning and implementing collaboration environments.

The ICE prototype has three main elements, which are shown in Figure 4. The first one is the user interface which was developed in a VB.net environment. VB.net was chosen since it did not require much coding for the appearance and location of the interface elements. The second element of the prototype is the database where all data entered through the interface are stored. Microsoft Office Access was chosen as the database. The third element is the report created as the output of the prototype. The medium chosen for the report creation was Microsoft Word. The links between these three elements were established by the codes written in VB.net.

At any time while the programme is running, the prototype is able to produce a detailed report on the planning and implementation of CE carried out up to that moment. Since all decisions made for the CE implementation, the results and outcomes of those decisions, and the difficulties met during the implementation are recorded, the report can also guide future implementations.

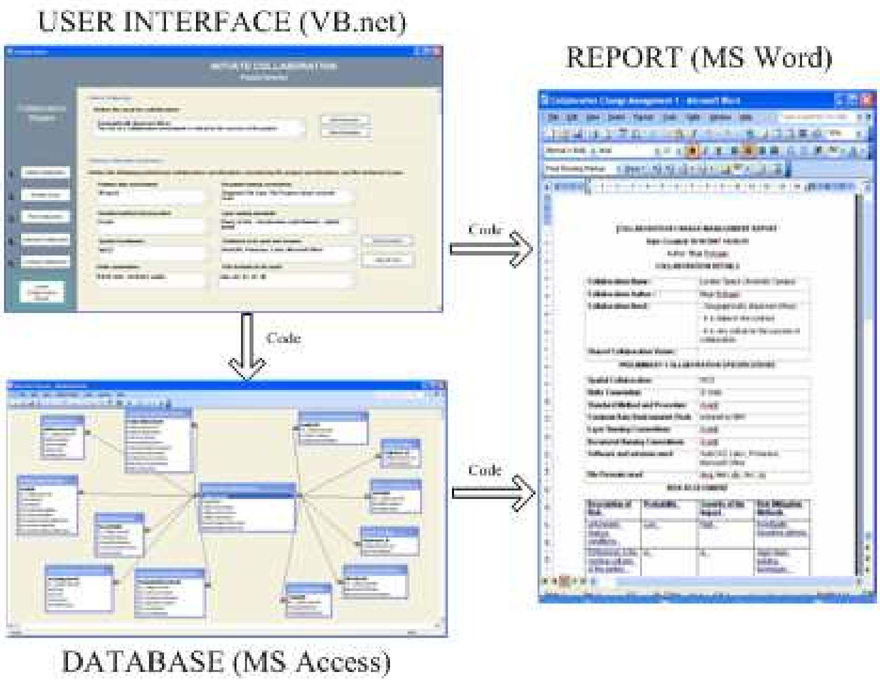


Figure 4: System Architecture of ICE Prototype (Erdogan, 2008)

EVALUATION OF THE FRAMEWORK AND THE PROTOTYPE

An evaluation was carried out in order to validate the conceptual ICEMOCHA framework and to determine the appropriateness and functionality of the prototype system developed to automate the ICE processes. For the evaluation methodology, it was decided to benefit from the triangulation of qualitative and quantitative approaches. The data collection was carried out using interviews and a questionnaire. The evaluators were thirteen senior managers in two contracting, three consultancy, two architecture and one design management companies.

The evaluation findings showed that both the framework and the prototype achieved their aims and objectives, although there were still some steps to be completed to make the prototype suitable for the use of industry professionals if it was commercialized. The participants were generally satisfied with the effectiveness and usability of the framework and the prototype. ICEMOCHA was found to be an effective and efficient tool to facilitate the implementation of collaboration environments and to help manage the resulting organizational changes. The participants also made comments on possible ways to improve the framework and the prototype.

CONCLUSIONS

This paper has described a research project on organizational change management for the implementation of collaboration environments. The implementation of effective collaboration environments in construction projects and the management of the required organizational changes in each organization collaborating on the project were investigated. The conclusions drawn from the research are listed below:

- Most of the organizations do not realise that they need to manage some organizational changes in order to implement collaboration environments successfully.

- The success of collaboration environments does not only depend on “what is introduced to the organization” but is also related to “how it is introduced”. Therefore, the change management required for the implementation should be considered carefully.

- From the analysis and interpretation of the case studies, thirteen issues were found to affect the success of collaboration environment implementations: Criticality of the collaboration environment implementation for the project success; binding clauses in the contract regarding the use of a collaboration environment; agreement between parties on the use of a collaboration environment; trust between the organizations and trust in the system; security of organizational data; top level commitment; user resistance to change; early user involvement; user friendly interface; training; consistency of data format, types and standards used; use of common conventions; efficiency of the collaboration environment.

- The case studies also showed that the issues listed above are interrelated and should be approached as a system.

- The efforts to manage the changes resulting due to collaboration environment implementations should focus on both project organization and organizational levels.

- Specifications for the people to work on the project, the workflow of the project, and the details for the technology solution, collaboration standards and procedures should be agreed before the collaboration environment is set up.

- At the project organization level, the ICEMOCHA framework provides a smooth and logical methodology to guide the collaboration parties to set up an effective collaboration environment for the construction project considering both organizational and project organizational factors.

- At the organizational level, the ICEMOCHA framework provides a methodology guided by organizational change management principles in order to manage how collaboration environments are introduced into the organization.

- The prototype system developed provides a practical tool which will enable the parties collaborating on a construction project to capture and integrate the needs and expectations of all collaborating parties.

- The prototype system captured the decisions required for the implementation of collaboration environments and documented all decisions and their outcomes as a collaboration change management report. This documentation can be used as a guide for future collaboration implementations.

- Both the framework and the prototype were evaluated by participants from the construction industry and were accepted as an effective guide and an effective tool for the successful implementation of collaboration environments and change management.

The future research will focus on the implementation of the framework and the prototype on a real project and converting the prototype into a web-enabled system.

REFERENCES

Allen, R.K., Becerik, B., Pollalis, S.N., Schwegler, B.R. (2005). Promise and barriers to technology enabled and open project team collaboration, Journal of Professional Issues in Engineering Education and Practice, 131(4), pp. 301-311.

Bartoli, A., Hermel, P. (2004). Managing change and innovation in IT implementation process, Journal of Manufacturing, 15(5), pp. 416-425.

Betts, M, Smith, D. (1999). Strategic management of IT in construction, Blackwell, Oxford.

Blumberg, B., Cooper, D. R. & Schindler, P. S. (2005). Business Research Methods, McGraw Hill, London.

Cheng, E.W.L., Li, H., Love, P.E.D., Irani, Z., (2001). An e-business model to support supply chain activities in construction, Logistics Information Management, 14(1/2), pp. 68-77.

Chinowsky, P. S., Meredith, J. E. (2000). Strategic Management in Construction. Journal of Construction Engineering and Management, 126 (1), pp. 1-9.

Clegg, C., Axtell, C., Damodaran, L., Farbey, B., Hull, R., Lloyd-Joness, R., Nicholls, J., Sell, R., Tomlison, C. (1997). Information technology: a study of performance and the role of human and organizational factors, Ergonomics, 40 (9), pp. 851-871.

Clegg, C.W., Icasati-Johanson, B., Bennett, S. (2001), E-business: boom or gloom? , Behaviour&Information Technology, 20(4), pp. 293-298.

Egan, Sir J. (1998). Rethinking Construction, Department of Environment, Transport and the Regions, HMSO, London.

Erdogan, B., (2008). Organizational Change Management for the Implementation of Collaboration Environments, PhD Thesis, Loughborough University.

Erdogan, B., Anumba, C.J., Bouchlaghem, N.M., Nielsen, Y., (2005). Change Management in Construction: The Current Context, In: Proceedings of the 21st Annual Conference of ARCOM, 7-9 September 2005, London, UK, Volume 2, pp. 1085-1095.

Erdogan, B., Anumba, C.J., Bouchlaghem, D., Nielsen, Y., (2008), Collaboration Environments for Construction: Implementation Case Studies, ASCE Journal of Management in Engineering. 24(4), pp. 234-244.

Fellows, R., Liu, A. (2003). Research Methods for Construction, Blackwell Science, Oxford

Gardner, S., Ash, C.G., (2003). ICT-enabled organizations: a model for change management, Logistics Information Management, 16(1), pp. 18-24.

Kuruppuarachchi, P.R., Mandal, P., Smith, R., (2002). IT project implementation strategies for effective changes: a critical review, Logistics Information Management, 15(2), pp. 126-137.

Laudon, K.C., Laudon, J.P., (2000). Management Information Systems, Prentice-Hall, Upper Saddle River, NJ.

Maguire, S., 2000, Towards a "business-led" approach to information systems development, Information Management& Computer Security, 8/5, pp. 230-238

Ruikar, K., Anumba, C.J., Carillo, P.M. (2005). End-user perspectives on use of project extranets in construction organizations, Engineering, Construction and Architectural Management, 12(3), pp. 222-235.

Wilkinson, P. (2005). Construction Collaboration Technologies: The Extranet Evolution, Spon Press, London.

Wolstenholme, E. F. (1999). Qualitative vs quantitative modelling: the evolving balance, Journal of the Operational Research Society, 50(4), pp. 422-428.

The challenges and opportunities in marketing the QS practice in Malaysia

Christopher Nigel Preece
International Islamic Univeristy Malaysia, Malaysia
Christopher_preece@hotmail.com

Roziha Che Haron
International Islamic Univeristy Malaysia, Malaysia
geech289@yahoo.com

Handzalah Abdullah
International Islamic Univeristy Malaysia, Malaysia
handzalah@gmail.com

Mohd Saiful Nizam Mohd Suhaimi
International Islamic Univeristy Malaysia, Malaysia
saifulnizam@iiu.edu.my

The challenges and opportunties facing quantity surveying practices is the focus of ongoing research looking at how QS firms can develop and improve their strategic marketing approaches given increasing domestic and international competition, proliferation of cost management and other services and the possible liberalisation of the profession with regard to advertising and marketing. This paper will identify whether quantity surveyors are equipped to develop their marketing and business development strategies. It will also attempt to identify what the future marketing challenges will be. Preliminary results show that quantity surveying practices that are working for increasingly private sector clients are possibly more developed in terms of their approaches to marketing than those still working predominantly for the public sector. The research is giving an insight into the organization and strategies being employed by firms. In addition, it is attempting to identify the influence of marketing on public and private client decision-making.

KEYWORDS: marketing, quantity surveying, Malaysia

Introduction

Marketing is defined by the Chartered Institute of Marketing as “the management process responsible for identifying, anticipating and satisfying customer requirements profitably”. Whereas Macnamara (2003) gives an all compassing definition that describes marketing as all activities that are involved in obtaining future work, from the strategic analysis and planning, to staff enthusiasm and performance, the service delivery and customer feedback. According to Morgan and Morgan (1991) in Bowen and Rwelamila (1995), marketing within the professional sector is considered at worst as an alien concept, and at best as a new development that is viewed with skepticism. In addition, it is important to notice that the marketing is not only about selling and advertising anymore. Those terms are only considered as the tip of the marketing iceberg and are part of a larger marketing mix which is a set of marketing tools that work together to affect the market place (Kotler & Armstrong, 2001).

The traditional technical and professional services of quantity surveyors relates to tender documents, tender appraisals, valuation and preparing and agreeing final accounts. These services have been the backbone of income for the majority of QS practices. However, within the last decade there has been a shift in approaches to procurement. There has been an increased move towards a one-stop, integrated philosophy in the delivery of construction. A decline in use of the traditional method of procurement presents a number of challenges for the QS profession. The QS sector has not stood still during this period of change. The profession has moved towards developing new services with a focus on risk management, value management, legal and environmental services. The development of these has been a response to changes demanded by the major procuring clients (Page et.al. 2004). The services provided by the profession is no longer restricted to the traditional forms. New services and greater competition from within and outside the profession demand a more effective approach to marketing.

In the past the construction sector has often been criticised due to the low priority and inadequate attention paid to the marketing function (Yisa *et al*., 1995).The quantity surveying profession has become more competitive with practices diversifying the services that they are offering and with an expansion of more demanding clients in both the public and private sectors. There is a need for practices to develop more effective marketing and business development strategies (Yoke Mui & King Keong 2001)

Consultants need to recognise that the client base is changing and is likely to continue to change. Firms more likely to succeed will be those that add value to clients' through excellence of performance and innovation,. As clients continue to focus on established business relationships with compatible firms, effective marketing is important, with significant emphasis required on the considerations of the needs of the client.

Major transformations in the environments of all professions are leading many professional service organizations down new paths (Kotler, 2002).Koren (2004) states that the marketing of professional services is a continuous ongoing process of using communication to develop business.

Marketing in the business-to-business sector

Industrial and organizational marketing is formally defined "as the performance of business activities which facilitate exchange processes between producers and organizational customers, the purpose of which is to create value for customers with goods and services that address organizational needs and objectives" (Filiatrault & Lapierre, 1997, p.214).

"Business-to-business markets differ from consumer markets in many ways: fewer and larger buyers, often geographically concentrated; a derived, fluctuating and relatively inelastic demand; many participants in the buying process; professional buyers; a closer relationship; absence of middlemen; reciprocity; technological links and others. Business-to-business services can even, and often do, influence the management practices of their clients" (Filiatrault & Lapierre, 1997, p.214). The key differences between consumer and construction marketing are in the nature of the long-term personal and professional contact that is required in the marketing of construction activities, while the most effective form of contact for consumer goods are mass advertising and promotional activities (Pettinger, 1998). In addition, loss of a single sale to a construction company can cause a significant and direct financial impact, while repeat business and long-term client relationships may involve no more than two or three contracts per decade (Pettinger, 1998).

Preece & Moodley (1996a) defines the client expectations as what they desire, hope, or anticipate from contractors' service. In order to implement a successful marketing, it is vital to know and appreciate what the client's expectations are and where their priority lies (Pettinger, 1998). It is suggested that the best way to master this successfully is to go out and meet with potential clients and ask them (Pettinger, 1998).

Client expectations are based on the following criteria (Pettinger, 1998):

- **Price, quality, value, volume, time:** the contractor is expected to produce and deliver the promised facility according to the agreed, time, price and quality.
- **Suitability:** that which was proposed at the outset is actually, what is delivered at the end.
- **Responsibility:** this suggests that the client does not expect the false excuses.
- **Problem solving:** at the outset of contract, the parties, as far as possible, who is the responsibility for specific problems as they arise. However, it is important to avoid to get involved in claims and disputes.
- **Confidence:** client's confidence is based on integrity, credibility and expertise and demonstrating that what has been promised is actually delivered.

The Importance of A Marketing Intelligence System

Many scholars have highlighted the importance of effective marketing intelligence to strengthen the useful application of market plan and support the marketing efforts in construction (Preece & Male, 1997; Gladden & Olitt, 1996; Morgan 1991; Fellows & Langford, 1993, cited in Mochtar & Arditi, 2001, p.144).

A marketing intelligence system is a set of procedures and sources used by managers to obtain their everyday information about pertinent developments in the environment in which they operate - supplying data about the market (Kotler, 2003). Another definition of marketing intelligence system is that it is a system for capturing the necessary information for business marketing decision making (Hutt and Speh, 1989, cited in Mochtar & Arditi, 2001, p.141).

Marketing research is the process of obtaining and evaluating information on the market and includes the investigation of economic, political, and social trends (Pearce, 1992). An opportunity analysis is carried out on each of the trends, especially growth prospects, major players, typical forms of procurements and so forth, with a view to identifying where the best prospects for future project opportunities lay (Vernea, 2003)

In the current climate of changing professional roles and status within the construction industry, the marketing of quantity surveying and other construction-related professions has taken on added performance. The marketing of professional services is a difficult task, as it involves selling a service rather than a product. As quantity surveyors look to diversify the services they offer, it is necessary for them to recognize their specific strength and weaknesses and those of their competitors (Ashworth and Hogg, 2007).

Key Issues in Construction

The environment of the construction sector in most countries is one of extreme competitiveness, with high risks and generally low profit margins when compared to other areas of the economy" (Mochtar & Arditi, 2001, p.140). Thus, firms need to confront competitive forces by differentiating their offers. According to Kale & Arditi (2001) businesses can differentiate themselves by deploying a range of competitive methods including competing on the basis of price, innovation, quality, and schedule. Differentiation can enable a firm to outperform its rivals (Kale & Arditi) but focus must be on a deep understanding of how the company provides satisfactory services to its clients (Murdoch & Hughes, 1996).

Traditionally, "the… profession is known to be conservative in reacting to evolutions and new changes" (Cheah, *et al.*, 2005, p.106). It can be seen as the consequences of inadequate investment in training, research and development within the industry. Research in the UK has have revealed how a lack of investment in training research and development in order to meet the ever-higher, growing and sophisticated demand from customers (Bower, 2003). The fluctuating and uncertain nature of construction demand causes difficulties for the typical small and medium construction enterprises (SMEs) to not only employ large numbers of workers on more permanent basis but also maintain high levels of training and staff development (Bower, 2003).

Clients are diversifying in organisational structure and managerial styles and the market will force the changes on the construction industry (Smyth, 2000). Smyth (2000) suggests that the winner will be those who embrace change, encourage further change and carve out the territory on their own terms. Thus, there is a need to achieve a balance between strategic oversight and practical outworking of marketing involves providing opportunities to reflect on the day-to-day activities, learning from mistakes and shortcomings (Smyth, 2000). "More than this, it is of great significance to implement dynamic and evolving sales efforts, sales systems which respond to client needs, add real service value for the client and deliver actual competitive advantage for the consultant or contractor" (Smyth, 2000).

In addition, marketing of overseas operations has become an increasingly important activity for international construction enterprises, which have to vigorously promote their services and products both at home and abroad. Hand (1998, p. 55, cited in Hall, 2002) suggests that until recently, 'marketing', as a separate business activity, was largely an unnecessary: "[a] well known name and a good estimating department was basically all that was required to win international construction work". However, the international construction client base has changed; and the clients are less likely to be multi-lateral funding bodies and government organisations and more likely to include developers, financial organisations and other construction enterprises (Chapman, 1998, cited in Hall, 2002). "Additionally, the market is no longer the preserve of firms from the developed world. Construction companies from developing and 'emerging' regions of the world have firmly established themselves in the international marketplace and are vigorously competing for their own market shares" (Hall, 2002, p. 2).

Whether persuading work in domestic markets or overseas, construction organisations have had to face the fact that their client groups now have a greater range of choice than ever before; and thus it is essential that companies enhance their ability to present their expertise to influence the client to buy from one organisation in preference to others (Pettinger, 1998). This depends largely on the quality and professionalism of marketing.

Marketing Professional Service Firms

Young (2005), states that the professional services industry is one of the largest and most diverse sector of modern economies. The common attribute that all the firms within it share, whether they are business to business or consumer-oriented business, is that the professional skills form the basis of what they offer to clients and the qualifications needed are generally the barrier to entry for aspiring newcomers. How each firm approaches the market and the processes it develops, however, differ according to its skill set, size, the organizational structure and the type of project it takes on.

Lim and Yap, (2003) highlighted that the professional services are constantly changing and expanding, in response to client demand and evolution of new technology. Clients are always seeking either a highly specialized or personalized service from a number of sources or a wide range of skills from a single source. The intensification of competition for Quantity Surveying services have lead to management and marketing expertise becoming as important as pure technical skill.

As stressed by Bowen and Rwelamila, (1995), further research within the marketing of professional quantity surveying services field is absolutely necessary, thus this study is carried out with the intention of focusing on the marketing of professional services of quantity surveying consultancy practices specifically in Malaysia for there is currently a lack of empirical study carried out on this topic.

The competition in obtaining projects is rapidly increasing in the construction industry. As identified by Low and Kok (1997), the clients of the construction industry have become more discerning as well as demanding on the quality and timeliness of the services they receive due to the improvements in education, advancement in technology and the increase in affluence in society. Smyth (2000) recognized the clients service expectations of consultants to be; personal trust sought, has an understanding of the clients, has common interests, and is reactive and spontaneous. On the other hand, the clients have reported dissatisfaction with consultants on specific areas where the consultants have lack of understanding the client’s needs, lack of flexibility and innovation, lack of tangibility as well as poor value for money.

Thus, the marketing strategies carried out by professional consultancies suggest to play a significant role in the client’s selection of his preferred consultants in order to obtain the most appropriate and quality professional service. Ajanlekoko (2000) in Lim and Yap (2003) has suggested that there is a need for the professionals to promote themselves proactively in the relentless search for business opportunities. However, Macnamara (2003) has stated that the construction industry has been slow to appreciate marketing as a tool to improve market shares, and sales or profitability. According to Low and Kok (1997), in today’s competitive marketplace, quantity surveyors must now realize that their services, regardless of how good these are, simply do net sell automatically. Quantity surveyors can no longer wait for clients to come by themselves. Although aware of the need to improve the way their services ought to be promoted, many quantity surveyors still do not seem to pay enough attention to marketing.

Macnamara (2003) has found out that the benefits of an organized, client-focused approach to marketing have been defined as increased profits, reduced uncertainty and the generation of new businesses. Marketing makes a critical combination in the process of finding new and sustaining old customers, as well as ultimately achieving long-term business success (Preece, Moodley and Brown, 2006). Collard (2003) further clarifies that if marketing is carefully planned and implemented it can be extremely effective and entirely accountable for its annual budget.

Therefore, marketing should be viewed as an essential ingredient in the building and maintenance of a rewarding and profitable professional quantity surveying practice. Nevertheless, many quantity surveyors have misinterpreted what marketing is all about. Some see it as manipulative, wasteful, intrusive and unprofessional, while others will equate marketing primarily as just plain advertising and selling (Low and Kok, 1997), (Lim and Yap, 2003). This statement is supported by Collard (2003) where he states that marketing is often perceived as an intangible, non-measurable activity, primarily an overhead and any time spent on non-fee earning activity is essentially ‘wasting’ resources. These beliefs have made it difficult for marketing to gain acceptance outside of the conventional business world (Lim and Yap, 2003).

QS Practices in Malaysia – The Marketing Challenges

In Malaysia, the profession of Quantity Surveying is governed by professional bodies, i.e. the Board of Quantity Surveying Malaysia (BQSM) under the Quantity Surveying Act 1967 (with Amendments 2002), which administers the Quantity Surveyors professional conduct. Strict rules, associated with advertising and sales promotion (Circular No. 2/93), are imposed on members to refrain them from canvassing for business. This is because active advertising and sales promotion are often regarded as placing the professional service in an unprofessional atmosphere (Lim and Yap, 2003).

Currently, a popular way of implementing marketing is via the internet. In this age of the internet, the usage of websites to match skills and market needs should be utilized to the fullest. CSM (2000) in Lim and Yap (2003) has highlighted that Quantity Surveying firms which include completed projects in their websites will enable potential clients to match their proposed projects and needs with the firms experience. Yet, the registered Quantity Surveyors must remember and adhere to the Guidelines on the use of Home Page on the World Wide Web (Circular No. 5/98) published by BQSM in order to ensure the professional Quantity Surveyor does not contravene the provisions of Quantity Surveyors Rules 1967 (with Amendments 2004). These restrictions imposed may cause limitations to the professional Quantity Surveyor to carry out their marketing strategies or techniques.

According to the research carried out by Bowen and Rwelamila (1995) regarding marketing of professional services by quantity surveying practices in South Africa, it can be seen that prohibition of advertising and marketing by professional quantity surveyors was only until the year 1985, where any infringement of this prohibition would lead to a disciplinary hearing and sanction by the South African Council for Quantity Surveyors. Since then, the council has amended the regulations where advertising and marketing is permitted as long as such activities are ‘professional’, not self-laudatory and does not praise one practice above another. In the United Kingdom, Newcombe, Langford and Fellows (1990) in Macnamara (2003) affirmed that consultant practices have had to become more market oriented due to the lifting of codes of practice to allow competition.

In view of above, Lim and Yap, (2003) suggest that professional bodies which govern the Quantity Surveying professional bodies in Malaysia must re-evaluate their regulations on marketing activities by the members. Alternatively, the professional institution could promote and educate the public on its services on behalf of its members, so as to release its members from dependence on other professions. There is a significant lack of information on the marketing and business development strategies and techniques of quantity surveying practices in Malaysia., An important question is how strategies are being developed and whether the level of activity is increasing in response to a highly competitive market environment. Given possible future liberalization of regulations regarding the marketing/advertising of quantity surveying services in Malaysia, this paper will identify whether quantity surveyors are equipped to develop their marketing and business development strategies. It will also attempt to identify what the future marketing challenges will be.

Research Method & Results To-Date

This research was commenced in September 2007 and consisted of a self-administered exploratory questionnaire. The survey was designed to provide information on the background and organization of marketing, the strategies, tools and techniques being employed and how QS practices perceived that their marketing approaches may change given the development of new services or challenges of greater competition in the future.

QS practices in the Klang Valley area of Malaysia were surveyed. From a total population of 100, 27 practices responded to the survey and the number of employees of the practices ranged from 6 to 100.

The research questions related to the areas identified in the literature review and the specific issues relating to QS practices in Malaysia. These covered background issues such as the size and organization of the practices and who their clients were i.e. public or private sector. Details were also gathered on the respondents i.e. their job titles and roles in the practice. Other more specific questions related to the attitudes of the respondents to marketing, strategies and techniques being employed and whether practices use the services of marketing consultants/agents. The key issues to be identified include how important the respondents felt marketing was, the primary objectives of the firms and the marketing and promotional techniques being used and their perceived relative importance. The final questions related to what the respondents believed their clients were looking for and what marketing activities were seen to be influential.

Table 1 shows the size of practice according to numbers of employees, average turnover and value of public and private sector projects.

Table 1 Size of Practice

		Project Value	
No of Employee	% Sample	Public	Private
50>	17%	18%	83%
20 to 49	46%	71%	29%
19>	37%	66%	34%

As may be seen from the table, the biggest percentage of private work is being carried out by the largest firms in the sample.

Respondents from the survey includes the Directors/Associate/Principals/Owner (15), Partners/Senior QS/Executives (8), Partners (2), Project Leader (1) Contract Manager (1). The average years of experience of respondents were 16 years.

Organisation of Marketing and Strategies being used

Based on the survey 100% of the practices do not have a dedicated marketing department. The main reasons for not having a specific department were that marketing was seen as a senior management role (56%) or that the practice were in the opinion that their practice is seen to be too small to warrant a separate function (26%). Only 14% of firms use the services of external marketing consultancies. However, there are respondents who are in the opinion that an external marketing consultancy is pointless. Reasons for not using outside marketing agents were obtained from the respondent. Among the popular answers by the respondents are (1) outside marketing service is considered unnecessary, (2) outside marketing consultants do not possess the knowledge on quantity surveying services and construction industry as a whole, and (3) budget constraints in hiring the external marketing consultant.

In addition when asked about the main problems and hurdles on reaching the clients, majority of respondents representing their practices indicated that they face difficulties in getting to know the clients better unless they have strong political connection and contacts. Interestingly some highlighted that the main barrier to break is the actual practice of most clients who tend to keep their own team therefore leaving little room for others to be given opportunities in securing projects.

Additionally, 70 % of the sample attributed less than 2% of their turnover to marketing activities. Respondents were asked to say whether they provided training to their staff on the basics of marketing. As a result, 50% of firms stated they provided regular training sessions for their staff.

Respondents were asked to state the level of priority afforded marketing within their business strategy. The average responses are shown in Table 2

Table 2 Level of Priority

Level of Priority	% of practices
High	20%
Moderate	60%
Low	20%

Subsequently, the respondents were asked to described the primary objectives of their marketing strategy of their firms and the result shown in Table 3 below;

Table 3 Primary Objectives of Marketing Strategies

Primary Objectives	% of practices
To achieve increased market share and new clients	38%
Service excellence	29%
Technical excellence and expertise	17%
Provide value added services	17%

Based on the result, 38% of the respondents are in the views to increased market share and new client. This result indicates their awareness on the increasing demand of client in the competitive construction market. The need to be more competitive by offering wide range of services could lead in achieving the primary objectives.

Based on the study, only 35% of firms carry out research into new markets.

Table 4 shows the use of marketing and promotional tools being used by the practices and Table 5 shows their perceived relative importance

Table 4 Marketing and Promotional Tools Used

Marketing Technique	% of sample using
Company brochure	76.00%
Company logo	76.00%
Introduction letter	64.00%
Industry seminars	54.17%
Website	54.17%
Company newsletter	52.00%
Entertaining	48.00%
Presentations	44.00%
Other forms of advertising	35.00%

Table 5 Marketing technique Relative importance

Very Important	5
Company brochure	44%
Company newsletter	36%
Presentations	33%
Entertaining	30%
Website	29%
Introduction letter	23%
Company logo	19%
Industry seminars	18%

CDs	0%
Other forms of advertising	0%

Note: (5=Most important 1=Least important)

When clients are selecting firms to carry out projects, the following activities were perceived by the QS practices as to be the most influential (see Table 6). The most influential relate to the way the practice uses its network of previous clients and contacts rather than the use of any direct marketing tools. This would seem to conflict with the previous results which appear to show that the practices consider the use of company brochures as most important as part of their promotional mix.

Table 6 Activities Most Influencing Client's Selection

Most Influential	**5**
Previous working relationships	56.52%
Industry reputation	52.17%
Contacts	52.17%
Recommendations	43.48%
Company CVs	26.09%
Introduction letters/portfolios	21.74%
Following leads	0.00%

Notes: Influence (5=Most influential 1=Least influential)

Conclusions

From the limited empirical research so far, there is little evidence to suggest that marketing is seen as a key management function, although directors, partners or senior members of practice staff appear to have responsibility for what is considered to be marketing activity. There is no evidence so far that marketing plans have been developed as part of broader strategic planning of practices. Little effort seems to be expended on analysis of markets or competitors.

To what extent the development of new services may be affecting marketing approaches is so far unclear despite firms belief in increasing market share and obtaining new clients.

Websites are seen as an important element of the marketing activities of QS practices, however the majority of the firms are still relying on the traditional company brochure to market their professional services to the industry. The notion leaves a question as to what on-line strategies are being developed to market the firms services.

Some key questions for further development would be to establish to what extent will branding become important for QS practices in the future in an increasingly competitive private sector market place. Also, to determine to what extent are QS practices in Malaysia thinking about the threats and opportunities in the international market place, particulary given the global economic turmoil.

In a nutshell, the roles of marketing for QS practices in Malaysia would seem to be in their infancy, despite awareness of increasing competitive demands from the client base. The role of the professional bodies is seen to be one of the initiator which could amend the regulations to allow more freedom for practices to market their professional services.

References

Abdul-Aziz, A.R., Ali, N. (2004) Outsourcing and Quality Performance: Malaysia's Public Work Department. Structural Survey, Vol.22, No.1, (p53-60)

Ashworth, A., Hogg, K. (2007). *Willis's Practice & Procedure for the Quantity Surveyor* 12th Ed. Oxford: Blackwell Publishing

Board of Quantity Surveyors Malaysia (BQSM) http://www.bqsm.gov.my (Retrieved: 17 January 2008)

Bowen, P.A., Rwelamila, P.D. (1995). *Marketing of Professional Service by Quantity Surveying Consultancy Practices in South Africa*. London: The Royal Institution of Chartered Surveyors (RICS) Research.

Bower D (2003) *Management of procurement*, Thomas Telford Ltd

Chong, S. N. (2003). *Professional Service Marketing- Part 3*. Berita QS, 2nd Issue June 2002/03 (p13-14). Petaling Jaya: Institute Surveyors Malaysia.

Cohen, G.T. (2006). *Barriers to Marketing within Professional Service Firms, A Study of the Understanding and Application of Marketing within Accountancy and Law Firms*. PhD Thesis, Brunel University

Collard, P. (2003). Marketing Planning- Planning the Way Ahead. In Preece, C., Moodley, K., Smith, P. (ed.) *Construction Business Development: Meeting New Challenges, Seeking Opportunity*. Oxford: Butterworth-Heinemann.

Filiatrault, P. Lapierre, J. (1997), Managing Business-to-Business Service Marketing Relationship. *Industrial Marketing Management*, vol. 26, 213-222.

Gilmore, A. (2003). *Services Marketing and Management*. London: Sage Publications

Hoxley, M. (1995). "How do Clients Select a Surveyor?". *Structural Survey*, MCB University Press, Vol. 13 No.2, (p6-12)

http://en.wikipedia.org/wiki/Quantity_Surveyor

Institution of Surveyors Malaysia (ISM) http://www.ism.org.my

Kominers, A. (2005). Professionalism Through and Through. In Pressman, A. (ed.) *Professional Practice 101- Business Strategies & Case Studies in Architecture*. New Jersey: John Wiley & Sons, Inc.

Koren, D. (2004). Top 10 Rules of Marketing. In Pressman, A. (ed.) *Professional Practice 101- Business Strategies & Case Studies in Architecture*. New Jersey: John Wiley & Sons, Inc.

Kotler, P. (2002). *Marketing Professional Services*. United States of America: Prentice Hall.

Kubal, M.T., Miller, K., Worth, R.D. (2000). *Building Profits in the Construction Industry*. New York: McGraw-Hill.

Lim Yoke Mui and Yap King Keong (2001) *Marketing the professional quantity surveying services – an overview* pp.76-84

Lim, Y.M., Yap, K.K. (2003). Marketing the Professional Quantity Surveying Services- an Overview. In Abdul Rashid, K. (ed.) *Quantity Surveying: A New Paradigm*. Kuala Lumpur: Pearson-Prentice Hall.

Low, S.P., Kok, H.M. (1997). *Formulating a Strategic Marketing Mix for Quantity Surveyors*. Marketing Intelligence & Planning. MCB University Press, Vol. 15, No.6 (p273-280)

Low, S.P., Tan, S.L. (2002). *Relationship Marketing: A Survey of Quantity Surveying Firms in Singapore*. Construction Management and Economics, Vol. 20, (p707-721)

Macnamara, P. (2003). Marketing of Civil Engineering Consultancies in the United Kingdom. In Preece, C., Moodley, K., Smith, P. (ed.) *Construction Business Development: Meeting New Challenges, Seeking Opportunity*. Oxford: Butterworth-Heinemann.

Mei, Z.L. (2007). *Quantity Surveying Marketing: Its Limitations and Associated Concepts as Applied to Small Quantity Surveying Firms in Malaysia*. BSc Thesis, The University of Salford School of the Built Environment

Mohamed, E. (2006). *Public Policy and Key Competitiveness Issues for Export of Professional Services*. Professional Bulletin, 3rd Quarter 2006, Balai Ikhtisas Malaysia (BIM), (p8-9)

Morgan, R. E. and Morgan, N. A. (1991) 'An appraisal of the marketing development in engineering consultancy firms', *Construction Management and Economics*, 9, 355-368.

Naoum, S. G. (2007). *Dissertation Research and Writing for Construction Students* 2nd Ed. Oxford: Butterworth-Heinemann.

Nkado, R., Meyer, T. (2001). Competencies of Professional Quantity Surveyors: A South African Perspective. Construction Management and Economics, Vol. 19, (p481-491)

Pacific Association of Quantity surveyors (PAQS). (2006). *What Can a Quantity Surveyor do for you?* [Online] PAQS. Available from: http://www.paqs.net.index.asp?s=700

Page M, Pearson S & Pryke S (2004) Innovation and current practice in large quantity surveying firms. Volume 4 Number 24 March RICS Foundation Research Paper Series

Pettinger R (1998) *Construction marketing; strategies for success*. Palgrave Macmillan.

Preece, C., Moodley, K., Brown, M. (2006). The Effectiveness of Marketing Spend. In Lowe, D, Leiringer, R. (ed.) *Commercial Management of Projects, Defining the Discipline*. (p155-171) Oxford: Blackwell Publishing.

Formatted: Font: (Default) Times New Roman, No underline

Pressman, A. (2006). *Professional Practice 101- Business Strategies & Case Studies in Architecture*. New Jersey: John Wiley & Sons, Inc.

Smyth, H. (2000). *Marketing and Selling Construction Services*. Oxford: Blackwell Science

Thomas, A., Darroch, J., Galvin, W. (2001). *Marketing and Service Orientation of New Zealand Law Firms.* Marketing Intelligence and Planning, Vol. 19/2, (p103-111)

Twyford, D. (2005). *Join the Brand Wagon*. RICS Business, Issue May 2005, (p30-31)

Yisa, S. B., Ndekugri, I. E. and Ambrose, B. (1995) 'Marketing function in UK construction contracting and professional firms', *Journal of Management and Engineering*, 11(4), 27-33

Young, L. (2005). *Marketing the Professional Service Firm: Applying the Principles and the Science of Marketing to the Professions*. England: John Wiley & Sons Ltd

REDUCING RESOURCES WASTE IN CONSTRUCTION PROJECTS

Per-Erik Josephson
Chalmers University of Technology, Sweden
per-erik.josephson@chalmers.se

Lasse Saukkoriipi
Chalmers University of Technology, Sweden
lasse.saukkoriipi@chalmers.se

This paper deals with the waste of resources in construction projects, which is parts of the work that are undertaken without providing any actual value for the customer. Based on a previous study of various activities in Swedish construction projects, it is argued that the costs for construction could be reduced by 30-35% within ten to twenty years, by reducing waste in most processes and for most products. In a following study, the reasons for waste as well as how waste could be reduced was discussed in a number of meetings within two groups of experienced practitioners, clients, designers, contractors and manufacturers of building material. One suggested strategy to come out of the meetings was to reduce uncertainty by standardizing products, processes and organizations. Another suggested strategy was to shorten times in most phases, since only a little amount of the total available time is used. The success of these strategies depends on managers' and employees' attitudes and personal values. However, as attitudes and values are difficult to change, the key to sustainable success is a long-term and systematic change process in which many small daily improvements are more important than a single major development in a project. The paper summarises types of waste and discusses underlying reasons for waste in construction projects. The suggested strategies have been developed into 23 recommendations for the industry related to product, process, organisation, leadership, and change.

KEYWORDS: cost reduction, standardisation, attitudes, Sweden

INTRODUCTION

A major challenge for construction firms is to reduce the long-term consumption of resources in design and production as well as in use. This is required by firms in order to (1) face the global competition by reducing their costs, (2) reduce their environmental impact by using less resources, (3) develop a better working life for personnel by requiring them to do fewer activities that do not add value, and above all (4) to achieve long-term profitability. A study performed in collaboration between Chalmers, R&D-West (a group in the Swedish Construction Federation) and the Centre for Management of the Built Environment (a collaboration between Chalmers and the Swedish construction industry) indicates that 30-35% of the production cost (i.e. what the customer pays) can be classified as waste (Josephson and Saukkoriipi, 2007).

For the purposes of this paper, the authors' definition of waste is activities which absorb resources without adding value to the customer. Before you can eliminate waste, you have to discover it and as most waste is hidden it is necessary to make it visible so that it can be discovered. Waste can be divided into the following four main groups (Josephson and Saukkoriipi, 2007):

Defects and checks. The costs of visible and hidden defects are enormous. Costs for checks, inspections, insurance, theft and destruction of property are also very high. Waste in this group accounts for more than 10% of a project's production cost.

Use of resources. Inventories typically show a surprisingly large proportion of waste in the form of waiting time, idle machinery and material waste. This waste corresponds to more than 10% of a project's production cost.

Health and safety. Waste associated with work-related injuries and illnesses is so large that it is classified as a separate group. The greatest portion of the cost is for rehabilitation and early retirement and indirectly adds extra cost to projects via taxes. Waste in this group represents more than 10% of a project's production cost.

Systems and structures. The examples of waste discussed in Josephson and Saukkoriipi (2007), such as long land use planning processes, extensive purchasing processes and a great deal of documentation, together account for approximately 5% of a project's production cost. This is the most underestimated group in the inventory. There is a tendency that improvement work leads to cumbersome management systems.

The inventory does not report all waste. Against that background, Josephson and Saukkoriipi (2007) suggested that the building sector adopt a common vision of halving production costs in the long term. They found support for the suggestion in several of their inventories, where the work done to increase value is considerably less than half of the total work that is carried out. They concluded that (a) there is very little knowledge about total waste, practitioners do not fully understand what adds value and what does not, (b) the construction sector has no customer focus in the sense that it does not care about the money passing through the organisation, (c) improvements seldom solve the problems, instead they tend to increase waste, (d) the construction sector hinders process thinking, since the actors make their roles stronger, and (e) the sector should focus much more on the core process, not only talk about doing so.

The purpose of this paper is to identify how the Swedish construction industry and their various companies could reduce the amount of waste. It is based on a series of discussions in two focus groups consisting of 7-8 experienced practitioners. The paper briefly discusses the concepts of uncertainty, standardisation, lean principles, and continuous improvement. Recommendations are presented and briefly discussed.

UNCERTAINTY AND STANDARDISATION

Uncertainty is a key concept in relation to a number of organizational areas. From an open system perspective, the environment is a key source of uncertainty, since all construction-related organizations need to interact with, and are dependent on, their environments. Thompson (1967) suggested that the technical core of an organization (e.g. the production process) needs to be "buffered" from uncertainty. In recent years, the trend has been for some construction companies to try to adopt just-in-time techniques and flexible working practices as alternative ways of coping with the uncertainty of a highly competitive environment.

Control over uncertainty can be a source of power. Hickson et al. (1971) suggested that coping with uncertainty is an important way for subunits of organisations to secure power, especially if the uncertainty affects a critical or central part of the organization. In construction it is generally accepted that site managers, who are adept at solving unexpected problems are role models for the industry. However, it may be that site managers tend to create more uncertainty than necessary in order to enhance their professional worth.

Working-life culture in Sweden is characterised, among other factors, as having low uncertainty avoidance (e.g. Hofstede, 1980), which means that there is less tendency to ask for standards and standardization than in many other cultures. Standardization in Sweden has been generally discussed by Brunsson and Jacobsson (1998), and analyzed by Räisänen and Linde (2004) in relation to project management models for multi-project organizations such as found in the construction industry.

Standardisation involves the development of pre-set procedures and referential material for performing a particular process or operation that are usually presented in writing (Imai, 1997). There are numerous case studies presented in the literature describing how construction companies develop written standards, but fail to implement and maintain standard practices. See for example Santos et al. (2002), who concluded that “it became clear that the abstract meaning of standardization has far larger possibilities than simply developing descriptions of practice in written documents.”

LEAN PRINCIPLES AND CONTINUOUS IMPROVEMENT

Reducing waste is a key element of lean philosophy. The effects of implementing lean principles vary. Al-Sudairi (2007) argued that lean principles are effective not only in complicated processes, but also in simple processes. Enhancing the flow of construction materials means that less time they will be spent in the value stream and as a result the process will become leaner. In fact, simple processes are good candidates for lean improvements. Based on case studies, Fearne and Fowler (2006) claimed that there are “many examples of practices or events that could be described as inefficient in the sense that they involved ‘waste’. However, in a project environment, which is subject to considerable levels of uncertainty, many of these practices were logical and enabled the projects to be delivered effectively.”

Based on a survey of ten managers in residential construction, Zhang et al (2005) described the most significant factors for waste reduction as being, in order of importance: 1) planning and control, 2) communication/coordination, 3) labour (availability, skill, motivation, etc.), 4) equipment and tools (appropriateness, quality, etc.), 5) working methods (sequences, technology, etc.), 6) site conditions, 7) material delivery, staging and site transportation, 8) weather, 9) safety programs, and 10) government regulations. Suggestions on how to reduce waste from a project management point of view was presented by Bertelsen (2004) who suggested seven steps for reducing waste: improve the system before improving the details; increase order as much as possible but do not expect a perfect situation; set clear objectives and communicate them widely; improve logistics; reduce the size of the window-of-order needed for the operations; manage the operations from the bottom up; and, welcome errors as an opportunity for learning.

The view that organizations should strive ceaselessly to improve, is a basic principle of most management philosophies, including total quality management and lean production. Bhuiyan and Baghel (2005) conducted a review of research into continuous improvement (CI). They defined CI as “more generally a culture of sustained improvement targeting the elimination of waste in all systems and processes of an organization. It involves everyone working together to make improvements without necessarily making huge capital investments.” They support the research presented in this paper by suggesting that “an interesting topic to pursue in the field of CI is how to determine the appropriate CI methodology for an organization to implement and what are the tools and techniques that need to be developed to achieve successful implementation.”

Imai (1986) suggested that there are at least three types of kaizen, which is often perceived as synonymous with CI: management kaizen, group kaizen, and individual-oriented kaizen. Individual-oriented kaizen is derived from the concept of bottom-up design, in which the workers make recommendations for dealing with problems. Even though this study does not only include workers but also managers, we adopted a bottom-up approach by starting from perceived problems and ideas based on data collected through various methods.

METHODOLOGY

The methodology employed for creating sound suggestions for reducing waste was to use focus groups since they have the benefit of discovering new knowledge and understanding different opinions (Morgan, 1988). Two groups were located in Gothenburg and Malmö, whilst a third group located in Stockholm functioned as a reference group. The groups consisted of 7-8 managers from client, design, contractor, material manufacturer and real estate companies. There were six sessions in both Gothenburg and Malmö, all lasting approximately three hours. The first session was mainly an explanation of the methodology as well as an account of what is currently known about construction waste. During the second session there was an analysis of causes of waste by using fishbone diagrams. Sessions three to five all dealt with creating ways to reduce waste. The focus during these three sessions was to reduce waste related to 1) individuals, 2) organizations, and 3) the whole industry or society. These sessions started with a description of the causes of waste that the participants had identified during the second session. The participants were then free to individually provide written recommendations for reducing waste. All these recommendations were then displayed on a white board and an opportunity provided for others to add some reflections. Sessions 3-5 were concluded with a vote on which recommendations were considered to be the most important ones. Based on the results from these sessions, a provisional list of recommendations was summarized and categorized. This draft of recommendations was discussed during the sixth and last session, which led to the final list of 23 recommendations.

RECOMMENDATIONS

Project organizations generally add uncertainty to most situations and activities in all phases of their building or civil engineering projects. This leads to variations in the processes with the consequence that waste is increased and customer value is reduced. One principle strategy should therefore be to increase precision in all parts of the project process. Generally project organizations use only a small amount of their total available time on value adding tasks. The investment in production resources, heating, etc cost every second with the same holding true for the customers’ investment in the project. The consequences are once again increased waste and reduced customer value. Another principle strategy should therefore be to shorten time in all phases. These principles are based on managers’ as well as workers’ attitudes and personal values, which are hard to change. This means that long-term orientation and patience are necessary in order to reach sustainable success. Many small daily changes are more important than single large development projects.

The strategy of increasing precision in all situations requires standardization of products as well as processes. Standardization is often perceived as something negative, but it is important to realize that the construction industry already is standardized in numerous respects and that the feelings of frustration that individuals at various managerial levels express are often a request for increased standardisation. In comparison with many other industries, the construction industry has a relatively high degree of freedom. One conclusion reached by the three discussion groups is that the standardisation processes has to continue if Swedish construction-related firms are to successfully face the challenges of global competitiveness, climate issues, working environment and profitability. The discussions lead to 23 recommendations, which are grouped into the following five categories:

Standardize the product

- Reduce the number of components for a specific use (1)
- Standardise components (2)
- Develop technical solutions that can be used in several projects and for several products (3)
- Chose components that you know work in the project (4)
- Designers control tolerances for increased precision (5)

Standardize the process

- The customer defines the project goal well (6)
- Make sure that all project members know and fully understand the project goals (7)
- Plan the production in detail and follow up continuously (8)
- Eliminate the dependence of weather changes by prefabrication and weather protected assembling (9)
- Discipline the structure of meetings and information flow (10)

Standardize the project organisation

- Purchase suppliers based on previous performance rather than price (11)
- Support your main suppliers in their development (12)
- Use a common way of working in all projects, developed from the best experiences from previous projects (13)
- Stimulate further education for all employees (14)
- Systematically develop ”individual efficiency” for every employee (15)

Disciplined leadership

- Base decisions on a long-term philosophy and vision (16)
- Strive for structured and clean construction sites (17)
- All managers give clear instructions that cannot be misunderstood (18)
- Encourage all employees to follow company rules and behave ethically (19)
- Reward performances in line with the company’s long-term philosophy (20)

To lead continuous improvements

- Measure performance systematically in order to discover weaknesses and to control improvement activities (21)
- Continuously reduce unnecessary activities and unnecessary administration (22)
- Continuously collect good experiences and use them in future projects (23)

DISCUSSION AND CONCLUSION

Most firms and practitioners agree that production costs can be reduced significantly by implementing more efficient processes and several top-managers agree on the importance of cost reductions. Tomas Carlsson, managing director of NCC Construction Sweden, is on record as saying ”we have decided on a difficult, challenging and ambitious goal, to reduce costs for construction by five per cent annually over the next five years. And this is not about lowering standards, because that will only reduce the amount of deliveries” (www.byggindustrin.com, 28 November 2007). Mats Williamson, former managing director of Skanska Sweden, contended that ”reducing costs is the most important issue for the civil engineering sector” (www.fiasverige.se, 22 April 2008). A test was carried out by asking practitioners “how much do you think the cost of production could be reduced within the next ten years?” Out of 457 responses, 90% thought that it would be possible to reduce costs by 10% or more, whilst 11% thought that costs could be reduced by 30% or more within ten years. However, it is not known whether they were thinking of reducing costs by purchasing materials in low cost countries or by reducing waste.

The group discussions led to an agreement that (a) there is too much focus on the industry instead of on companies, which leads to the customer receiving a lower priority, (b) there is a high level of risk in most organisations and processes, which leads to many negative surprises, (c) companies choose uncertain and risky situations, but the managers try to find explanations in the environment for their behaviour, (d) employees have learned to handle uncertain situations so that there are no longer incentives for change, and that (e) there is a great need for increased standardisation, but with freedom and flexibility. These opinions guided the groups in the development of the recommendations for reducing waste. Afterwards, a test was carried out by asking another group of ten experienced practitioners from various firms to comment on the recommendations. Specifically, they were asked to choose one of their on-going projects and individually evaluate to what extent they practice each recommendation. A scale of 1-10 was used, where 10 meant that the recommendation is fully practiced and 1 meant that the recommendation is not practiced at all. The highest average score for groups of recommendations was for standardize processes, (6,0) followed by disciplined leadership (5,6), standardize the product (4,9), lead continuous improvements (4,7) and standardize the project organisation (4,4). The recommendation “Plan the production in detail and follow up continuously” (No. 8) got the highest score followed by recommendations Nos. 19, 6, 10 and 17. The recommendation “Systematically develop ‘individual efficiency’ for every employee” (No. 15) got the lowest score followed by recommendations Nos. 12, 21 and 14.

Here, it is argued that reducing waste is one of the greatest challenges facing the construction industry and should be one of the highest priorities for both individual companies and the building sector as a whole. An initial step towards meeting this challenge is to provide all concerned with an ability to judge what activities increase value and what activities are wasteful. One way is to conduct further studies to gain a greater knowledge of the size and different types of waste as well as to gather more examples in order to stimulate the waste debate and eventually develop better processes for reducing construction waste.

Two crucial questions occur when planning standardized processes. The first question is which sub-processes (or activities) should be standardized and which should not? In other words, what should be standardized without negatively influencing individuals’ free choice of how to manage projects? This sense of freedom is highly appreciated by managers and workers alike on construction sites. The second question is who should firms collaborate with and who should they compete with? In other words, which sub-processes should be standardized at project level, firm level, and industry level respectively?

REFERENCES

Al-Sudairi, A. (2007) Evaluating the effect of construction process characteristics to the applicability of lean principles, Construction Innovation, 7(1), 99-121.

Bertelsen, S. (2004) Lean construction: Where are we and how to proceed?, Lean Construction Journal, 1(1), 46-69.

Bhuiyan, N., and Baghel, A. (2005) An overview of continuous improvement: from the past to the present, Management Decision, 43(5), 761-771.

Brunsson, N., and Jacobsson, B. (1998) Standardisering, Santérus förlag, Stockholm.

Fearne, A., and Fowler, N. (2006) Efficiency versus effectiveness in construction supply chains: the dangers of “lean” thinking in isolation, Supply Chain Management: An international journal, 11(4), 283-287.

Hickson, D.J., Hinings, C.R., Lee, C.A., Schneck, R.E., and Pennings, J.M. (1971) A strategic contingencies theory of intraorganizational power, Administrative Science Quarterly, 16(2), 216-229.

Hofstede, G. (1980) Culture’s consequences: International differences in work-related values. Beverly Hills, CA: Sage.

Imai, M. (1986) Kaizen: The key to Japan’s competitive success, Random house, New York, NY.

Imai, M. (1997) Gemba Kaizen: a commonsense, low-cost approach to management, McGraw-Hill, New York, NY.

Josephson, P.-E., and Saukkoriipi, L. (2007) Waste in construction projects – call for a new approach, The Centre for Management of the Built Environment (CMB), Chalmers University of Technology. ISBN 978-91-976181-7-5.

Morgan, D. (1988) Focus groups as qualitative research, Sage Publications, Newbury Park.

Räisänen, C., and Linde, A. (2004) Technologizing discourse to standardize projects in multi-project organizations: Hegemony by consensus? Organization, 11(1), 101-121.

Santos, A., Formoso, C.T., and Tookey, J.E. (2002) Expanding the meaning of standardisation within construction processes, The TQM Magazine, 14(1), 25-33.

Thompson, J.D. (1967) Organizations in action. New York: McGraw-Hill.

Zhang, J., Eastham, D. L., and Bernold, L. E. (2005) Waste-based management in residential construction, Journal of Construction Engineering and Management, 131(4), 423-430.

INITIATING SUPPLIER DEVELOPMENT THROUGH VALUE STREAM ANALYSIS: THE CASE OF SKANSKA SWEDEN AND ITS LARGEST SUPPLIER

Mikael Frödell
Skanska Sweden AB & Building Economics and Management, Chalmers University of Technology, Sweden
mikael.frodell@skanska.se

Per-Erik Josephson
Building Economics and Management, Chalmers University of Technology, Sweden
per-erik.josephson@chalmers.se

Even though the manufacturing industry has benefited from Supplier Development and Value Stream Analyses during the past twenty years, the construction industry has lagged behind in this respect. This may be because the geographically spread and project-based nature of the industry together with the desire to maximize profits in every construction project, gives the industry a unique character. The purpose of this case study is to identify the strengths and weaknesses of the interface between a major Swedish contractor and its largest supplier, a construction machinery rental company, using a Value Stream Analysis approach. By interviewing key individuals in both organisations and studying historical data of deliveries, the major interface issues have been identified as related to flexibility and uncertainty in the construction process. For instance, orders from the contractor were placed so late that the supplier had to compromise their ordinary processes in order to satisfy the contractor's demands. Considerable potential for decreasing total cost for the delivery process have been identified as a result of the study and the main conclusion is that efficiency in the interface between contractor and supplier can be improved by reducing the flexibility in their relationship.

KEYWORDS: construction industry, service blueprinting, buyer-supplier relationship, case study

INTRODUCTION

During the last couple of years, distinct changes in the Swedish construction industry have been seen. An increasing number of international actors have entered the market using methods and strategies new to the Swedish market, resulting in a new kind of competition. As a result of the increasing competition, Swedish construction companies need to develop new strategies for increasing productivity and decreasing total costs. Strategies adopted by several Swedish contractors relate to purchasing patterns. This may have been as a result of realising that approximately 80% of contractors' turnover is related to the purchasing of products and services.

The construction industry is characterized by a geographically spread and project-based structure where every project is run as though it was an individual company with the associated responsibility to deliver good financial results. Furthermore, communication between projects is limited, resulting in minor dissemination of knowledge and experiences within companies. Consequently, project managers tend to rely on their own supplier base and their own way of working with suppliers. Supplier issues have been researched in other industries for decades with the Japanese automotive industry leading the way. However, since the characteristics of industries are quite different, it is not considered appropriate to transfer research from another industry, automotive or otherwise, to the construction industry.

This study therefore addresses a need for research into the interface between contractors and suppliers exclusively for the construction industry. Using a Value Stream Analysis approach, a case study was used to identifying strengths and weaknesses in the interface between a major Swedish contractor, Skanska Sweden, and its supplier of rented construction machinery, Skanska Maskin. Skanska Sweden is a subsidiary of the global construction company Skanska AB and Skanska Maskin is a subsidiary of Skanska Sweden.

SKANSKA SWEDEN

Skanska Sweden is one of the major construction companies in Sweden with a turnover of MSEK 27,389 in 2007, during which time they were continuously active in approximately 3,000 projects. Their vision is to become a role model in Swedish industry but they firstly aim be the most professionally outstanding construction company in Sweden. Skanska Sweden is organised in 25 regions of which 12 are focused on civil construction and 11 on building construction. Two regions are so-called special units whose activities do not form part of Skanska Sweden's core business but are considered of such importance to the core business that they have been kept in-house. Skanska Maskin is one of these special units.

In 2007, 71.5% of Skanska Sweden's turnover consisted of purchasing costs. Purchases are mainly divided in two sorts, project specific purchases and coordinated purchases. Project specific means that sourcing is conducted for every specific project and thereby the suppliers are continuously exposed to competition. Coordinated purchases are built on framework agreements with the supplier and from Skanska's side the agreement part is either Skanska AB or Skanska Sweden. Of the total purchased volume during 2007, coordinated purchasing accounted for 30%.

The total supplier base of Skanska Sweden consisted of 28,000 suppliers in 2007, of which 10.26% of the suppliers represented 90% of total expenditure. Approximately 600 of these suppliers have signed a framework agreement with Skanska Sweden, the largest of which is Skanska Maskin to whom Skanska Sweden paid MSEK 454.2 during 2007.

SKANSKA MASKIN

The interface between Skanska Sweden and Skanska Maskin is two-fold. In addition to Skanska Maskin being a wholly-owned subsidiary of Skanska Sweden, Skanska Maskin is also Skanska Sweden's single largest supplier. Its vision is to self-evidently become the construction industry's best service partner by working closely with customers; it had a turnover of MSEK 542.3 during 2007. Skanska Maskin specialise in delivering knowledge, service, machinery, equipment and utilities for the construction industry and its fleet comprises approximately 45,000 units. In 2007 it employed 313 workers.

Skanska Maskin is geographically divided into three districts in Sweden: the Northern, Western, and Southern districts. In each of these districts a main depot is located where the offices and the major part of their business are located. In addition to the three main depots, 13 minor depots of varying size are geographically spread throughout Sweden. These minor depots hold a small stock of units for delivery and also serve as a return centre for projects nearby. Most of the deliveries from Skanska Maskin are made from the main depots.

Skanska Maskin's main business is rental of construction equipment and machinery and is mainly divided into five business areas: builder's huts, machinery, lifts, logistics, and service. This study focuses on construction machinery and the associated services and logistics.

FRAME OF REFERENCE

Contractor-Supplier Relations

Literature about relations between contractors and their suppliers often discusses temporary contract relations, especially how and the criteria on which contractors should base their choice of suppliers for specific projects. There are less papers dealing with studies relating to how long-term relations can be developed, even though there is a common view that long-term relations between companies reduce problems and lead to better products. The idea is that historical collaboration and expected future collaboration leads to higher efficiency and better results. Kamann et al. (2006) show in a study of 448 contractor-supplier relations that this correlation can be found especially in cases where individuals rather than firms have historical and expected future collaboration.

Supplier development has received increased attention in other industries. For example, Rogers et al. (2007), evaluated supplier development programs in the North American automotive industry, while Sánchez-Rodríguez et al. (2005) shows in their study of 306 manufacturers in Spain, that performance had been positively influenced by applying processes and methods for supplier development. In the construction industry, Errasti et al. (2007) studied development of partnership with sub-contractors and argue that bigger purchasing volumes and fewer suppliers leads to significant improvements.

Krause and Ellram (1997) argue that supplier evaluations are necessary for more systematic supplier development while Carr and Pearson (1999) found that implementation of supplier evaluations in itself leads to increased profits. One discussed reason is that evaluations make it more evident for the customer what is important. Nevertheless, the ambition with supplier evaluations has to be higher than that. A great number of models for evaluating suppliers have been developed over the years. One such model was developed by Safayeni et al. (1992) and Purdy and Safayeni (1993), who focused on supplier working processes and an evaluation of their management systems. Another model was developed by Tracy and Vonderembse (1999), who aimed at understanding how supplier evaluation criteria and supplier performance influence the bottom line.

Value Stream Mapping

Value stream mapping is an analysis method for identification and removal of non-value adding activities in processes, in order to improve productivity. It was initially developed in 1995 and is often linked to lean thinking (Hines et al., 1998). Hines and Rich (1997) presented a correlation matrix of seven value stream mapping tools and seven wastes from the Toyota production system (see for example Liker, (2004)) as well as an overall value stream structure. The correlation matrix shows different tools along with their ability to identify specific wastes and presents the process activity mapping tool as the most comprehensive of the investigative tools. Furthermore, Panizzolo (1998) studied 27 leading international firms that had adopted lean production, identifying the major challenges and difficulties with its implementation. Panizzolo argues that management of external relations was the major problem and that the challenge lies in how to integrate external value-adding organisations into the value process. He further states that the focus must move from operations management to relationship management.

Twelve rules for simplifying material flow were presented by Towill (1999), who argues that this is closely coupled to elimination of waste in supply chains. The main issues are elimination of all uncertainties in all processes as well as the streamlining and visualising of all information flows. The elimination of uncertainties in the processes are based on a four dimensional model called the uncertainty circle. The four dimensions are supply side, control system, value-added process, and demand side. Mason-Jones and Towill (1998) state that all four dimensions are necessary to investigate reducing uncertainties since they are all significant and of approximately equal importance. They also argue that many companies focus their effort on value-added processes and the supply side while neglecting control systems and the demand side, resulting in remaining supply chain uncertainty.

A more critical view was taken by Fearne and Fowler (2006) who conducted case studies of construction projects that had adapted lean thinking, studying the potential effects of having too narrow a focus on lean issues. They conclude that focus on efficiency in the use of resources undermines effectiveness in delivering projects. They argue that construction projects to a large extent are exposed to uncertainties and in order to deal with them, non-lean practises sometimes make practical sense and enable the project to proceed more effectively. They further argue that in order for the industry to advance in both efficiency and effectiveness, a more integrated and customised approach to lean thinking is essential. This integration requires a fundamental change in the relationship between contractors and suppliers.

Service Blueprinting

Shostack (1984) presented a value stream mapping method called service blueprinting. The method deals with some of the issues discussed above by focusing on the relationship between customer and supplier and by presenting a method for visualising the complexity and divergence in the interface. Additionally, Bicheno (2004) argue that service blueprinting is particularly applicable when there are multiple contacts between supplier and customer, which is the situation with Skanska Sweden and Skanska Maskin. Service blueprinting was therefore chosen as the analysis tool for this case study.

Shostack (1987) suggested that when it comes to service, it is often easier to define what is done rather than how it is done. However, the use of service blueprinting facilitates the engineering of processes at the drawing board and can also be used for educational purpose as well as comparative and competitive assessment. Additionally, blueprints provide participants with a holistic view of the process rather than just the specific part that they are responsible for, and are more useful if produced for a specific process rather than as a generic visualisation.

Furthermore, Shostack (1987) identified two dimensions of the service process. The first dimension she termed complexity, which is the number and difficulty of the steps, whilst the second dimension she termed divergence, which is the degree of freedom in the execution of the steps. Shostack's study found that a process with greater divergence often commands higher prices due to flexibility and customization and is also more difficult to manage, control and distribute. Consequently, she proposed two alternative ways of making the process more efficient: either by decreasing complexity or by decreasing divergence.

METHODOLOGY

In order to understand the relationship between the customer and the supplier, a total of 25 interviews were conducted. Ten of the interviews were conducted with respondents on the customer's side, lasting 45 to 90 minutes. These interviews were primarily individual, although on one occasion two respondents were interviewed simultaneously. Eight respondents were production managers and two were foremen who between them represented building and civil engineering projects of all sizes across the customer's entire geographical area of operation. On the supplier's side 15 individual interviews were conducted lasting 40 to 65 minutes and, in order to get an overall picture of the interface, the respondents represent all three main depots and all five of the supplier's business areas. All respondents had continuous contact with other parties in the interface. Interviewees were encouraged to speak freely but a semi-structured approach was adopted in order to keep the discussion within the intended area. As a first step, respondents were asked to describe the interface between customer and supplier and also to sketch the interface along with the most important activities. The discussion was then based on this description in order to cover the entire interface and minimize the risk of getting stuck in a specific area of discussion. Respondents were not only asked to identify strengths and weaknesses in the relationship but to also put forward suggestions for improvement and to explain how such improvements would develop the interface.

In addition to the interviews, two workshops were carried out with the management team of Skanska Maskin and the purchasing team from Skanska Sweden. These workshops focused on the effectuation of the case study and the preliminary results. Furthermore, statistics of the deliveries were obtained from the supplier, which contributed to the empirical part of the study.

THE RELATIONSHIP

A clear picture of the relationship crystallised during the interviews. Even though the relationship was mostly described as well functioning and satisfactory, interviewees also highlighted parts of the interface that could be improved.

By discussing the different activities in the interface and the possible actions in each activity, a blueprint of the interface between Skanska Sweden and its largest supplier has been produced. The activities are in chronological order from left to right and positioned according to whether the activity is related to the customer or supplier; the intersections show where interaction between customer and supplier occur. The blueprint of the relationship is presented in Figure 1.

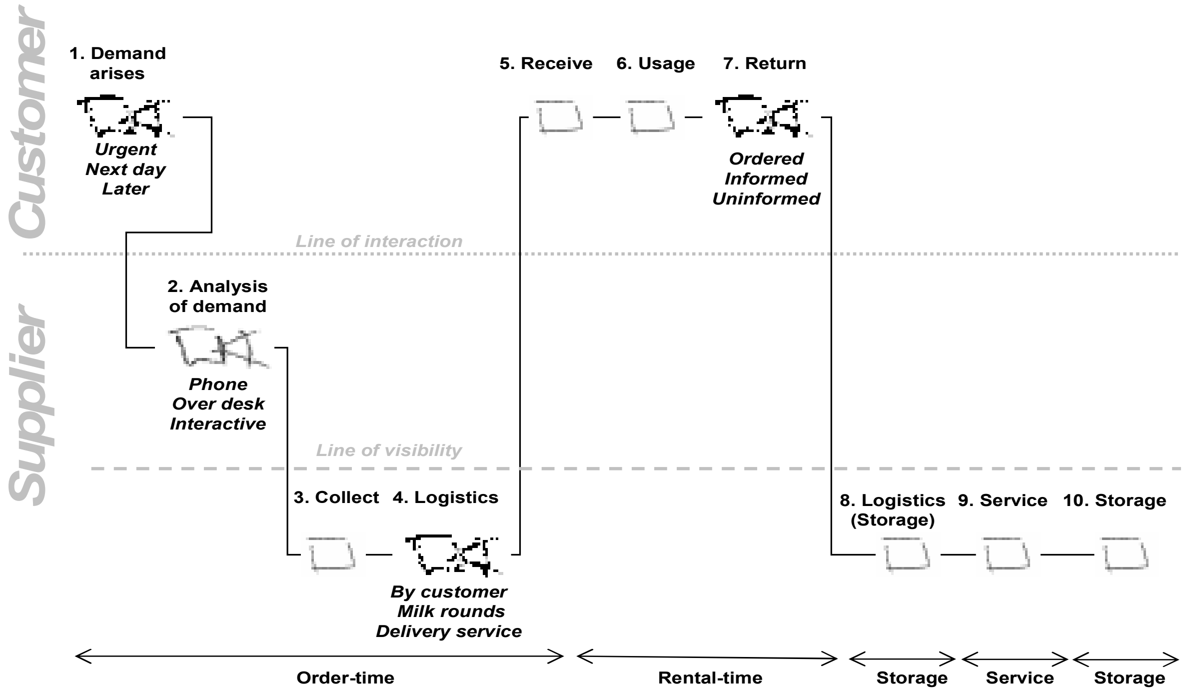


Figure 1. Blueprint of the interface between Skanska Sweden and its largest supplier

It can be seen from the blueprint that there are ten main activities in the interface. In the first activity, a demand arises for one of the supplier's products in the project. The product might be needed immediately so that delivery is a matter of urgency or it may not be needed until some point in the future in which case there is no urgency for delivery. However, one interviewee, a salesperson, said that "in most cases, the projects need the deliveries yesterday." Examination of 181 orders revealed the following: 75 orders were required to be delivered at the project within the same day, of which 32 orders were required immediately, hence with no planning from the projects; 89 orders needed to be at the project the day after the order; and only 17 of the orders were placed two or more days in advance of the required delivery date despite the fact that the supplier offers a rebate on all such orders.

The second of the main activities is the analysis of demand. Respondents revealed that approximately 50% of the time when an order is communicated to Skanska Maskin the customer has not yet decided what type of machine is needed. In such cases, the supplier's sales people often recommend machines suitable for specific situations since they possess knowledge of their mechanism as well as their uses. This service is greatly appreciated by customers and many of the respondents were full of praise for the supplier's competence in their field of knowledge. The analysis of demand is made in three different ways: by phone, through an interactive procurement tool, or over the counter when the customer visits the supplier. One of the goals of Skanska Sweden is that 100% of its purchases shall be done though the interactive procurement tool by 2010. However, according to statistics from the supplier, only 1.78% of the orders during 2007 were communicated through the interactive procurement tool with the remainder having been by phone or in person.

The third and fourth main activities concern collecting machines from the storage and transporting them to the construction sites. The collecting is primarily done by the logistics staff. However, in some urgent situations, the salespeople themselves will collect the machines and prepare them for transport. This might also be the case when the inventory levels are low and the salespeople want to assure the customer that they will not run out of stock and that they will be able to deliver. When it comes to logistics several options are available to both the supplier and customer. According to an interviewee from Skanska Maskin, since all logistical costs are paid for by the projects it is possible to use whichever logistics solution they prefer. However, three alternatives account a majority of the deliveries. Statistics from 2007 show that approximately 46% of the transports are managed by the projects themselves, which might be through a trip to the supplier's office to pick up the machine in person or by hiring a logistics company to pick it up for them. Additionally, 22% are delivered through milk rounds managed by the supplier, and 12% are sent by a delivery service. The remaining 20% are difficult to categorise or are unspecified in the statistics. In addition to these alternatives, respondents from both the supplier and the customer described cases where salespeople from Skanska Maskin personally delivered the machines to projects if the situation was really urgent.

The fifth, sixth and seventh main activities are related to the receiving of the machines, the usage of the machines, and the returning of the machines to the supplier. The process of receiving the machines is quite different from project to project, although the supplier's logistics personnel claim that in most of the cases when the supplier manages the delivery a representative from the project has to meet up and confirm the delivery. According to one of the production managers this can be very time consuming, especially if there are many deliveries and they are spread out over the day. Once the machines arrive at the project the sixth activity, usage, takes place. Although usage was not further examined by this study, However, Josephson and Saukkoriipi (2007) presented a study of the usage of construction machinery and equipment in the Swedish context and conclude that machines are often used less than 10%, of the time that they are on site. A logistics interviewee employed by the supplier claimed that return of the machines is done in three different ways: ordered, informed, or uninformed. Ordered implies that projects contact the supplier and ask them to pick up the machines, in which case the same logistic solutions as in the fourth activity are used. Informed implies that projects contact the supplier and inform it that some returns are on their way, they can then be sent by delivery service or be returned with transport scheduled to deliver other machines to the project and would be going back to the depot anyway. The last way of returning the machines, uninformed, is similar to the previous method but without communication between the projects and the supplier. In such cases machines may not be found until weeks after they have been returned and negotiations will then have to take place between the project and the supplier in order to sort out if the project should pay for this period of time or not.

Generally for the fifth, sixth and seventh activities, supplier respondents stated that in many cases machines are held by the projects for a very long time and it is often unclear when they will be returned. Opinions as to whether this is for good or for bad vary greatly. On one hand a long rental period brings in more money for the supplier, on the other hand the machines are not inspected and serviced regularly, which might decrease their value and shorten their life-span. Statistics from the supplier for the five product groups with the highest purchasing value show that they were rented out 46% - 90% of the time during 2007.

The eighth, ninth and tenth activities concern the service and the storage at the supplier. Primarily the machines are received by the logistics department and then transported to the storage yard where they are stored until they are serviced. These storage yards are differently designed, but there are cases where there is only one way in and out of these. A consequence of this is that machines placed in the back of the storage yard will receive service more seldom than the once that have recently arrived; a first in - last out approach. However, respondents from the service department pointed out that the machines in the back of the yard can be prioritized for service if the demand is very high. This prioritization is mainly initiated by the sales department and, according to the service personnel, is often done without prior consultation with the service department. After the service has been carried out, the machine is placed back in the storage until the process restarts.

In addition to the issues related to the main activities, some issues related to the relationship in general were pointed out by respondents. Firstly, in many cases there are too many contact persons involved in the interaction between the supplier and a project. Respondents pointed out that this can easily lead to misunderstandings and situations where they have to devote much time to determine what had been agreed in relation to specific projects. The second issue is the adaptability and flexibility in the relationship, which project respondents see as a very good feature. Supplier respondents mentioned many times that they do what they can in order to satisfy the customer and that in many cases they have to relinquish their ordinary processes to do so. One respondent claimed that Skanska Maskin spoils the projects by always doing what they can to satisfy them and that it probably would be a less stressful work environment for the supplier's personnel if they did not have to take urgent measures all the time.

Thus, ten main activities are carried out in the interface between Skanska Sweden and its main supplier where the general opinion expressed by the respondents is that these activities function well. Nevertheless, certain areas for improvement have been identified for both the main activities and for the relationship as a whole.

DISCUSSION AND CONCLUSIONS

The purpose of this study is to present strengths and weaknesses in the interface between a major Swedish contractor (Skanska Sweden) and their largest supplier (Skanska Maskin). By using Service Blueprinting-technique, the interface between them has been visualised and certain areas for improvement have been identified even though most of the respondents expressed satisfaction with the relationship. The greatest strength identified in the relationship was the supplier's competence with the products which facilitates the analysis of demand in the second main activity, while one of the weaknesses was related to the first activity, when the demand arises. It was found that the supplier in many cases does much to fulfil the need of the projects and in many cases at very short notice since as many as 75 of 181 investigated orders were required to be delivered to the projects the same day. Furthermore, it is evident that many of the supplier's activities are divergent or flexible, allowing many possible ways of carrying out an activity. For example, the supplier's sales people personally deliver machines to projects in urgent cases. According to Shostack (1987), such divergent activities often commends higher prices due to the flexible and customized service offered by the supplier.

Nevertheless, flexibility is a difficult issue to handle due to uncertainties on the demand side of the relationship and, according to Mason-Jones and Towill (1998), the uncertainty at the demand side of a supply chain relation is often neglected when it comes to supply chain development. A question that arises is whether the supplier is too flexible or not. Skanska

Maskin's philosophy is to satisfy the customer, but to what extent should suppliers adapt their practices to the needs of projects and do the projects necessarily know which solution is best for them and for the relationship as a whole. Even though the construction industry is a highly decentralised industry it might be a step in the right direction to reduce the flexibility in this kind of interaction, from a holistic supply chain perspective, in order to minimize the risk of a sub-optimised solution.

To conclude, the total cost of the relationship would most probably decrease if the processes at the interface could be determined and stringently followed, since the need for flexibility would not be necessary. However, since uncertainty in projects is a part of every-day work, the question of how much flexibility is needed in order to keep and improve the effectiveness of projects is a major variable in this kind of interaction.

REFERENCES

Bicheno, J. (2004) *The New Lean Toolbox.* Buckingham, England: PICSIE Books.

Carr, A. S. & Pearson, J. N. (1999) Strategically managed buyer-supplier relationships and performance outcomes. *Journal of Operations Management,* 5(17), 497-519.

Errasti, A., Beach, R., Oyarbide, A. & Santos, J. (2007) A process for developing partnerships with subcontractors in the construction industry: An empirical study. *International Journal of Project Management,* 3(25), 250-256.

Fearne, A. & Fowler, N. (2006) Efficiency versus effectiveness in construction supply chains: the dangers of "lean" thinking in isolation. *Supply Chain Management: An International Journal,* 4(11), 283-287.

Hines, P. & Rich, N. (1997) The seven value stream mapping tools. *International Journal of Operations & Production Management,* 1(17), 46-64.

Hines, P., Rich, N., Bicheno, J., Brunt, D., Taylor, D., Butterworth, C. & Sullivan, J. (1998) Value Stream Management. *The International Journal of Logistics Management,* 1(9), 25-42.

Josephson, P.-E. & Saukkoriipi, L. (2007) Waste in construction projects – call for a new approach. *The Centre for Management of the Built Environment (CMB).* Chalmers University of Technology.

Kamann, D.-J. F., Snijders, C., Tazelaar, F. & Welling, D. T. (2006) The ties that bind: Buyer-supplier relations in the construction industry. *Journal of Purchasing and Supply Management,* 1(12), 28-38.

Krause, D. R. & Ellram, L. M. (1997) Critical elements of supplier development The buying-firm perspective. *European Journal of Purchasing & Supply Management,* 1(3), 21-31.

Liker, J. (2004) *The Toyota Way, 14 management principles from the world's greatest manufacturer.* McGraw-Hill.

Mason-Jones, R. & Towill, D. R. (1998) Shrinking the supply chain uncertainty circle. *IOM Control,* 7(24), 17-22.

Panizzolo, R. (1998) Applying the lessons learned from 27 lean manufacturers.: The relevance of relationships management. *International Journal of Production Economics,* 3(55), 223-240.

Purdy, L. & Safayeni, F. (1993) Computerized performance monitoring systems. IN Lederer, A. (Ed.) *Handbook of Human Resource Information Systems.* New York: Warren Gorham Lamont.

Rogers, K. W., Purdy, L., Safayeni, F. & Duimering, P. R. (2007) A supplier development program: Rational process or institutional image construction? *Journal of Operations Management,* 2(25), 556-572.

Safayeni, F., Irving, R., Purdy, L. & Higgins, C. (1992) Potential impacts of computerized performance monitoring systems: Eleven propositions. *Journal of Management System,* 2(4), 73-84.

Sánchez-Rodríguez, C., Hemsworth, D. & Martínez-Lorente, Á. R. (2005) The effect of supplier development initiatives on purchasing performance: a structural model. *Supply Chain Management: An International Journal,* 4(10), 289 - 301.

Shostack, G. L. (1984) Designing services that deliver. *Harvard Business Review,* 1, 133-139.

Shostack, G. L. (1987) Service Positioning Through Structural Change. *Journal of Marketing,* 1(51), 34.

Towill, D. R. (1999) Simplicity wins: Twelve rules for designing effective supply chains. *IOM Control,* 2(25), 9-13.

Tracey, M. & Vonderembse, M. A. (1999) The Impact of Supplier Selection Criteria and Supplier Involvement on Manufacturing Performance. *The Journal of Supply Chain Management: A Global review of Purchasing and Supply,* 3(35), 33-39.

SELECTION OF COMMERCIAL OFF-THE-SHELF SOFTWARE-BASED SYSTEMS WITHIN THE CONTEXT OF LEADING CONTRACTORS IN PORTUGAL

José Barreiro Lima
Research Institute for the Built and Human Environment,
School of the Built Environment, University of Salford, UK
barreiro.lima@mail.telepac.pt

Michail Kagioglou
Research Institute for the Built and Human Environment,
School of the Built Environment, University of Salford, UK
m.kagioglou@salford.ac.uk

José Cardoso Teixeira
Department of Civil Engineering,
School of Engineering, University of Minho, Portugal
jct@civil.uminho.pt

The fundamental goal of all Commercial Off-The-Shelf Software-Based Systems (CBS) selection is to obtain the most suitable market offered solution. CBS selection should consider a diversity of 'requirements engineering' and 'qualification and evaluation' initiatives, ranging from 'pre-elicitation of (high-level) requirements' to 'validating requirements (and agreeing)' and from 'identification of candidate products' to 'final decision and acquisition'. Furthermore, within the CBS selection literature a diversity of patterns might be found, as phases, stages and activities, aspects, factors and perspectives, stakeholders and other issues. Based on field surveying initiatives, this paper summarises a selected group of major patterns related with CBS selection practices, among leading construction contractors in Portugal. Additionally, a roadmap is introduced, emphasising on further research that could lead to fundamental improvements in CBS selection within the context of leading construction contractors in Portugal.

KEYWORDS: CBS selection, requirements engineering, qualification and evaluation, construction contractors, Portugal.

1. INTRODUCTION

Construction already applies some management principles as presented in modern theories (Koskela, 1992; Santos *et al.*, 1999). An increasing number of contractors in Portugal are Quality - ISO[1] certified (APCER, 2005) and/or have determined to implement elements of this Quality standard as a means to improve business processes and/or to meet customer requirements (e.g. ME, 2004). Following the application of those principles within the context of leading construction contractors in Portugal, this research considers and further discusses the following premises related to business software applications[2]:

---

1 International Organisation for Standardisation (ISO).
2 Not covering embedded systems or command and control systems.

- *Software systems benefit process improvement.* Software is an enabler of process improvement among different units within individual companies and between construction partners.
- *COTS[3]-Based System (CBS) products are an option when selecting software systems.* COTS products, generic or package products are being used/preferred to developed software or bespoke solutions by a considerable number of leading contractors in Portugal.
- *Among leading contractors in Portugal there is a considerable experience in CBS selection*, although supported on ad-hoc selection initiatives based on the experience of practitioners, not guided by prewritten, standard processes specifically designed for selecting COTS software products.
- *Software selection decisions should enclose economic/investment factors.* Software Engineering (SE) and design investment approaches should incorporate the economic perspective into the decision-making process.

Regarding the premise *software systems benefit process improvement*, the European Commission (EC) Information Technology (IT) working group for the construction industry states that main attention should be paid to IT as an enabling tool in the construction process, since several studies indicate that major economies can be obtained through better communication and data-interchange, not only between the partners in the construction process, but also among the different units within individual companies (EC, 1999). In line with that statement, there is a diversity of institutions and research centres developing work on the effective use of IT in the construction industry[4].

Adopting the view that IT is an enabler (i.e. process integrated) rather than a driver of processes (Aouad *et al.*, 1999), Koskela (1992) states that process improvement is the primary phenomenon that can be supported by IT. More specifically, IT may benefit process improvement in two ways[5] (Koskela, 1992): IT might be used for automating specific conversions and sub-flows, leading to variability reduction, shortened cycle times, adding transparency (and other benefits) and IT might allow process redesign, causing radical process simplification.

Premise definition that *CBS products are an option when selecting software systems* is based on the rapid growing of CBS software industry in Portugal (Datamonitor, 2000) and on the researcher field experience, indicating that: CBS solutions supporting business activities have been selected, are already implemented and used by an overwhelming majority of leading construction contractors in Portugal. In fact, that perceived trend is corroborated by some other industry and country contexts where the standard way to acquire application systems is to purchase software packages (Martin *et al.*, 1998). It is also considered that *among leading contractors in Portugal there is a considerable experience in CBS product selection*, although, it is also understood that the difficulties of software selection are made accurate by ad-hoc and unsystematic approaches adopted to this problem (Hargitay and Dixon, 1991).

Inclusion of premise *software decisions should enclose economic/investment factors* relates to the need of emphasising a strategic investment perspective into the selection of CBS portfolio of products, incorporating into the selection a more sophisticated economic perspective. In

[3] Commercial Off-The-Shelf (COTS) software.
[4] For example: (BuHu, 2006; CICA, 2006; CIFE, 2006; CE, 2005; CITFB, 2006; CSTB, 2006; VTT, 2006).
[5] Some restrictions apply; for additional information/comments on restrictions please see (Koskela, 1992).

fact, past work focuses largely on costs and not on benefits leading to the mismatch of consistency with the company goal of maximising value (Boehm and Sullivan, 2000).

Furthermore, introduction of economic rationality to support the decision making/investment process is demand-driven within the Portuguese context. Using other words, COTS (potential) buyers and selection practitioners are also contributing to put new challenges in front of the consulting, research and academic communities, related to the need of supporting decision making/investment processes on economic reasoning. Considering the proposed software economics approach (analysing costs and benefits), investments in software should incorporate a financial perspective and decision makers need to understand the project overall analysis before committing resources.

2. RESEARCH OVERVIEW

A specific *Demand-Supply Selection (DSS) Methodology* of CBS is being developed, based on contextualised premises and practices in use by practitioners and on review of literature, considering context/stakeholders interaction of leading contractors in Portugal. The DSS Methodology comprehends the design of a *full study*, based on the identification of a feasible need/opportunity discussed on a former *feasibility study* requiring the selection of CBS products[6].

The following six segments are central to this research development:

- *Premises, principles & knowledge area.* Encloses research premises validation (e.g. software impact on process performance), confirmation of experience in CBS products selection (e.g. major identified problems), and discussion of core principles for the development of a CBS selection methodology.
- *Methodological phases, stages & activities.* Major focus is on the identification of main phases, stages and activities of the selection process.
- *Tools & techniques.* Covers discussion on selected/strategic tools, techniques and methods related to requirements elicitation/acquisition and specification (e.g. formal or natural language, requirements reuse), identification and qualification of CBS products (e.g. using publications, internet), evaluation of CBS products (e.g. prototyping, interviews, request for proposal) and decision about CBS products (e.g. decision making techniques).
- *Aspects, factors & characteristics.* Encloses major factors supporting the evaluation of CBS products, e.g. economic, soft, technical, time.
- *Dimensions & perspectives.* Studies major dimensions and perspectives related to the development of CBS solutions (e.g. architecture, marketplace, programmatics, risk).
- *Stakeholders.* Considers the identification of market offerings of CBS (i.e. suppliers, products) and *market offerings* of consulting services (obtaining benchmarking information about the use of CBS products and acquisition of consulting services for CBS product selection by leading contractors) and lists *categories of stakeholders* involved in the process of CBS selection.

This paper summarises some of the research already undertaken, giving a special emphasis (not a comprehensive view) about three of the above segments: (1) *premises, principles & knowledge area aspects*, (2) *methodological phases, stages & activities*, and (3) *aspects,*

---

[6] In other words, please be aware that the *full study* considers that the need is already understood at some level, since that was what has forced to get the selection started.

factors & characteristics. Regarding further coverage, not only of these three and of other *research segments*, but also of (future) related *research deliverables, please* see section *5.1. Further research*.

3. METHODOLOGY

A questionnaire survey technique is used, being supported on an on-line survey tool (Key Survey, 2006) and delivered to the leading (largest) Portuguese construction contractors' Chief Information Officers (CIOs). A Questionnaire has been distributed on November 10th, being all responses received till December 10th, 2006, considered. The questionnaire development involved a systematic literature review, the development of a multicompany CBS selection (informing) case study, and consultation with international[7] experts and Portuguese researchers (e.g. by e-mail), to test content, comprehension and to pilot the questionnaire developed, before the final version was drawn up.

Table 1: Questionnaire, Validation

		International experts			Portuguese researchers		
		Number	%		Number	%	
Invitations sent	a	54	100.0%	a/a	25	100.0%	a/a
Invitation reachable	b	52	96.3%	b/a	25	100.0%	b/a
Invitation unreachable	c	2	3.7%	c/a	0	0.0%	c/a
Invitations reaction							
Invitations accepted	d	20	38.5%	d/b	14	56.0%	d/b
Comments received and incorporated	e	14	26.9%	e/b	8	32.0%	e/b
Comments received (out-of-date)	f	0	0.0%	f/b	1	4.0%	f/b

The questionnaire (bilingual) was validated in consultation with international experts and Portuguese researchers by e-mail in several occasions between September 21st and November 9th, 2006. Those initiatives were used to triangulate and, therefore, validate the questionnaire data, in order to find out if the questionnaire to be distributed was able to provide the correct information. The consultation with Portuguese researchers is further justified to assure the validation of the Portuguese language content of the questionnaire. The participation received from the consultation with (international and Portuguese) experts/researchers is quantified in Table 1.

From the 52 invitations sent (and reachable) to *international experts*, 38.5% accepted to participate in the research. Comments and views were received from 26.9% of those who received an invitation to participate, being those views discussed and, as justifiable, incorporated into the research. Regarding the *Portuguese researchers* (from the 25 invitations sent), 56.0% of those respondents accepted to participate in the research, but only a subgroup of 32.0% sent their comments and views until the closing date. Identified issues were considered as inputs for questionnaire validation and optimisation.

Table 2: Questionnaire, Distribution

		Number		%	
Questionnaires sent	a	50	b+c	100.0%	a/a

[7] Expert consultation targets authors of previously identified CBS selection methodologies. Additionally, questionnaires developed for similar/related purposes have been reviewed (e.g. Ferguson *et al.*, 1997; Ncube, 2000; Kunda, 2001).

		Number		%	
Delivered questionnaires	B	49		98.0%	b/a
Undelivered questionnaires	c	1		2.0%	c/a
Received responses	d	34	e+h+k	69.4%	d/b
Completed responses	e	25	f+g	51.0%	e/b
Experienced responses	f	20		40.8%	f/b
Inexperienced responses	g	5		10.2%	g/b
Incompleted responses	h	8	i+j	16.3%	h/b
Incompleted and identifiable responses	i	6		12.2%	i/b
Incompleted but unidentifiable responses	j	2		4.1%	j/b
Out-of-date responses	k	1		2.0%	k/b
Non-received responses	l	15	b-d	30.6%	l/b
Considered responses	m	31	e+i	63.3%	m/b

The questionnaire was constructed on-line, being distributed by e-mail to the CIOs of the 50 leading construction contractors in Portugal. Table 2 summarises data related to the distribution and the received questionnaire responses. From the 50 questionnaires sent, responses were received from 69.4% of the identified respondents. From those delivered questionnaires, 51.0% were completed and 16.3% uncompleted responses. Both completed and uncompleted but identifiable responses were considered *valid responses*, achieving a response rate of 63.3% constituted by 31 received responses. Only 1 questionnaire sent was undelivered to the potential respondent; 1 questionnaire response was received out of date.

Completed responses include those cases in which the respondent, not regarding to respondent's experience in package software selection, properly answers the questionnaire. *Incomplete responses* relate to those respondents, who either did not complete some of the questions and/or do not identify themselves when responding to the questionnaire. *Non-received responses* enclose those cases in which the questionnaire was properly delivered but no response was received (e.g. the cases that respondents indicated telephonically that it is their policy not to participate in surveys and, therefore, they would not complete the questionnaire).

4. CBS SELECTION, CONTEXTUALISED

An overwhelming majority of respondents (83.3%) indicated to have experience with package software selection. Among those, 96.0% of the respondents have more than a 5-year of overall experience with selecting package software. If the experience is constrained to their actual company, the percentage of respondents with more than 5 years of experience selecting package software drops to 72.0%. None (0.0%) of the respondents indicated that they had more than 21 years of *experience in their actual organisations* and only 16.0% of the respondents indicated they have more than 21 year of *overall experience*.

Generally and in the first instance, the discussion of these issues contributes to support the research premise stating that: *among leading contractors in Portugal there is a considerable experience in CBS product selection*. Furthermore, 100.0% of the respondents confirm the research premise: *software systems benefit process improvement*.

Demand-side target population members are the 50 biggest construction contractors in Portugal, detaining a company's sales volume that goes from € 40,091,146 to € 978,531,000 and a company's number of workers ranging from 96 to 2,500. From those, 96.0% of the respondents companies already have package software supporting business activities;

although 44.0% of the companies prefer to choose package software and 52.0% prefer developed software. In line with that data, the research premise *CBS products are an option when selecting software systems* is considered corroborated. Furthermore, the survey response rate (69.4%) and the interest in receiving the survey results about CBS selection, indicated by all respondents (100.0%), are variables that indicate interest, also contributing to illustrate the importance of package products and CBS selection among leading construction companies in Portugal.

Having in mind the discussion around the research premise stating that *among leading contractors in Portugal there is a considerable experience in CBS product selection* occurred previously, the fact that an overwhelming majority of respondents (76.0%) states that they follow a direct assessment approach according to a standard, proprietary or customised software acquisition process, further contributes to validate the premise. However, it is also true that only 26.3% of those performing a direct assessment approach specifically have an acquisition process that formally considers package software.

4.1. Methodological phases, stages or activities

A section of the questionnaire consisted of questions which evaluate if a group of selected phases and stages are developed (or "not at all") and how they are developed. In case they are developed, the questions also intend to clarify if they are developed "explicitly (required and definite)" or "implicitly (performed but indefinite)".

Requirements engineering phase is developed by all respondents (100.0%), under an explicitly approach by 65.2% and it is developed implicitly by the other 34.8% of the respondents. Analysing open-ended question contents, respondents highlight the importance of the requirements engineering as a critical issue within the COTS software selection process, being the lack of sensibility of demand-side stakeholders for COTS software selection also recognised. The *qualification and evaluation phase* is developed by 91.3% of the respondents: 56.5% of the respondents develop the process explicitly and 34.8% of the respondents identified the phase as being developed implicitly; 8.7% of the respondents selected the option "Not at all".

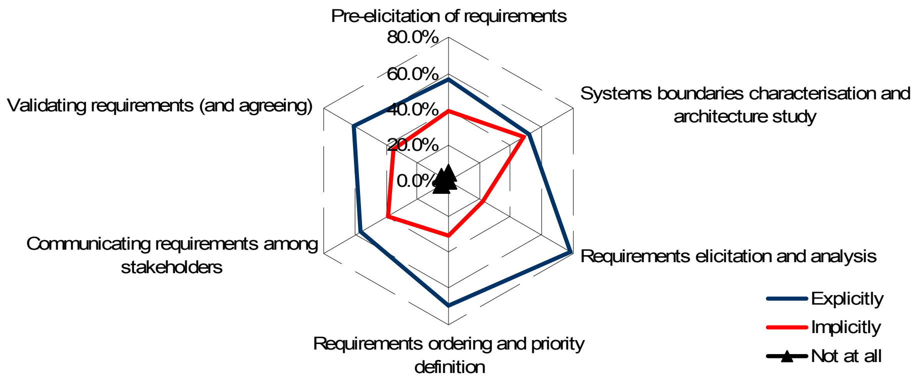


Figure 1: Requirements Engineering Stages

To summarise, survey data suggests that *requirements engineering* phase and *qualification and evaluation* phase are developed by an overwhelming percentage of respondents. Within the *requirements engineering phase*, identified stages are consistently developed in higher degree under an explicitly format and in a lower degree under an implicitly format. As represented graphically in Figure 1, despite the fact that the stages of *validating requirements (and agreeing)* and *communicating requirements among stakeholders* are developed by the majority of respondents, there is 1 respondent (out of 23) that has answered *not at all*.

Regarding the *qualification and evaluation phase*, identified stages are generally developed in a higher degree under an explicitly format and in a lower degree under an implicitly format. The exception is the *evaluation criteria definition stage*; although confirmed, it is generally implicitly performed by 59.1% of the respondents. Furthermore, as represented graphically in Figure 2, stages *identification of candidate products*, *proposal reception and content assessment*, *final decision and acquisition* and *evaluation criteria definition* are not developed by 1 respondent (out of 22). Despite the results above on *evaluation criteria definition*, survey received comments highlight that requirements coverage evaluation seems to be recommended, as a basis to understand if COTS software products cover identified needs/requirements.

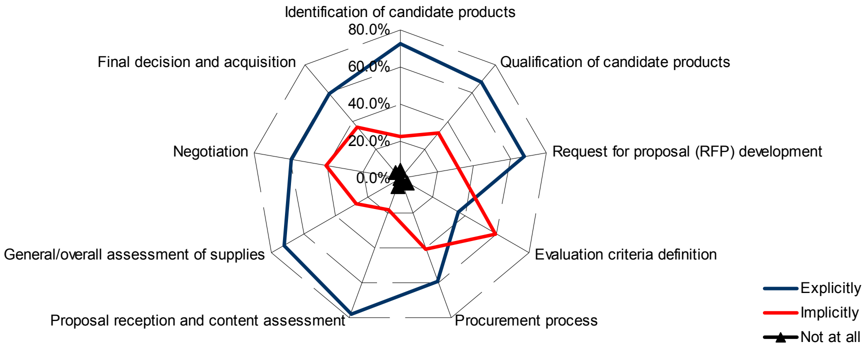


Figure 2: Qualification and Evaluation Stages

To summarise, survey data suggests that stages related to the *qualification and evaluation* phase are developed by an overwhelming percentage of respondents. Furthermore, stages were identified as being predominately developed under an explicitly format, with the exception of the *evaluation criteria definition* stage that, although developed, is generally implicitly performed by respondents.

Respondents' comments emerging from the related open-ended question are of a diversified nature. Some of those are: efficient communications among related stakeholders are identified and suggested as a key success factor; formalisation of requirements engineering related activities is recommended. It is also suggested that qualification and evaluation of COTS software selection activities should be specifically developed and documented.

4.2. Aspects and factors

Respondents indicated which *assessment issues* are on the mindset of those selecting package software. Considering the number of respondents selecting *hard/technical aspects* (e.g. stored data, software architecture) and *soft/human aspects* (e.g. functional organisation of work, process change, business processes coverage) their relative importance is of 75.0% and 95.0%, respectively. Furthermore, under a respondent's basis, *soft/human aspects* and *hard/technical aspects* are simultaneously identified by 70.0% of the respondents. 25.0% of the respondents only identified the *soft/human aspects* and those who selected the *hard/technical aspects* exclusively represent 5.0%. If the author analyses responses individually, *the soft/human aspects* perspective is the one that receives more attention from practitioners. To summarise, the data analysis suggests that the conjoint consideration of *hard/technical* and *soft/human aspects* is common during the package software selection.

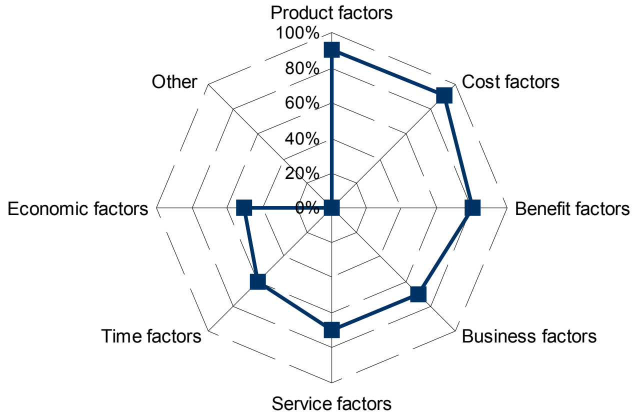


Figure 3: Assessment Factors

From a complementary and more detailed perspective, importance is distributed among product factors (90.0%, e.g. functional features, integration, interface, performance), benefit factors (90.0%, e.g. cost savings, personnel reduction, major control), service factors (80.0%, e.g. maintenance, upgrade, warranty), business factors (70.0%, e.g. vendors credibility, product market leadership), cost factors (70.0%, e.g. acquisition, annual licence costs), time factors (60.0%, e.g. implementation schedule, implementation kick-off date) and economic evaluation (50.0%, i.e. quantified cost-benefit analysis), as represented in Figure 3. All assessment factors were indicated by the majority of respondents as considered for package software selection.

However, the results analysis of the survey on *economic factors* have low relevance (50.0%), under a comment view/format some respondents highlight the importance of economic evaluation; related to that, it might be difficult to determine the economic evaluation. Furthermore, from an implementation perspective, respondents' comments suggested that definition of key performance indicators based on a *as-is* (before selection and implementation) versus *to-be* (after selection and implementation) are interesting to help measuring CBS impact. Additionally, other emerging issues impacting on the CBS selection are:

- *Time factors*. Time factors are identified as important.
- *Business factors.* Product market leadership is viewed by some respondents as a risky related factor, if the product is not properly tested by other clients.
- *Cost factors.* Assure that different lifecycle related costs are properly identified during the selection process.

Nevertheless, the lowest results were obtained by the *time factors* (60.0%) and *economic factors* (50.0%), more than half of respondents indicated these factors for package software selection.

5. CONCLUSIONS

This paper summarises major patterns related with CBS selection practices and highlights (among other validated premises) that *among leading contractors in Portugal there is a considerable experience in CBS product selection* according to a standard, proprietary or customised software acquisition process, although on the overwhelming percentage of those cases, not guided by prewritten, standard processes specifically designed for selecting COTS (software) products.

The relative importance of *soft/human aspects, social and organisational issues* and *hard/technical and software aspects* shows that similar importance is given to both, although *soft/human aspects* are seen as slightly more important. It seems that evaluators do not tend to focus on technical capabilities at the expense of non-technical or soft issues, as mentioned by authors as Clements (1995)[8] and Powell *et al.* (1997). Furthermore, these results are further confirmed by the diversity of (non-technical) *assessment factors* identified and under utilisation by leading construction contractors in Portugal.

Proposed phases of *requirements engineering* and *qualification and evaluation* are confirmed by the target population, *explicitly* by 65.2% to 56.5% and *implicitly* by 34.8% (each[9]) of the respondents. *Stages* within each phase have also been confirmed by the target population of contractors. Exceptions relate to the *evaluation criteria definition* that, although confirmed as performed by respondents, it is more developed under an implicitly (59.1%) format and less under an explicitly format.

Regarding *assessment factors* considered for COTS software selection, *economic factors* are less used by practitioners. This is not surprising since, although organisations are aware of *benefit factors*, it is difficult to quantify *benefits* in a way that they could be compared to those values related to *costs factors*.

5.1. Further research

Beside the development of a specific (1) *Demand-Supply Selection (DSS) Methodology*, a systematised list of functional high-level requirements for CBS evaluation is being obtained to produce a comprehensive (2) *Requirements Reference (RR) Model*, so that the effort to elicit the needs of leading contractors through further development of requirements models from scratch is reduced. A benchmarking report of leading contractors systems in use and a demand-supply cross analysis being delivered on a (3) CBS *Market Offerings (MO) Report*, contributes to answer the question: 'which are the actual market offerings of CBS products supporting the needs of leading contractors in Portugal'.

Based on previous three perspectives, the research study aims to provide an original contribution to knowledge, developing a comprehensive study covering supply and demand viewpoints. In this respect, the direct and practical purpose of this study is to facilitate the planning phase at the beginning of a project and offer comprehensive information to construction industry players (e.g. consultants, CBS providers) that could lead to better products (e.g. changes in functions of CBS) and services (e.g. Requirements Engineering services, CBS selection services) for leading construction contractors in Portugal.

8 For exampled: "Organisations are discovering that more than technical issues must be solved… While the right architecture … is critical, there are also organizational, process, and economic and marketing issues that must be addressed..." (Clements, 1995).

9 8.7% of respondents *do not perform* the *qualification and evaluation* phase.

REFERENCES

Aouad, G. and Kagioglou, M. and Cooper, R. and Hinks, J. and Sexton, M. (1999) Technology management of IT in construction: a driver or an enabler? Logistics Information Management. 1/2(12), pp. 130–137.

APCER - Associação Portuguesa de Certificação (2005) "Lista de certificações, Resumo de empresas certificadas por distrito e área de actividade", available at: http://www.apcer.pt/modules.php?name=News&file=article&sid=9.

Boehm, B. W. and Sullivan, K. J. (2000) Software Economics: A Roadmap. In:, Proceedings of the Conference on The Future of Software Engineering table of contents, Limerick, Ireland. International Conference on Software Engineering archive. pp. 319-343.

BuHu – Research Institute for the Built and Human Environment (2006) "Homepage", available at: http://www.buhu.salford.ac.uk/.

CE - Constructing Excellence (2006) "Homepage", available at: http://www.constructingexcellence.org.uk/.

CICA - Construction Industry Computing Association (2006) "Homepage", available at: http://www.cica.org.uk/.

CIFE - Centre for Integrated Faculty Engineering (2006) "Homepage", available at: http://cife.stanford.edu/index.html.

Clements, P. C. (1995) From Subroutines to Subsystems: Component-Based Software Development. American Programmer. Cutter Information Corp., 8(11), November 1995.

CITFB - Construct IT For Business (2006). "Homepage", available at: http://www.construct-it.org.uk/.

CSTB - Centre Scientific et Technique du Batimat (2006) "Homepage", available at: http://www.cstb.fr/.

Datamonitor (2000) The growth of the packaged software industry in Portugal – Its impact on the Portuguese economy. Packaged software in Portugal. [Report].

EC - European Commission (1999) Europe, European Commission, Enterprise, Industry Sectors, Construction, Competitiveness in Construction, Information Technology, Information Technology as an enabling tool in the Construction process. First Phase, Final. [Report].

Ferguson, J. and Cooper, J. and Falat, M. and Fisher, M. and Guido, A. and Marciniak, J. and Matejceck, J. and Webster, R. (1997) Software Acquisition Process Maturity Questionnaire. CMU/SEI-97-SR-013. [Special Report].

Hargitay, S. and Dixon, T. (1991) Software Selection for Surveyors – A Guide and Directory. United Kingdom: The Royal Institution of Chartered Surveyors, Macmillan Publishers, Ltd..

KEY SURVEY (2006) “Homepage”, available at:
http://www.keysurvey.co.uk/.

Koskela, L. (1992) Application of the New Production Philosophy to Construction. CIFE 72. [Technical report]. Stanford, CA: Stanford University.

Kunda, D. (2001) A social-technical approach to selecting software supporting COTS-Based Systems. PhD thesis, University of York, Department of Computer Science, UK.

Martin, E. W. and Brown, C. V. and DeHayes, D. W. and Hoffer, J. A. and Perkins, W. C. (1998) Managing Information Technology - What Managers Need to Know. Prentice Hall, Upper Saddle River, New Jersey, USA.

ME – Mota Engil. (2004). Projecto SIME (from 2001 to 2004). [Project information]. Lisbon, Oporto.

Ncube, C. (2000) A Requirements Engineering Method for COTS-Based Systems Development. PhD thesis, School of Informatics, City University, London.

Santos, A. dos and Powell, J. A. and Formoso, C. T. (1999) Evaluation of Current Use of Production Management Principles in Construction Practice. In: Proceedings to the 7th Annual Conference of the International Group for Lean Construction, July 26th-28th, Berkeley, California, USA.

Powell, A. and Vickers, A. and Lam, W. and Williams, E. (1997) Evaluating Tools to support Component Based Software Engineering. In: Proceedings of the 5th International Symposium on Assessment of Software Tools, SAST’97, Institute of Electrical and Electronics Engineers Computer Society, June, Los Alamitos, California. pp. 80-89.

VTT - Technical Research Centre of Finland (2006) “Homepage”, available at:
http://www.vtt.fi/services/cluster6/index.jsp.

THE CAPITAL MARKET AND CONSTRUCTION AS ECONOMIC INDICATORS: THE CASE OF NIGERIA

Saka, N. Department of Quantity Surveying, Federal University of Technology, Akure, Nigeria.
saka_najimu@yahoo.com

The capital market and the construction sector are both lead economic indicators that may be used to forecast the behavior of the economy. The study made a comparative appraisal of the efficacy of the capital market and the construction sector as lead indicators of the Nigerian economy. Annualized time series data of indices of the capital market, the construction sector and the Gross Domestic Product (GDP) were extracted from Central Bank of Nigeria (CBN) statistical bulletin volume 16, December 2005. Econometric techniques including unit root test, cointegration test and Granger causality test were used to analyze the data. The unit root test indicated that the data are stationary at second difference of their natural logarithm. The cointegration test indicated that the GDP and construction investment (CNV) and Value of Trade (VOT) are co-integrated. Granger causality test among co-integrating variables indicated that the CNV granger causes or leads the GDP far more than the VOT. The study therefore concluded that the construction sector is a better indicator of the Nigerian economy than the capital market.

KEYWORDS: Capital Market, Construction Investment, Econometric Techniques,

INTRODUCTION

The concepts of forecasting and planning are fundamental to any organization the engage in economic activities whether public or private. the public sector need to forecast and plan the economy to ensure sustainable economic growth, full employment and control of inflation through the implementation of appropriate fiscal and monetary polices (Begg, Dornbusch & Fischer 2000;Samuelson &Nordhaus 2005). In the same vain private firms need to generate economic and business data that improve their ability to make reliable forecast as a basis for production and marketing decision that expand market share and profitability of the firm in a high competitive and globalised economy(Mansfield, Allen, Doherty & Weigelt, 2002).

In making reliable socio-economic planning in the public sector or business planning in the private firm, planners, economists, statisticians and managers etc invariably employ certain indicators of the economy to build statistical or econometric model that predicts the economy with a certain level of confidence, if the prediction is to be used at all. Economic indicators such as housing starts, new tenders, new contracts, housing starts etc or stock market indexes such price indices , capitalization, number of deals and value of transactions etc are collectively known as lead indicators because they typically go down or up before the economy does . Some Economic indicators that tend to turn simultaneously with the economy such as employment, industrial production, corporate profit and the gross domestic product (GDP) are called coincidental indicators. While retail sales, manufacturers' inventories and personal income are said to be lagging indicators because they move or change direction after the economy has changed (Mansfield, et al. 2002).

For most people, the stock market has traditionally been viewed as an indicator or predicator of the economy. Many believe that large decreases in stock prices are reflective of a future recession, whereas large increases in stock price suggest future economic growth. Theoretically, reasons for why stock prices might predict economic activities include the traditional valuation model of stock prices and the wealth effect. The traditional valuation of prices suggests that stock prices reflect expectations about the future economy, and can therefore predict the economy. The "wealth effect" contends that prices lead economic activity by actually causing what happens to the economy (Comicioli, 1996). While this may be valid for developed economies with sophisticated stock market, it is not without controversy in Nigeria that the stock market can predict the economy reliably. The reasons are not far-fetched; the Nigerian stock market is inefficient and not diversified enough to reflect economic activities in Nigeria accurately. Most Nigerians are oblivious of the stock market as a vehicle for investment and wealth creation (Abudu, Bamidele, Okafor & Adamgbe, 2004). The Construction sector performance is a very important indicator of economy, which is rarely mentioned or used by the private and public firms for forecasting future economic outlook. Housing starts, tender advertisement, number of new contract signed etc are direct indicators of the expectations of the future growth of the economy. Construction facilities investment contributes about 50% to the gross capital formation, which is a direct contribution to the overall growth of the economy (World Bank , 1984).

The question of which between the stock market and the construction sector can predict the economy the better has been widely debated. Those who support the stock market's predictive ability argue that the stock market is forward looking and current prices reflect the future earnings potential or profitability of corporations. For those who support the construction sector argue that construction industry contributes to the physical infrastructure of the country which is the driver of rapid economical growth as postulated by Smith (1776) and Keynes (1936) etc. In contrast, stocks transactions are driven by the expansion of the performance of the quoted firms and the national economy and do not directly add to the nation's capital stock (physical infrastructure) at best, they represent changes in the title of the financial assets. Between stock prices and construction investment which is the most reliable lead indicator of the Nigerian economy? The purpose of this paper is therefore, to make a comparative evaluation the performance of stock market and construction sector investment as lead indicators of Nigerian economy and determine the most reliable in the contest of a developing economy like Nigeria.

The Nigerian Capital Market

The Capital market is a veritable economic barometer for assessing the pulse of the economy. The trend in the number of listed companies, number of listed securities, market capitalization and all share indexes are important indicators which can be used to evaluate the performance of the market (Babalola and Adegbite, 2001). The Nigerian Capital Market started in 1946 with the issuance of securities by the colonial government. The Lagos State Exchange (LSE) was established in 1960 and restructured into the Nigerian Stock Exchange (NSE) in 1977, the same year SEC was established to regulate the market (Ebajemito, et al. 2004). The growth in the total number of listed equities has been impressive given the multitudes of incorporated companies. Listed companies on the NSE rose from 92 in 1984 to 100 in 1988 and further to 195 in 2002 (Odoko, et al. 2004). The increase is traceable to the establishment of the second tier securities market in 1985, the deregulation of interest rate in 1987 and the privatization of some State

Owned Enterprises (Englama et al. 2004) perhaps the most important challenge before SEC and NSE is the difficulties of getting more Nigerian firms listed on the NSE. One of the factors responsible for the apathy in stock market by indigenous firms is the aversion to ownership dilution (Odoko et al., 2004). Another factor is the stringent listing requirement of Securities and Exchange Commission.

The review of performance in the Nigerian stock market showed that the value of instrument traded on the floor of the NSE rose from N1.5m in 1961 to N388.8m in 1980. By 2002, the value of these instruments has increased to N59, 406.7m this was greatly facilitated by the privatization programme of the government. The market capitalization relative to GDP gives an indication of the potential to raise fund for investment and provide information on prices that guide the allocation of resources. Data shows rising but relatively low rate of market capitalization / GDP ratio. This ratio improved from 9.2% in 1999 to 10.3% and 12.5% in 2000 and 2001, respectively, and by 2003 it peaked as 19.8%. This compares favourable with 18.0% in Ghana in 2000, but unfavourable with 88.6% in Egypt in 1996 (Abudu, et al. 2004).

The Construction Sector

The construction sector performance is a very important indicator of economy, which is rarely mentioned or used by the private and publics firms for forecasting future economic outlook. Housing starts, plan approvals, tender advertisements, numbers of new contract signed are direct indicators of the expectations of the future growth of the economy. The Construction industry is referred to as capital goods industry because its services and products often constitute the substructure that other economic activities are built upon. The relationship between the construction industry and national economy is very strong construction industry usually accounts for between 3 and 8 percent of developing country's Gross Domestic Product (World Bank 1984).

Construction makes considerable contribution to the national economic output of developed and developing countries, it generates employment and incomes (Field & Ofori, 1988). The effect of the construction sector on the national economy is on all levels (Hillebrandt, 2000) and virtually all aspects of our life (Hillebrandt, 1985). The significant impact the sectors makes to economy means that it is linked to virtually all sectors of the national economy(Pietroforte & Bon , 1995; Bon, 2000; Bon, et al.,1999; Pietroforte et al., 2000) this therefore implies that whatever happens to the sector will directly and indirectly affect other industries and ultimately the well being and wealth a nation. The importance of the sector stems from its strong linkages with sectors of the economy (World, 1984). Fluctuations or shocks in construction flow can therefore cause rippling effects in the economy (Chan, 2002) which may have serious repercussions on sectors of the economy. The very strong linkages that the construction sector has with other sectors of economy underlie its significant multiplier effects on the economy and its value as a lead indicator of the economy especially in developing economies. Construction leads the GDP as it is the main buyer from other sectors, it determines the demand for produce and their output activities feed back to the economy (Briscoe, 1988; Ofori, 1990). Construction sector can therefore be used as economy barometer which can be used for measuring, determining or assessing the changes in the economy. This is probably why Governments have use control of investment in the sector as a basis for controlling the direction of the economy through fiscal and monetary policies (Seeley, 1984).

ECONOMETRIC METHODOLOGY

This study uses a set of econometric techniques to determine the best economic indicator between the stock market and construction. These set of econometric techniques includes unit root test, Johansen cointegration test, and Granger causality test .

Unit root tests:

In most econometric analysis the unit root test or test for stationarity is always the first major step. The first procedure is to test for unit root or to check if the data are stationary. A series is said to be stationary if it displays the tendency of returning to its mean value and fluctuates around it within a more or less, constant range, i.e. it has variance (Harris, 1995). This step is very important because if non – stationary variables are not identified and used in the model, it will lead to a problem spurious regression (Granger and Newbold, 1974). The number of times the data have to be differenced to become stationary is the order of integration. If a series is differenced one time to be become stationary, it is said to be integrated of order I (0). Several tests are available for testing the order of integration. The study adopted the most common procedures of Dickey Fuller (DF), Augmented Dickey fuller (ADF). The optimal lag lengths are chosen based on the Pairwise Final Prediction Error (FPE), which has received wide acceptance among time series analysts (McClave, 1978). Once, the variables are integrated of the same order, it implies that the differenced variables can be expressed in a mathematical form. A vector autoregression (VAR) model can be utilized to present the relationship, and causality among the variables must exist in at least one direction (Granger and Newbold, 1986). This can be tested using Granger causality procedure.

Johansen cointegration test:

The Granger causality test, pioneered by Granger and Newbold (1986), is used to determine the Granger causality relationships between construction stocks, stock market and the economy. Two variables are said to be cointegrated i.e. they exhibit a long-run equilibrium relationship, if they share a common trend. If cointegration exists between the two variables, causality must exist in at least one direction, either unidirectional or bidirectional (Granger and Newbold, 1986; Granger 1988). Engle and Granger (1987) pointed out that a linear combination of two or more non-stationary series may be stationary. If such a stationary linear combination exists, the non-stationary time series are said to be cointegrated. The stationary linear combination is called the cointegrating equation and may be interpreted as a long-run equilibrium relationship among the variables. The purpose of the cointegration test is to determine whether groups of non-stationary series are cointegrated or not. The presence of a cointegrating relation forms the basis of the Vector Error Correction (VEC) specification. EViews the econometric package used for this study implements VAR-based cointegration tests using the methodology developed in Johansen (1988, 1991 & 1995).

Granger causality:

Test Correlation does not necessarily imply causation in any meaningful sense of that word. The econometric graveyard is full of magnificent correlations, which are simply spurious or meaningless. The Granger (1969) approach to the question of whether X causes Y is to see how much of the current Y can be explained by past values of X and then to see whether adding lagged values of Y can improve the explanation. Y is said to be Granger-caused by X if it helps in the prediction of Y, or equivalently if the coefficients on the lagged are statistically significant. Note that two-way causation is frequently the case; X Granger causes Y and Y Granger causes X. It is important to note that the statement X" Granger causes "Y does not imply that Y is the effect or the result of X. Granger causality measures precedence and information content but does not by itself indicate causality in the more common use of the term.

The data

There are five variables in this model, Construction Investment (CNV) Construction Sector (CNS) No of Deals (NOD) Value of Transaction (VOT) and Gross Domestic Product (GDP). All the data used in this study are extracted from Central Bank Nigeria (CBN) Statistical bulletin December 2005, Volume 16 and National Bureau of Statistics (NBS) Abstract of Statistics for relevant years.

Operationalisation definition of variables

i. Construction Investment (CNV); this is the total expenditure on the building of new constructed facilities within a country in a given year; this entry in the national account also includes money expended on the maintenance of these facilities.
ii. Construction Sector (CNS); this is the measure of market value of all economic activities within the construction sector during a given year.
iii. Gross Domestic Product (GDP); this is a measure of the market value of all final goods and services produced in a country within a given year.
iv. No of Deals (NOD): This is the total number of agreements in the capital market for the purchase or sale of securities within the year.
v. Value of Transactions (VOT); this is the aggregate monetary value of all securities (bonds and stocks) bought or sold in the capital market within the year.

RESULT

Table 1: Presents the descriptive statistics for CNS, CNV, GDP, NOT and VOT series. The Jarque-Bera P value – indicates that all the series are normally distributed.

Table 1: Descriptive Statistics

	CNS	CNV	GDP	NOD	VOT
Mean	28682.61	44252.12	2959790.	181051.9	32311.01
Median	8019.100	14633.83	701472.9	42074.00	850.3000
Maximum	215786.1	205121.0	14894454	1021967.	262935.8
Minimum	1532.000	2957.000	50749.09	10014.00	215.0000
Std. Dev.	51832.54	56268.83	4180049.	292784.0	69737.83
Skewness	2.734851	1.434353	1.541334	1.956578	2.471655
Kurtosis	9.552226	4.063355	4.324949	5.611299	7.906116
Jarque-Bera	75.88470	9.750204	11.72743	23.05382	50.52739
Probability	0.000000	0.007634	0.002841	0.000010	0.000000
Sum	717065.1	1106303.	73994760	4526299.	807775.2
Sum Sq. Dev.	6.45E+10	7.60E+10	4.19E+14	2.06E+12	1.17E+11
Observations	25	25	25	25	25

Table 2 presents the correlation matrix of the series the matrix shows that all the series are of high correlation with the GDP with value ranging between 91.5% and 97.28%. NOD has the highest correlation of 97.28% to the GDP while CNS has the lowest correlation of 91.58% to the GDP.

Table 2: correlation matrix of GDP, VOT, CNS, CNV and NOD.

	GDP	*VOT*	*CNS*	*CNV*	*NOD*
GDP	1	0.9345	0.9153	0.9461	0.9728
VOT	0.9345	1	0.9836	0.8840	0.9798
CNS	0.9153	0.9836	1	0.8947	0.9509
CNV	0.9461	0.8840	0.8947	1	0.9166
NOD	0.9728	0.9798	0.9509	0.9167	1

The results of Dickey Fuller (DF) and Augmented Dickey Fuller (ADF) tests are summarized in Table 3. The test of hypothesis of stationarity is performed at the usual 1%, 5%, and 10% significance levels with the natural logarithm of the data. The associated critical values for the tests are presented in table 4. The results from the DF test indicate that none of the data series are stationary. Based on ADF test, all the first differenced data are stationary except for LVOT. However, at the second differencing, all the data series are stationary at 1% and 5% significance level.

Table 3: unit root test result with log of series

	DF test at level		*ADF test in first difference*		*ADF test in second difference*	
Series	Constant	With trend	Constant	With trend	Constant	With trend
LCNS	-0.453	-1.683	-3.672**	-4.632***	-5.264***	-5.227***
LCNV	0.285	-1.764	-3.888***	-4.323**	-6.376***	-2.254
LNOD	-0.058	-1.786	-3.770***	-3.817**	-6.016***	-5.849***
LVOT	-0.399	-1.273	-1.735	-2.442	-3.930**	-4.126**
LGDP	-0.142	-2.087	-3.561**	-3.433*	-5.264***	-5.227***

Figures marked with *, ** and *** denote rejection of the hypothesis at the 10 %, 5% and 1% levels

Table 4: test critical values

	DF test at level		*ADF test in first difference*		*ADF test in second difference*	
Critical value	Constant	With trend	Constant	With trend	Constant	With trend
1%	-2.680	-3.770	-3.788	-4.668	-3.788	-4.468
5%	-1.958	-3.190	-3.012	-3.733	-3.012	-3.645
10%	-1.608	-2.890	-2.646	-3.310	-2.646	-3.262

Table 5 reports the Eigenvalue, the associated likelihood ratio statistics (also referred to as the trace test statistics) and the hypothesized number of cointegrating equations of Johansen cointegration tests performed between VOT, GDP, NOD, CNV and CNS. The corresponding critical value for rejection of the cointegration test at 5% significance level is also presented. A trace test indicates cointegrating equation at 5% level. There is no unique cointegrated relation between these variables except between GDP and CNV as well as GDP and VOT. This means that there is a cointegrating relation between them and they are dependent on each other. Since cointegration cannot indicate the direction of Granger causality among the variables. Pairwise Granger causality test is used to determine the direction of causality.

Table 5: Johansen cointegration test result (Log)

VARIABLES	*Hypothesized No. of CE(s)*	*Eigenvalue*	*Trace Statistic*	*5 Percent Critical Value*	*1 Percent Critical Value*
LGDP and LCNS	None	0.406716	13.21947	15.41	20.04
	At most 1	0.028319	0.689478	3.76	6.65
LGDP and LCNV	None **	0.610241	34.01481	15.41	20.04
	At most 1 **	0.378150	11.40135	3.76	6.65
LGDP and LNOD	None	0.405492	12.18703	15.41	20.04
	At most 1	0.009801	0.226534	3.76	6.65
LGDP and LVOT	None **	0.544060	20.47123	15.41	20.04
	At most 1	0.099369	2.407166	3.76	6.65

*(**) denotes rejection of the hypothesis at the 5 %(1%) level

The number of Lags in the Granger causality model is set at 2, 3, 4, 5, 6 and 7 even though test is run to search for the optimal lag structure. Table 6, presents the probability values of the Granger causality test for logarithmic second differenced of the variable. Gross Domestic Product granger causes the CNV and VOT at all lags tested though the causal effects running from the GDP is stronger toward the CNV than the VOT. The CNV granger causes the GDP at lags 2, 3, 6 and 7 while the VOT granger cause the GDP at lags 3, 4 and 7. The CNV therefore granger causes the GDP at more lags than the VOT showing that the CNV leads the GDP than the VOT.

Table 6: pairwise Granger Causality test(p-values)

Variables	*2lags*	*3lags*	*4lags*	*5lags*	*6lags*	*7lags*
LGDP → LCNV	0.001***	0.000***	0.000***	0.000***	0.000***	0.003***
LCNV → LGDP	0.002***	0.005**	0.160	0.363	0.001***	0.006**
LGDP →LVOT	0.043**	0.004***	0.001***	0.005**	0.000***	0.016**
LVOT →LGDP	0.165	0.023**	0.088*	0.184	0.380	0.018**

*(**) and *** denotes rejection of the null hypothesis at the 10 %,(5%) and 1% level

Discussion

The pair wise Granger causality test indicates the direction of causality between the data series. LVOT leads LGDP by 3years while LCNV leads LGDP by 2years; this is a very clear indication that the construction sector has more direct linkages with the economy than the capital market. This is not surprising, as Abudu et al (2004) have observed that the Nigerian capital market is not deep, diversified or efficient as to be able to accurately lead or predict the Nigerian economy. similarly it is also very apparent from the granger test that the LGDP granger causes both the LCNV and the LVOT the strength of the causality running from LGDP is however stronger on LCNV than LVOT . this is another empirical evidence to support the stronger linkage between the economy and construction than between the economy and the capital market.

CONCLUSIONS

The result concludes that the Construction Sector is a better indicator of the economy than the capital market because from the analysis it shows that the relationship between Gross Domestic Product and Capital Market is inferior to that which exists between Gross Domestic Product and Construction Sector. Government must therefore increase direct spending in the construction sector enhance the development of physical infrastructure of the country which is the driver of rapid economical growth. Construction investment stimulates the economy and help in poverty alleviation, as construction industry would provide gainful employment for a barge number of skill and unskilled workers. The public and Private sector can forecast future economic outlook by considering a number of construction sector performance indicators such as plan approvals, housing starts, tender advertisement, and number of new contract signed etc.

REFERENCES

Abudu, M, Bamidele, A, Okafor,P.N and Adamgbe,E.T(2004), an overview of Financial markets in Nigeria .In Nnanna, O.J, Englama,A. and Odoko, F.O.(Eds) Financial markets in Nigeria. Abuja: CBN Pp 28-41.

Babalola, J.A. And Adegbite, M.A. (2001). The Performance Of The Nigerian Capital Market Since Deregulation In 1986 . CBN Economic and Financial Review Vol. 39 March No. 1.

Begg, D., Fischer, S. and Dornbusch, R. (2000).Economics (6^{th} Edn) London: McGraw Hill Book Company

Bon, R. (2000). Economic Structure and Maturity: Collected papers in input – output modeling and Applications. London: Ashgate, Aldershot.

Bon, R., Birgonul, T. and Ozdogan, I. (1999). An input output analysis of the Turkish construction sector, 1973-1990: A note, Construction Management and Economics, 17, 543-51.

Briscoe, G. (1988). The economics of the construction industry London: Mitchell

Chan, S. (2002). Response of selected economic indicators to construction output shocks: the case of Singapore, Construction Management and Economics 20, 523-33

Comicioli, B. (1996). The Stock Market as a Leading Indicator: An Application of Granger Causality. The University Undergraduate Journal of Economics, Illinois Wesleyan Sample Issue.

Ebajemito, J. O. Kama, U., Salam, N. G. And Anyakola, C. U. (2004). 'Introduction' In Nnanna, O.J., Englama, A. And Odoko, F.O (Eds) Financial Markets In Nigeria . Abuja: CBN Pp 28 - 41.

Englama, A., Raheem , R.A., Ihekuna P.A., Sanni, G.K. And Inuwa, A.T. (2004). Evaluation of Financial Market Performance. In Nnanna, O.J., Englama, A. And Odoko, F.O (Eds) Financial Markets in Nigeria. Abuja: CBN Pp 141 - 159

Engle, R.F and Granger, C.W.J. (1987). Cointegration and Error Correction Representation, Estimating a Testing Econometrica, 55(2)-76.

Field, B. & Ofori, G. (1988). Construction and economic development –a case. The third world planning review, 10(1), 41-50.

Granger C. W. J. (1969).investigating causal relations by econometric methods and cross spectral methods, Econometrica, 34, 541-51.

Granger C. W. J. (1988). Some recent developments in the concept of causality. Journal of Econometrics, 39, 199-211.

Granger, C.W.J. And Newbold, P (1974). 'Spurious regressions in econometrics'. Journal of Econometrics, 2 111 – 20

Granger, C.W.J. and Newbold, P. (1986). Forecasting Economics Time series, Orlando, FL: Academic press.

Harris, R. (1995). Using Cointegration Analysis in Econometrics Modeling. Englewood, Cliff NJ: Prentice Hall

Hillebrandt, P. (1985). Analysis of the British Construction industry. London; Macmillan

Hillebrandt, P. (2000). Economic Theory and the Construction Industry. London; Macmillan.

Johansen, S. (1988). Statistical Analysis of Cointegration Vectors, Journal of Economic Dynamics and Control, 12, 231-54.

Johansen, S. (1991). Estimation and Hypothesis Testing Of Cointegration Vectors in Gaussian Vector Autoregressive Models, Econometrica, 59, 1551-80.

Johansen, S. (1995) Likelihood-Based Inference in Cointegrated Vector Autoregressive Models, Oxford University Press: Oxford.

Keynes, J.M. (1946). The General Theory of Employment, Interest and Money.

Mansfield, E., Allen, W. B., Doherty, N.A. Weigelt, K. (2002). Managerial Economics Theory, Applications, and Cases (5th). New York: W.W. Norton & Company, Inc.

McClave, J.T., (1978). "Estimating the order of autoregressive models, the max C^2 method (in theory and methods). Journal of the American Statistical Association, 73 (2, 61); 122.

Odoko, F.O., Adamu, I., Dina, K.O., Golit, P.D. And Omanukwue, P.N., (2004) The Nigerian Capital Market, In Nnanna, O.J., Englama, A. And Odoko, F.O. (Eds) Financial Markets in Nigeria. Abuja: CBN pp 65 - 100

Ofori, G. (1990). The construction industry; Aspects of its Economic and Management. Singapore: Singapore University Press,

Pietroforte, R and Bon, R. and Gregori, T. (2000). Regional development and construction in Italy: an input-output analysis, 1959 – 1992. Construction Management and Economic 18, 151 – 9.

Pietroforte, R. and Bon, R. (1995). "An input – output analysis of the Italian Construction sector, 1959-1988. Construction Management and Economics, 13 (3), 253-62.

Pietroforte, R. and Bon, R. (1999). "The Italian Residential construction sector; an input-output historical analysis Construction Management and Economic, 17, 297 – 303.

Samuelson, P. A. and Nordhaus, W.D. (2005). Economics (18th Ed.). New Delhi: Tata-Mcgraw Hill

Seeley, I.H. (1984). Quantity Surveying Practice. London: Macmillan.

Smith, A. (1776). An Enquiry into the Nature and Causes of the Wealth of Nations.

World Bank (1984). The construction industry: issues and strategies in Developing countries. Washington. DC: Author

SUSTAINABILITY ABSENCE IN SOCIAL HOUSING: CONSEQUENCIES

M. Fernanda S. Rodrigues
Civil Engineering. Department, Aveiro University, Portugal
mfrodrigues@ua.pt

José M. Cardoso Teixeira
Civil Engineering. Department, Minho University, Portugal
jct@civil.uminho.pt

J. Claudino P. Cardoso
Civil Engineering. Department, Aveiro University, Portugal
claudino@ua.pt

Building sustainability is a current international trend nowadays. Accordingly, some countries have adopted national policies for sustainable rehabilitation and to extend durability of buildings. However, most social dwellings in Portugal have not been built in compliance with essential sustainability principles, therefore compromising their present value. This has been concluded from a recent field survey conducted by the authors to a set of social dwellings in Aveiro district, in the centre of the country. The survey revealed several anomalies of the buildings' envelope and a number of corresponding pathologies mostly related to insufficient insulation. Additionally, energy efficiency of the houses is low and heating costs too high. This has lead to tenant dissatisfaction and generated social problems. The survey was supported by a visual inspection methodology and by an inquiry to tenants based in a multi-attribute analysis. The aim of this paper is to present the results of the most relevant problems detected in a sample of rental social dwellings surveyed. This was used in the scope of a research project on prioritising refurbishment interventions in the Portuguese social housing stock.

KEYWORDS: sustainability; social housing; case study.

INTRODUCTION

Building sustainability is a current international trend nowadays. Accordingly, some countries have adopted national policies for sustainable rehabilitation and to extend durability of buildings. However, most social dwellings in Portugal have not been built in compliance with the current National Strategy to the Sustainable Development, accordingly to the principles of the Local Agenda 21. The early deterioration of the buildings and its deficient thermal and acoustic insulation, contributes to its lack of quality. Its degradation level is consequence of low durability design solutions and deficient construction processes control, increased by the absence of maintenance actions. Analysing the principal pathologies identified in buildings, it can be verified a great incidence in its envelope. That implicates minor performance level of the elements where they appear, internal pathologies, low energetic efficiency, extraordinary rehabilitation needs and high resource waste. To evaluate the lack of durability consequences, a visual survey of a dwelling social housing set was carried out in eight local city councils situated in the Aveiro district in the centre of Portugal.

The visual survey included the external envelope assessment, internal surveys and interviews in 15.13% of the apartments. The aim of the survey is to obtain a global degradation level and a performance level to each building.

BUILDING ANOMALIES

General Results

The “Agence Qualité Construction” has published the data analyses corresponding to the accidents occurred in buildings registered by the insurance companies in France, relative to the constructed buildings. Through this data it can be verified that the roofs and façades are the most affected elements, corresponding in 66.9% of the cases to a lack of waterproofing. The registered anomalies occurred mainly in façades (21%), flat roofs (13.8%) and pitched roofs (9.7%), also referring that 5.4% of the anomalies occur in the frameworks (AQC, 2006).

The Portuguese statistical analysis published by the 2001 Censuses gives out quantitative and qualitative data about the buildings degradation/conservation state at that date. From this statistical data it can be verified that 40% of the Portuguese buildings have structural anomalies, 45% have roof anomalies and 47% have anomalies in the external walls and frameworks (INE, 2001). So we can conclude that the building’s envelope presents a high rate of anomalies, frequently responsible by internal deterioration. It is relevant the great incidence of these anomalies in the buildings constructed after 1971 (Figure 1).

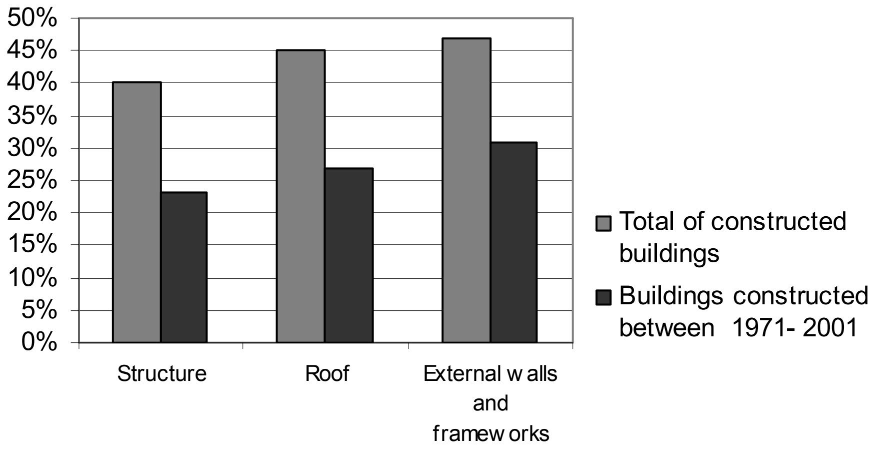


Figure 1: Buildings repair needs by anomalies incidence (INE, 2001)

Social housing anomalies: studies

The different Portuguese social housing programmes carried out, resulted in a great diversity of dimensions, typologies, housing standards and degradation state, as it is referred in Table 1 (Cabrita et al., 2000). This table also reveals the great incidence of anomalies in the buildings constructed after 1971 similarly to the generality of the constructed buildings, as referred in the last point, what can be partially justified with the increase of buildings construction after this decade.

Table 1 – General aspects of social housing degradation

Typology/Construction period	Characteristics/Degradation state
Individual houses from the decades of 30/40 to 90 in the 20th century.	Reduced dimension, application of well knows and tried construction processes, take to punctual physical degradation, frequently solved by the residents.
Buildings of dwellings from the decades of 40 to 60 in the 20th century.	Reduced dimension, application of well knows and tried construction processes, take to punctual physical degradation, especially in the external frameworks and finishes.
Small buildings of dwellings from the decades of 70 to 90 in the 20th century.	In spite of its reduced dimension, it can be finding in these buildings, degradation situations resulting from the use of unknown and less tried construction processes, resulting from the unloading external walls.
Great dwellings buildings from the decades of 70 to 90 in the 20th century.	These buildings have the greatest concentration of the more relevant problems. They present high degradation levels resulting from constructive problems, dues to deficient's construction solutions, dues to the implementation of unknown and less tried construction processes and materials, and the conjunction of problems between construction, equipments, components, facilities, functional solutions of buildings and lodgements.

Source: Cabrita et al., 2000.

To analyse the behaviour of the applied rehabilitation solutions to 32 social housing sets, constructed in the north of Portugal, with a total of 4200 lodgements a study about its envelope behaviour has been carried out. This set of buildings was subject to rehabilitation operations in its envelope – roof, external walls, frameworks, joint zones, drainage facilities. Before these works were identified as more frequent anomalies (Abrantes et al., 1999):

- walls coatings crakes and penetration of rain water inside the lodgements;

- aging and detachment of waterproofing material in the joint between the framework and the wall;

- lack of mechanical resistance of the brick cover in the warping;

- degradation of the rain water drainage facilities;

- lack of elasticity and consequent crack and detachment of the waterproofing material in the expansion join between buildings;

- dampness in the interior of the ceilings of the higher lodgement, because the lack of waterproofing layer in the roof.

It was verified the incidence of similar anomalies before and after the rehabilitation operations. These anomalies implicated negative effects in the performance of the elements of the building's envelope, especially in respect to waterproofing, thermal-hygrometric and durability requirements. About the durability of the rehabilitation solutions used Abrantes (1999) said that they were not the most efficient because in the evaluation after these works, 31% of the set of buildings were classified from deteriorated to accented deterioration, between 6 to 9 years after those interventions (Table 2).

Table 2 - Deterioration evaluation synthesis after the rehabilitation

Global evaluation after the rehabilitation works	Number of buildings sets	Percentage (%)	Δ t *									
			0	1	2	3	4	5	6	7	8	9
D1 – No visible deterioration	10	31.3	1	2	5	1	1					
D1-2 - No visible deterioration to slightly deteriorated	2	6.3				1						1
D2 - Slightly deteriorated	5	15.6								3	2	
D2-3 - Slightly deteriorated to deteriorated	5	15.6					1	1		1	2	
D3 - Deteriorated	4	12.5								1	3	
D3-4 - Deteriorated to accented deterioration	2	6.3									2	
D4 - Accented deterioration	4	12.5							1	2		1

Δ t * - time interval between the rehabilitation interventions and the anomalies evaluation after rehabilitation.
Source: Adapted from Abrantes et al., 1999.

Similarly to earlier studies (Henriques, 2001; AQC, 2006), it can be concluded that the great incidence of precocious anomalies in the constructive elements is due to non suitable design solution, choice of low durability materials, conjugated with low quality of construction works and with the absence of conservation and maintenance of the buildings and its elements.

It is essential not to have too much short cycles of rehabilitation/degradation. It must be guaranteed the durability of constructive solutions, the satisfaction of specific levels of performance, the reduction of maintenance and repairing interventions, the introduction of systems, components and materials that contribute to facilitate any future intervention with high health and safety levels, high environment preservation and reduced costs.

The Civil Engineering National Laboratory published the 3rd retrospective analysis of the social housing park financed by the National Institute of Housing (INH). In the scope of this analysis, relative to the years of 1995 to 1998, an inquiry to the residential satisfaction was carried out. An ordinal scale composed with 4 values was applied to obtain the classification of the contemplated items, from the following values and meanings associates (LNEC, 2004):

1 = No satisfy;

2 = Satisfy insufficiently;

3 = Satisfy;

4 = Satisfy sufficiently.

The average of the scale is the value 2.5. So in this inquiry the appreciations situated below this value represent negative levels of satisfaction, while that ones that are above this value indicate positive levels of satisfaction (LNEC, 2004). In respect to the lodgement the inquired showed no satisfaction about the exterior sound insulation, the insulation of windows frameworks and doors, and to the temperature and ventilation of the lodgement, as referred in Table 3.

Table 3 – Dwelling satisfaction

Evaluated Category	Evaluated Items (referred)	Attributed Evaluation
Dwelling	Satisfaction with exterior sound insulation	1.99
	Satisfaction with windows and doors frameworks insulation	1.90
	Satisfaction with thermal conditions of the house	2.34
	Satisfaction with house ventilation	2.27

Source: 3rd Retrospective Analysis of the Housing Park Financed by INH in the period of 1995 to 1998, (LNEC, 2004)

The inquire result's revealed no satisfaction relatively to the building exterior aspect, to the building construction materials and to the conservation state of the building (Table 4).

Table 4 - Building satisfaction

Evaluated Category	Evaluated Items (referred)	Attributed Evaluation
Building	Satisfaction with the exterior aspect of the building	2.30
	Satisfaction with the building	1.97

	construction materials	
	Satisfaction with the conservation state of the building	2.40

Source: 3rd Retrospective Analysis of the Housing Park Financed by INH in the period of 1995 to 1998, (LNEC, 2004)

According to this study these levels of satisfaction can be corroborated by the identification of anomalies registered in the dwellings related with the construction and used materials. Anomalies were identified in 92.6% of the inquired lodgements, being 8 the average number of anomalies for each one. The analysis of the results obtained revealed that 29.8% of the verified anomalies correspond to moisture manifestation in several compartments (sanitary installations, kitchens, rooms, interior and exterior walls and ceilings), 16.3% to wide and fine cracks (in interior and exterior walls and ceilings), 8.7% to problems in water distribution nets, 6.8% to problems in the nets of sewers and 38.4% to diverse damages (LNEC, 2004, adapted from Table 8: 243).

This study stands out the great anomalies incidence in the building's envelope, whose degradation level must be identified and characterized. These anomalies often imply the appearance of several problems in the interior of the lodgements, with the consequent decrease of living quality and tenant satisfaction.

Earlier studies referred by Watt (1999) also point out this great incidence of anomalies in the building's envelope and its negative influence in the buildings performance especially in respect to waterproofing, durability, dampness, thermal and sound insulation.

CASE STUDY

Objective

The aim of this study was the visual survey of the social housing park, constructed and rented by eight local city councils. These city councils are situated in the Aveiro district in the centre of Portugal. The visual survey included the external envelope inspections accomplished by internal surveys in 15.13% of the apartments. With the results of the survey it was obtained a global graduation to each one of the buildings – degradation level (DL) - and an evaluation index (IA) that represents the evaluated requirements performance.

The requirements defined to be measured are the:

- envelope waterproofing (roof, external walls and frameworks);

- external visual aspect (coating cracks, detachment, spread of vegetable and micro organisms, glazing frameworks, roof and rain water drainage facilities degradation);

- durability.

Sample characteristics

The building set considered was constructed, between 1981 and 2004. The buildings are localized in 8 different local regions of the Aveiro district, in the centre of the country.

- Elements number – the sample have 27 buildings groups, 52 buildings, 138 blocs and 1276 apartments.

- Age of buildings – building's age range from 26 to 3 years old.

- Number of storeys - 3 or 4 housing storeys including the ground level.

- Constructive characteristics - external brick cavity walls, external finishing in single-coat render mortar and in some cases ceramic tiles, metal frameworks with simple glazing, flat and pitched roofs.

Methodology

It was created a visual survey methodology to the external envelope. Its aim is to identify the external pathologies and its level of severity trough an evaluation scale. To apply this evaluation scale it was established the deterioration parameters to be considered in each level, associating a visual scale with a physical scale similarly to the scale of Shohet and Paciuk (2006). The evaluation scale implemented with eight levels, Table 5, was based in the Hermione scale (ALBATROS, 2005) and also indicates the action to be taken. The assessment in each level is given attending the pathologies intensity, its location and extension, according to a graduation scale constructed to support the field survey evaluation. This scale describes to witch level the pathologies must be considered, according to its extension and severity. This scale describes witch level must be attributed to each pathology, according to its extension and severity.

Table 5 - Evaluation scale

Description/Action	DL
Exceptional without any intervention need. Keep and plan maintenance actions to keep the conservation level.	10
Good without reserves. Current clean and maintenance actions must be taken.	9
Good with some minor reserves. Clean and maintenance actions must be taken in the elements with deterioration symptoms.	8
Acceptable with necessity of low rehabilitation actions.	7
Acceptable with necessity of moderate rehabilitation actions.	6

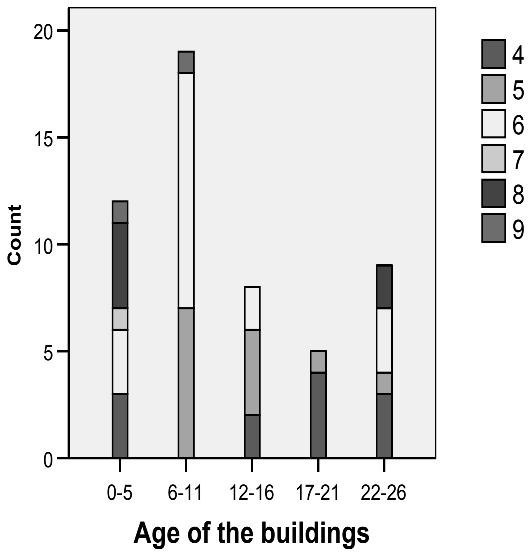
Acceptable with necessity of deep rehabilitation actions.	5
Unacceptable. Priority intervention. Exceptional rehabilitation.	4
Unacceptable. Without rehabilitation possibility. Demolish/substitute.	3

DL– Degradation Level

Visual survey data analysis

In the social housing set considered 58.4% of the buildings surveyed were constructed after 1996. During the contact with the city council's technicians it was verified that preventive planed maintenance actions are not taken. In the sample 41.5% of the buildings never were submitted to any maintenance action and 24.5 % only to punctual reactive repair actions (Rodrigues and Teixeira, 2007). The visual survey results obtained according the evaluation scale presented in Table 5, to each evaluated requirements - façades coating cracks, façades discolour coating, frameworks, roofs, rain water drainage facilities – were aggregated by a model developed from the Hermione aggregation model. These results revealed that the façade coating cracks and the discoloration are the pathologies with the worst assessment. The deterioration, the bad watertightness and high air permeability of the frameworks contribute to its low assessment. The roof and rain water drainage systems degradation level is more relevant in the eldest buildings, with one exception in a recent building that present great problems in its roof caused by construction deficiencies. In general the global degradation level is lower than eight and worst in the buildings with more than twelve years (Figure 2). The eldest case with a DL=8 has been subjected to rehabilitation actions in its envelope (Rodrigues and Teixeira, 2007). It can be verified that recent constructions present significant degradation in its envelope contributing to the appearance of pathologies in the interior of the houses with the consequent reduction of its performance.

From this global degradation level an evaluation index was obtained to each building (Figure 3). These results reveal that 81% of the buildings obtained an evaluation equal or less than 6 (22.6% with 4 and 5; 35.8% with 6). The others 19% had an evaluation higher than 7 (13.8% equal to 8).



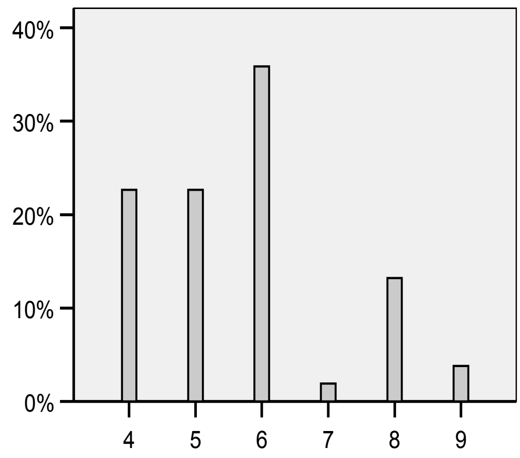


Fig. 2 – Global degradation level of the building

Fig. 3 – Buildings evaluation index (IA)

Analysis of data from interviews

The requirements defined to be measured during the inhabitants' interviews were: the envelope waterproofing (roof, external walls and frameworks), the interior hydrothermal conditions (winter and summer comfort, humidity and interior moisture), the interior acoustics conditions (air sound propagation from inside and outside the building, percussion sound propagation), the external visual aspect (coating cracks, detachment, spread of vegetable and micro organisms incidence, frameworks, roof and rain water drainage facilities degradation), durability and maintainability. The aim of these interviews was the achievement of a performance global evaluation to each requirement and to the global building (Table 6). To achieve this goal the interview's results obtained by a multi-attribute analyses were quantitative and qualitative graduated with the scale (performance level) indicated in Table 6.

The average performance level of the surveyed buildings attributed by the inhabitants is 5.98 (satisfy less). To the hydrothermal conditions are 5.92. The acoustic of the dwellings was the worst classified requirement (average of 4.42 – do not satisfy). The durability requirements present an evaluation majority below satisfy due to the inhabitant's confirmation of the low durability of these dwellings and buildings and its consequent precocious degradation.

Table 6 – Per cent distribution in each performance level

Performance level	Waterproofing	Hydrothermal	Acoustic	External visual aspect	Durability	Building performance level
Excellent 9≤ ND ≤10	3.1	0.0	0.0	0.0	0.0	0,0
Very good 8≤ ND <9	20.7	0.5	0.0	1.6	0.0	0,0
Good 7≤ ND <8	27.5	11.4	0.5	64.2	3.1	2.6

Satisfy 6≤ ND <7	26.9	28.5	3.1	30.1	37.3	50.3
Satisfy less 5≤ ND <6	15.5	44.0	22.8	4.1	45.6	40.4
Do not satisfy 3≤ND <5	6.2	15.5	73.6	0.0	14.0	6.7
Total (%)	100.0	100.0	100.0	100.0	100.0	100.0

CONCLUSIONS

It can be concluded about the low performance level of this set of social housing. The precocious appearances of pathologies in the constructed buildings represent a greater financial effort due to the need of extraordinary rehabilitation actions. Its social and economic value implies the necessity of planed rehabilitation activities to get higher levels of habitability and a greater durability. To eliminate this waste of money and avoid the low durability of the buildings, the public owner must implement sustainable rehabilitations interventions contributing to higher habitability conditions.

It can be conclude by the importance of the conjunction of the technical evaluation with the inhabitants' performance level evaluation. They evaluate the habitability and comfort requirements with the real knowing of the existing anomalies in the dwellings. According to this evaluation the rehabilitations solutions must be planned with the purpose to solve the hydrothermal and acoustic discomfort as the low durability of the buildings.

Research in energetic efficient is being conducted in two different groups of this set of buildings.

REFERENCES

ALBATROS (2005). Mertz, C.; Flourentzou, F.; Gay, J.B. Méthode d´aide à la décision intégrant les enjeux du développement durable en phase de planification d´un project de construction publique available at www.eco-bau.ch/francais/.

AQC (2006) Qualité, progressons ensemble. Bilan 1995-2005. Agence Qualité Construction. Observatoire de la Qualité de la Construction, available at www.qualiteconstruction.com/webzine/default. asp?main=38.

Abrantes, Victor; Freitas, Vasco P.; Sousa, Marília (1999) Reabilitação de Edifícios – Estudo do comportamento e análise técnico-económica das soluções utilizadas nas obras de construção e reabilitação. Porto: IGAPHE – DGHN – FEUP.

Cabrita, A. R.; Coelho, A. B.; Freitas, M. J. (2000) Gestão Integrada de Parques Habitacionais de Arrendamento Público – guião recomendativo. Intervenção Operacional Renovação Urbana – IORU. Lisboa: LNEC.

Henriques, Fernando M. A. (2001) A noção de qualidade em edifícios. Comunicação ao Congresso Nacional da Construção. 17-19 Dezembro. Lisboa: IST, available at http://www.dec.fct.unl.pt/seccoes/smtc/pub7.pdf.

INE (2001) Censos 2001: resultados definitivos: XIV recenseamento geral da população: IV recenseamento geral da habitação. 1º Volume. Lisboa: INE.

LNEC (2004). 3ª Análise Retrospectiva do Parque Habitacional Financiado pelo INH anos de 1995 a 1998. Relatório 239/04 – NAU. Lisboa: LNEC.

Rodrigues, M. Fernanda S; Teixeira, José M. Cardoso (2007) Social Housing: The Absence of LCC. LCM2007 From Analysis to implementation. Zurique, Suiça: Abstract book, 118, Manuscript as pdf-file.

Shohet, Igal M.; Paciuk, Monica (2006) Service life prediction of exterior cladding components under failure conditions. Construction Management and Economics, 24, 131-148.

IMPORTING INTERNATIONAL TECHNOLOGY THROUGH INTERNATIONAL TECHNOLOGY TRANSFER (ITT) PROJECTS IN CONSTRUCTION: SYNTHESIS OF ITT PROJECTS MODELS

Roshartini Omar
Graduate Centre Department, Faculty of Architecture, Planning & Surveying, University Technology MARA, Shah Alam, Malaysia
E-mail: *: tni_0912@yahoo.com*

Roshana Takim (corresponding address)
Graduate Centre Department, Faculty of Architecture, Planning & Surveying, University Technology MARA (UiTM) Shah Alam, Malaysia
E-mail: rtakim59@yahoo.co.uk

Abdul Hadi Nawawi
Graduate Centre Department, Faculty of Architecture, Planning & Surveying, University Technology MARA (UiTM) Shah Alam, Malaysia
E-mail: *:* abdulhadinawawi@yahoo.com

ABSTRACT: International technology transfer (ITT) by means of construction projects development attracts many organisations in developing countries as well as Malaysia. The main reason is that ITT in construction is one option for organisations in developing countries to acquire newer technology internationally to enhance local technological capabilities. This paper attempts to broaden the understanding of the ITT phenomenon based on the experience learned from various international projects models from different countries (i.e., China, Indonesia and Tanzania).

Based on the consideration of these models, the paper proposes an amalgamated model of ITT in Malaysia. The proposed model consists of three major components; technology transfer, projects and organisations, in which technology from abroad is transferred into organisations of the country via international project development. The transfer of technology could be in the form of knowledge, skill and tools, while technological capabilities are the organisational coherence to make ITT function in an organisation. Moreover, the efficiency and effectiveness of absorptive capacities by the organisations are important factors of ITT and are depending on various factors such as cultures, language, policies, political believe, and needs and expectations of the organisations. The aim of the model is to gain a better understanding of ITT in construction and to contribute to the improvement of local technological capabilities particularly in Malaysia.

KEYWORDS: absorptive capacities of ITT**,** construction industry, international technology transfer (ITT), Malaysia, and technological capabilities

INTRODUCTION

In most developing countries, 'international technology transfer (ITT)' projects have been extensively studied in many academic fields. ITT involves the cross-boarder technology transfer by means of construction project development with the purpose of enhancing local technological capabilities by acquiring newer technology internationally. Historical experience suggests that the economic growth of developing countries depends to some degree on the successful application of international transfer of technology via the development of construction projects into organisations (Byun and Wang, 1995). Many developing countries implemented Mega projects for the purpose of gaining access to modern technology in which, relevant information, the nature of technology, the modes of transfer, cultural difference, benefits and barriers from international experience and different sources of the world could be adopted to be used locally (Saad et al. 2002; Putranto et al. 2003; Wie, 2003).

In this respect, the construction industry is targeted due to the fact that the TT transaction encompasses extensive and significant project-based work throughout the four phases of project life cycle starting from the strategy formulation, procurement, construction, and project completion phase (Takim, 2005). It undertakes the production of various construction products in the form of buildings, infrastructure works, refurbishment works and the installation of various equipment and facilities. The study reviewed theoretical TT project models from China, Indonesia, and Tanzania to capture several information of different styles and perspectives of TT that could have different impacts on organisations via projects implementation.

BASIC CONCEPT

Technology, according to many researchers (Bell et al. 1984; Putranto et al. 2003; Wie, 2003), is a collection of physical processes that transform inputs into outputs with procedural techniques and organizational arrangements for carrying out the transformation. According to Chee (1981), technology is viewed as the knowledge and machinery that are needed to run an enterprise. This could include both software (blueprints and operating manuals) and hardware (equipment). Stock & Tatikonda (2000) draws a more sophisticated definition for technology as a tool or technique, product or process, physical equipment or method of doing. While, in operational context, technology is defined as technical knowledge and could also be associated as a machine, an electrical or mechanical component, a chemical process, software code, a patent, a technique, or a person.

Technology transfer however, is the transfer of skills, technical know-how, machinery and other capital equipment (Wei, 2003). This is in line with the opinion of Putranto et al. (2003) that define technology transfer as the transfer of capital goods and operating skills to the development of technological capabilities. Technology transfer could also be seen as a communication process between the transferor and the transferee which depends on the capability of the transferee to receive technical information from the transferor (Lin and Berg, 2001). Technological capabilities however, could be in the form of investment (feasibilities and project execution) and production (process engineering, product engineering and linkages within economy). Furthermore, according to Lall (1996a), technological capabilities are the skills, technical knowledge and organizational coherence required to make industrial technologies function in an enterprise. Technological capabilities reflect not only the ability in using resources, but also capacities of resources, such as training, research and development (R&D), and maintenance of resources (Cohen, 2004).

Meanwhile, construction project within the context of this study is defined (after Young, 2000) as a temporary endeavour to achieve some specific objectives in a defined time. According to Cheung et al. (2000), a construction project is viewed as a complex sequence of activities to deliver clearly defined objectives. Projects may vary considerably in size and duration, involving a small group of people or large numbers in different parts of the organisation. It is usually unique in content and unlikely to be repeated again in exactly the same way.

Since all advanced technologies are imported from advanced industrial countries, technology transfer (TT) projects involve the cross-border transfer in which, technological capability regards the effective use of the imported technologies abroad which enable local firms or enterprises to adopt these technologies to the development of new products and processes in response to a changing economic environment. Several researchers (Perlmutter and Sagafi-Nejad, 1981; Contractor and Sgafi-Nejad, 1981; Simon, 1982 and 1991; Stobaugh and Wells, 1984; Agmon and Glinow, 1991) regard technology transfer (TT) project as a complex process that needs time to develop. The development process of TT could be in the form of acquisition, adaptation, and improvement (Rosenberg and Frischtak, 1985).

Moreover, in TT projects, there are numerous forms of channels or modes of TT (Cohen, 2004) which takes place in the public and private sectors; that is from the private and public firms of the advanced countries to private and public sectors locally. Some of the channels are considered to be very effective (i.e., training programs, managerial and institutional programs, procurement and contractual contracts) whilst others are regarded as less effective (i.e. licensing agreement) (Ming 1999; Wie, 2003). Therefore, one of the important research issues is to investigate further the effectiveness of different channels or modes of technology transfer in Malaysia.

Apart from channels, the process of knowledge diffusion and the level of absorptive capacity are important in TT. Knowledge diffusion is a spread of technology transfer by means of communication in which potential users become informed about the availability of a new technology and are persuaded to adopt it through communication (Attewell, 1992). The process of diffusion could be made in five stages: knowledge, persuasion, decision, implementation, and confirmation (Rogers, 2003). Knowledge means gaining initial knowledge about new ideas; persuasion could be the altitudes towards new ideas, to adopt or reject; decision means decision making for adoption new ideas; and finally, confirmation is the confirmation of decision on the new imported ideas. The ease of knowledge diffusion and the level of absorptive capacity in the recipient country are widely cited as important in affecting the incentives for technology transfer. Farrands (1990) reckons that absorption of technologies was crucial and to a certain extent it depends on their organisations and management culture, the role and the structure and needs and expectations of organisations of the recipient country. Furthermore, it is important for policy makers of the recipient country to understand the art of diffusion, the factors governing foreign firms' willingness to transfer technology, and the value of domestic firms' investment in international technology mastery. Therefore, the level of absorptive capacity on technology transfer (TT) projects deserves further investigation, particular in the Malaysian Construction Industry.

SCENARIO OF MALAYSIAN CONSTRUCTION INDUSTRY

Over the last 20 years, the fast growing Asian region has experienced rapid industrialisation and economic growth. Much of this change can be attributed to international technology transfer (ITT) (Devapriya and Ganesan, 2002; Marton, 1986; Saad et al. 2002; Schnepp et al. 1990). The construction industry in Malaysia is of no exception, experiencing unprecedented growth through the formation of large building and infrastructure programs that are largely partnered with foreign enterprises (Economic Planning Unit, 2007). Therefore, the phenomena of TT projects occurred at the macro and micro level in firms and organisations. The main problem identified for international technology transfer (TT) is lack of managerial capabilities (Sharif, 1995; Ramanathan, 1994; Kumar, et.al. 2004). The common question is how to managed technological capabilities efficiently and effectively from the viewpoint of technology receivers.

The involvement of Malaysian contractors in many Mega projects locally and abroad has nurtured the capabilities and expertise of Malaysian contractors locally. The construction industry benefited tremendously with the implementation of large infrastructure projects encompassing highways, ports, airport, power plant, and urban development various function projects. Several major projects in Malaysia were speeded up through collaborations between the private sector and the public sector which helped to force the economic development of the nation. Consequently, Malaysia has world class infrastructure such as the Petronas Twin Towers and Kuala Lumpur International Airport (CIDB, 2007). Since 1995, it was reported that the Malaysian construction companies have completed almost 300 overseas construction projects amounting to RM 20,912 billion and are currently implementing 56 projects valued at RM 24, 583 billion. About half of these projects are roads and highways, while building works represent approximately one fifth of the total volume of work (CIDB, 2007).

There are numerous channels or modes of TT open to Malaysia. These include direct investment (domestic and foreign) and privatization. Through privatization channels, foreign technology is transferred by means of build-operate-transfer (BOT) and Private

Finance Initiative (PFI) procurement systems. Organisations are important as players to TT despite the difficulties in defining significant organisations that could measure the benefits of technology transfer (Cohen, 2004). With the support of organisations such as Construction Industry Development Board (CIDB), Malaysia External Trade Development Corporation (MATRADE) and Professional Services Development Corporation Sdn Bhd (PSDC), Malaysia has a more focused strategy to market construction services through Government-to-Government arrangements abroad.

Given the above, TT in construction is one option for developing countries to acquire newer technology internationally to enhance local technological capabilities. Hence, the paper is purely focussing on importing cross-boarder international technology by means of construction project development to Malaysian construction organisations with the ultimate aim to improve the local technological capabilities.

SYNTHESISE OF INTERNATIONAL TECHNOLOGY TRANSFER (ITT) PROJECTS MODELS

Figure 1, 2, and 3 present ITT project models in construction and manufacturing developed by various researchers. The ITT projects models are taken from China, Indonesia, and Tanzania. These are discussed in turn:

INTERNATIONAL TECHNOLOGY TRANSFER (ITT) PROJECT MODEL OF CHINA

Recently, China has been one of the largest importers of international technology. Since the early 1990s, more and more local companies and factories have purchased technology directly which increased the amount of technology imported from abroad. Figure 1 presents ITT project model of China based on the understanding of work done by Guan et al. (2006). The major concerns of the model are: types of technology transfer (knowledge, skills and tools), technological capabilities (the efficiency and competitiveness in the use of imported technologies), the channels (modes of ITT), barriers of ITT and finally, the Chinese organisations/stakeholders.

Furthermore, technological capabilities are divided into operative, acquisitive, adaptive, and innovative capabilities. Operative capability deals with knowledge and skills in order to run the tools (i.e. machinery and equipments). Acquisitive capability refers to the search of new skills and knowledge, adaptive capability is to adapt TT in the operation of the product, while, innovative capability means the use of knowledge, skills and tools to innovative new products. Therefore, to acquire these technological capabilities, various forms of channels (i.e., training programs, managerial and institutional programs, procurement and contractual contracts) are required. Through these channels foreign technology could be transferred to Chinese organisations such as the buyers. Nevertheless, in China the lack of organisational skills, management and marketing are the form of ITT barriers that should be taken into consideration as suggested by Guan (2002) and Guan & Ma (2003).

Given the above, the model implies that absorptive capacities of ITT into Chinese organisations/stakeholders via projects implementation should depends on the organisational and managerial culture, the role and the structure, the needs and expectations of Chinese stakeholders and is inline with the idea of Farrands (1990).

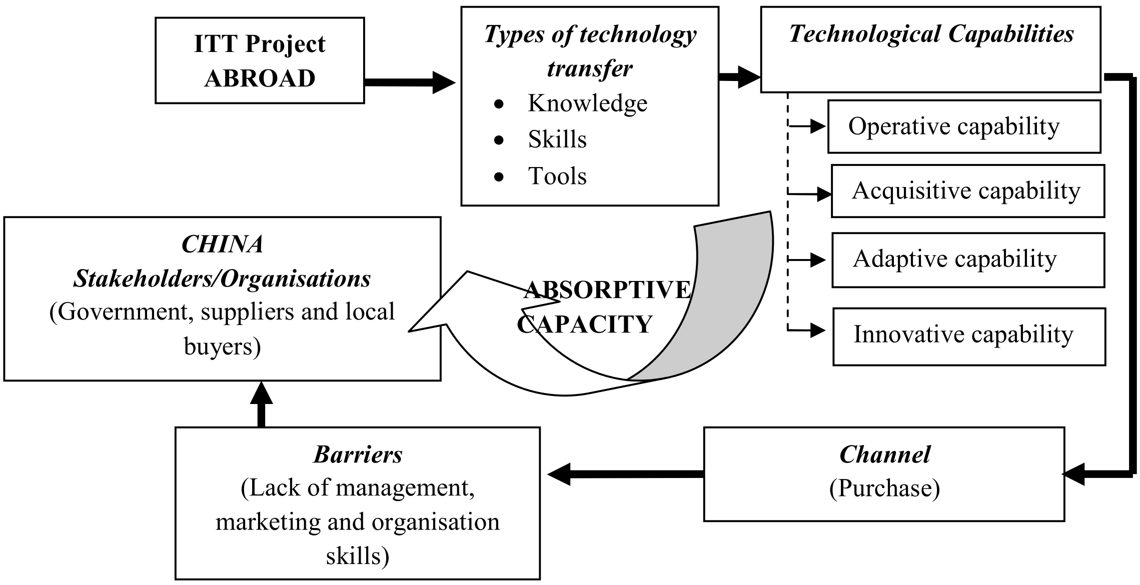


Figure 1: International technology transfer (ITT) Model in China
(Source : Guan et al. 2006)

INTERNATIONAL TECHNOLOGY TRANSFER (ITT) PROJECT MODEL OF INDONESIA.

Indonesia, like other developing countries is a net importer of advanced technologies abroad (Wie, 2003). ITT projects regard as important source in Indonesia and could be seen through the development of many Mega development projects such as monorail, bus ways and bridges. These advanced technologies are put into practice in order to raise the standard of living of the Indonesian. Figure 2 shows ITT project model developed by Wie (2003). The model highlighted four important factors. The first factor is the types of technology transfer (knowledge, machinery/ tool, skills and technical know-how) that are needed to run an enterprise, while the second factor deals with technological capabilities (i.e., the ability of the Indonesian utilising the imported technology effectively to develop new products and processes) and in line with the opinion of Bell et al. (1984) and Kim (1997). The third addresses different forms of channels or modes of international technology transfer which could be viewed in the form of Foreign Direct Investment (FDI), licensing agreement, import of capital goods, foreign education and training, and technical consultancies. Finally ITT is transferred via projects into organisations or stakeholders. These stakeholders are the Government, foreign suppliers and local buyers. In the model, Wie (2003) reckons that in order to capitalize on the TT projects in Indonesia, these organisations should have the capability to use, adopt, replicate, modify and able to implement TT locally and, further extend the knowledge and skills to nearby countries. Therefore, in order to develop the Indonesian technological capabilities, the efficiency and effectiveness of absorptive capacities by stakeholders are seen to be the utmost essential.

Hence, the two models of ITT projects (China and Indonesia) appear to be similar in which, both of them emphasize on the capability of local stakeholders/organisations to adopt newer technology abroad and use locally for the benefits of the nations.

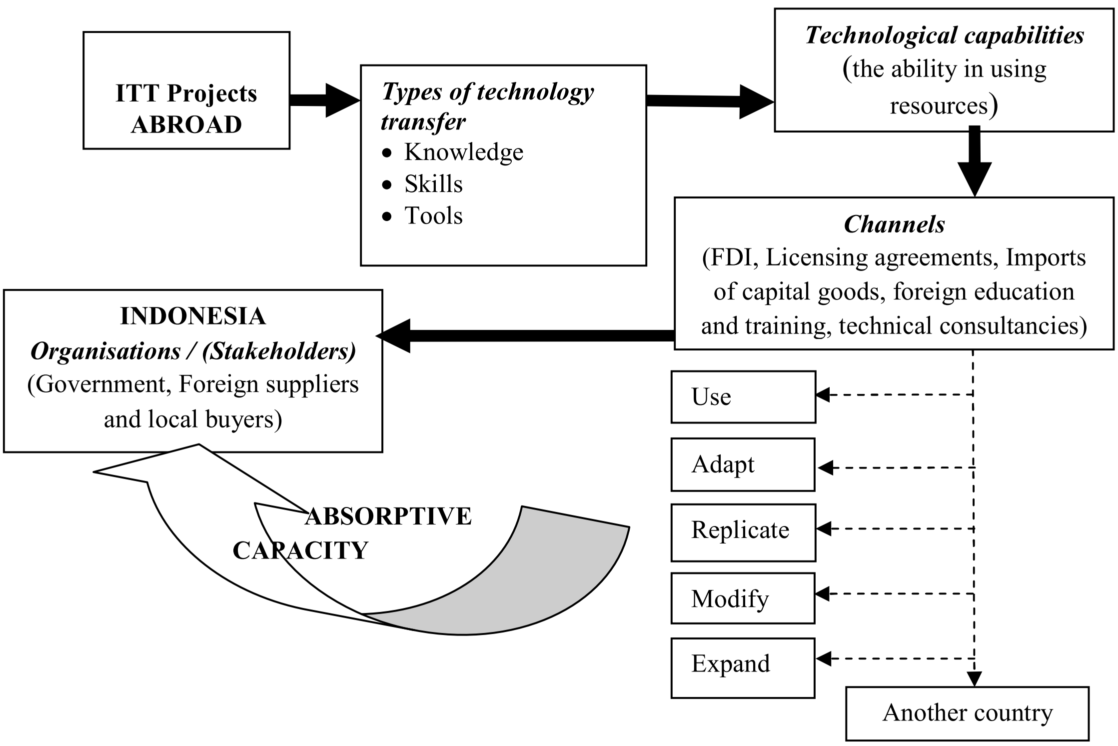


Figure 2: The International technology transfer (ITT) model in Indonesia (Source: Wie, 2003)

INTERNATIONAL TECHNOLOGY TRANSFER (ITT) PROJECT MODEL OF TANZANIA.

The construction industry in Tanzania plays a major role in the country's economic and technological development (Mansfield and Sasillo, 1990). Most sizeable construction works, especially large development projects are funded, administered and executed by international agencies. Figure 3 shows an international technology transfer (ITT) project model of Tanzania developed by Mansfield and Sasillo (1990). Based on the model, the stakeholders' organisations are the government, local contractors and international firms that participated actively throughout the construction project phases; ranging from feasibility study, design, construction and supervision. Most of the construction works are carried out by foreign or international firms whilst, local contractors are required to take merely a low proportion of new construction work. The reason for the above predicament is most likely due to the lack of management capabilities by Tanzania's contractors to manage construction projects efficiently and effectively as claimed by Mansfield and Sasillo (1990).

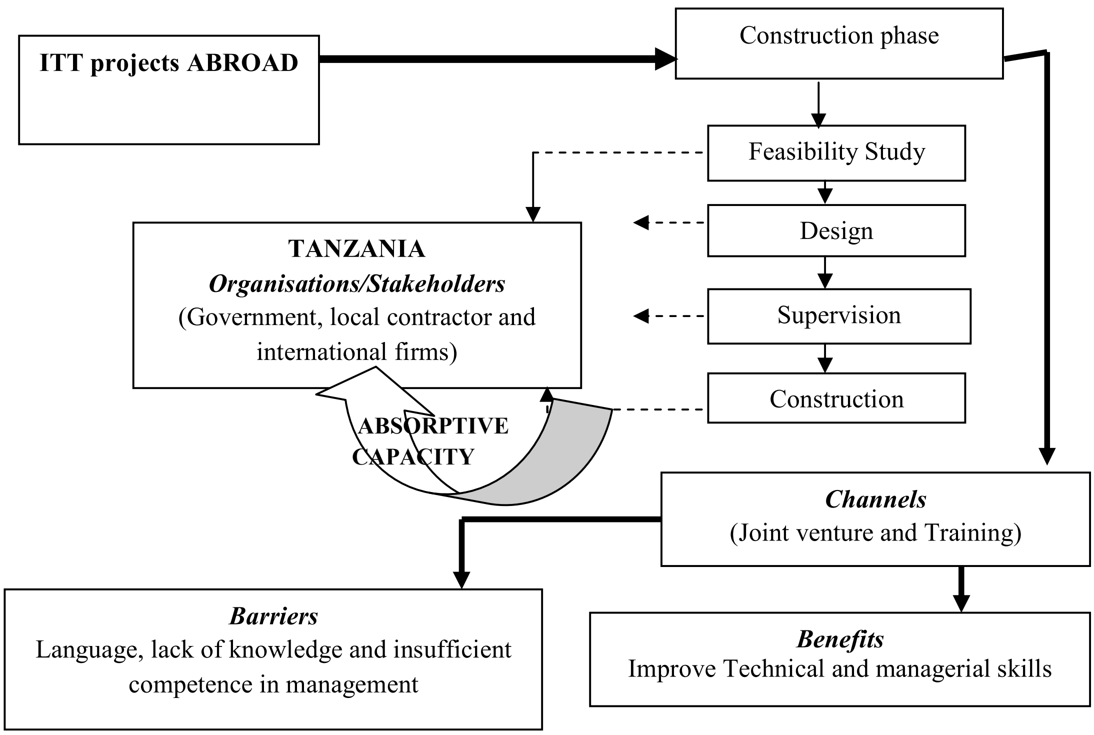


Figure 3: International technology transfer (ITT) Model in Tanzania
(Source : Mansfield and Sasillo, 1990)

The main criticism of ITT projects in Tanzania is that some technology borrowed from outside tends to be more advanced and impractical to be implemented for the Tanzania's projects due to the lack of knowledge of the local practitioners. These are the main barriers faced by them. The absorptive capacity therefore, depends on the local practitioners. With regards to Tanzanian, due to the lack of knowledge of the local practitioners, the absorptive capacity is regarded as minimal. By and large, it is suggested that local engineers should be given a chance to practice their knowledge, with emphasis on promoting self-reliance in the industry. Furthermore, training should also be given a greater recognition for those who have participated in the construction industry. Mansfield and Sasillo (1990) suggest that in order to enhance transfer of technology, self determination and confidence should be developed within the local practitioners for the fact that the mode of transfer of technology (i.e., channels) via joint-venture and training and development are the recipes for ITT projects.

Most of the ITT models approaches above, if not all, stressing on the concept of cross-boarder international technology transfer project to enhance local firms technological capabilities by acquiring new technology internationally focussing in the four areas of concern i.e., types of technology; technological capabilities; numerous channels of ITT; and the absorptive capacity of construction organisations.

Despite the outcomes of these project models usually depending upon the perspectives of each individual country, all these models are good on their own. An ITT projects model of China developed by Guan et al. (2006) seems to provide a complete development stage of ITT project process. The models developed by Wie (2003), Mansfield and Sasillo (1990), on the other hand, are simple to understand and comprehensive. The concept and approach of these models could be used as a guideline, in the course of developing an amalgamated model for a successful ITT projects in Malaysia.

PROPOSE AN AMALGAMATED MODEL OF INTERNATIONAL TECHNOLOGY TRANSFER (ITT) PROJECT MODEL IN MALAYSIA

Figure 4 proposes an amalgamated model for a successful of ITT project in Malaysia. This has been developed based on the preliminary literature review and understanding of the information gathered by the various models above (China, Indonesia and Tanzania). The conceptual model consists of three major components; technology transfer, projects and organisations based on the understanding of ITT is transferred into organisations via international project development.

The process of technology transfer to developing countries, such as Malaysia involves a complex series of stages. The <u>first component</u> refers to the flow of technology transfer which consists of types of technology transfer. Three types of ITT are; knowledge (soft technology), skills and tools (hard technology) which usually congregate from advanced country to the developing countries. Knowledge transfer is about getting the right knowledge to the right people at the right time (Li-Hua, 2004). The knowledge is transferred perhaps when foreign and local managers have intimate interaction while working together. There are two major elements of knowledge namely: explicit knowledge and tacit knowledge. The explicit knowledge is transferred through formal means, such as conferences, meetings, seminars, and training sessions. Tacit knowledge on the other hand, is transferred in an informal manner, during job training sessions, telephonic communications, and other social occasions.

The tools of technology transfer could be referred as machine, electrical or mechanical component, a chemical process, software code, a patent and a technique. According to Bennett and Zhao (2004) the tools transfer could be benefited to developing countries in the form of generating greater revenues. Moreover, technology may be transferred between persons, between organisations, between regions and countries. Technology transfer occurs because of the existence seller (transferor) and buyers (transferee). Technology transfer normally refers to formal and direct arrangements between a transferee and a transferor or non-commercial arrangements between donor and recipient. This form of transfer in particular, may well be a two way process between transferor and transferee. Transferor and transferee play a major role in which, the transferor willing to transfer the technology and the transferee willing to learn the technology, hence encourages the technology transfer process.

Skills transfer however; comprise of the technical, managerial and institutional, which utilizes the capital equipment and technical information efficiently. The combination of knowledge, skills and tools are needed to support and sustain technological capabilities to make industrial technologies function in an enterprise (Harris and Harris, 2004; and Wie, 2003). Further, technological capabilities could be divided into four levels; operational, acquisitive, adaptive and innovative. In the production/ operational capability, skills and knowledge are required to control the production process and the machinery in the plants, including the maintenance and repair of the machinery. The investment/ acquisitive capabilities require knowledge and skills to search, assess, negotiate, and procure relevant technologies as well as the installation and setting-up the production facilities. While in the adaptive capability, (minor change capability) knowledge and skills are required to digest the transferred technologies for the improvements of the existing product. Finally, is the innovative (major change capability) in which the knowledge and skills are essential to perform research and development, products modifications and developing new products.

Apart from types of technology transfer and technological capabilities is the various modes of technology transfer or sometimes called as channels. These could include; direct investment, procurement agreements, and contractual arrangements and training (Cartlidge, 2004; Cohen, 2004; Li-hua, 2004). The direct investment could be regarded as public direct investment and foreign direct investment. The procurement agreements are described as build operate transfer (BOT), Private Finance Initiative (PFI), build own operate transfer (BOOT), design and build and turnkey contracts, joint venture (JV), partnering, and alliancing. Another important mode of ITT is training (Uko, 1987). Training packages are often included by governments in contracts involving foreign companies. In short, firms in Malaysia can accelerate the speed by which they can produce globally competitive products through rapid technology transfer from developed nations.

The next component is projects in which ITT is transferred via project implementation. Project Implementation facilities the combination of material and components, procurement of material, labour and managerial capability and other construction production resources to implement development programmes. Occasionally, international construction projects are naturally large and complex which involves a multitude of objectives with a large number of stakeholders.

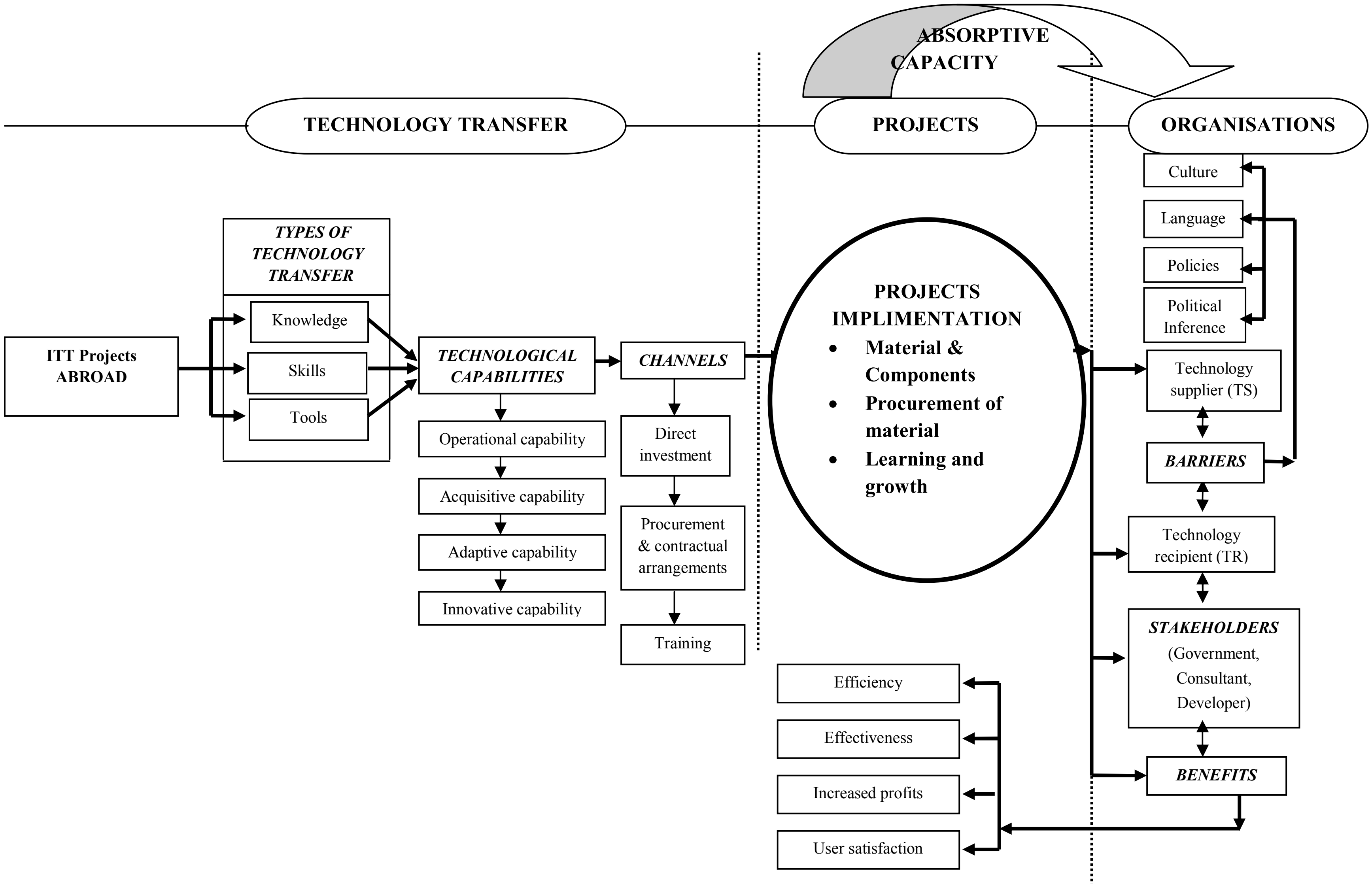

ABSORPTIVE CAPACITY
TECHNOLOGY TRANSFER
PROJECTS
ORGANISATIONS
ITT Projects ABROAD
TYPES OF TECHNOLOGY TRANSFER
Knowledge
Skills
Tools
TECHNOLOGICAL CAPABILITIES
Operational capability
Acquisitive capability
Adaptive capability
Innovative capability
CHANNELS
Direct investment
Procurement & contractual arrangements
Training
PROJECTS IMPLIMENTATION
Material & Components
Procurement of material
Learning and growth
Culture
Language
Policies
Political Inference
Technology supplier (TS)
BARRIERS
Technology recipient (TR)
STAKEHOLDERS (Government, Consultant, Developer)
BENEFITS
Efficiency
Effectiveness
Increased profits
User satisfaction

Figure 4: Propose an amalgamated model of International Technology Transfer (ITT) Project Model in Malaysia

Transfer of technology requires an extensive components which includes physical elements (equipment, tools and machines), documentation that embodies the knowledge (e.g. specifications, drawings and computer programs), clients' objectives and project characteristics as being major conditions of ITT projects (Simkoko, 1992). The concept of ITT project leads to the formation of 'integrated project teams' and temporary joint venture organisation between local and foreign firms. Further, the participation of local construction firms as subcontractors to foreign firms is an important element in ITT projects. ITT projects also support the process of learning and growth in project implementation.

The third components refers to project organisations, involving various project stakeholders such as suppliers, governments, workers, managers and wider community representative that have a stake to ITT (Cohen, 2004). Stakeholders are those people or organisations who have vested interest in the industry. Stakeholders can be those who are affected by the industry, have influence and power over the industry, and have interest in the success and failures of the industry. Stakeholders are important as players to TT despite the difficulties in defining significant stakeholders that could measure the benefits of technology transfer. Navarre and Schaan (1987) suggest that the key success factor of TT project is the ability to satisfy the stakeholders' needs and expectations in the technology transfer programmes.

Apart from stakeholders, barriers are also vital to be considered to the success of ITT projects. Li-Hua (2004) reckons that the barriers of knowledge transfer are known as cultural differences, language barriers, social values, and dissimilar objectives. Among others, culture difference could become the major barrier in ITT (Kedia and Bhagat, 1988**).** The cultural difference exists between the technology provider and the technology receiver. This is in line with the opinion of Black et al. (2000) and Malik (2002) pointed out that for the technology transfer to function properly, the organisations involved in the process should endeavour to build a culture of mutual trust through effective communication between transferor and transferee. Working in unfamiliar markets is often burdened with difficulties due to culture differences. New cultures and business practices require time to understand, placing greater pressure on international construction companies to adapt to their new surroundings (Malaysia Going Global, 2007). In addition, political interference, policies, regulations and enforcement practices could also have a great impact on the effectiveness of TT initiatives (Calantone et al. 1990). Therefore, the differences in culture, language, policies, and political believe in any organisations could affect the absorptive capacity of technology transfer via project implementation.

Finally is the benefit of ITT. Benefits are perceived in the form of improving project efficiency, effectiveness, increased profits strategic goal, user satisfaction, social & environmental impacts, personal development, professional learning, profit, minimized production problems and economy impact to surrounding community (Roger, 1962).

Hence, given the above, it could be deduced that technology transfer (TT) project commence with the existence of international construction in which, one company resident in one country perform work in another country in today's global business world as suggested by Mawhinney (2001). The proposed amalgamated model of ITT project in Malaysia intends to suggest that project implementation is at the core of the process. This is vital due to the fact that construction project is an important part of the global economy, affected by and affecting all parts of the globe. Moreover, the growth of multinationals in truly global operation has been an important factor in the internationalisation of construction projects. The effectiveness of ITT and the level of absorptive capacity into construction organisations are depending on management culture; the role and the structure; and needs and expectations of organisations of the recipient country (Malik, 2001). Other factors such as types of technology transfer, technological capabilities and modes of ITT (channels) are also important components in the cross-boarder of ITT via project development. Nevertheless, a more extensive empirical research works on these factors are needed for the future findings.

CONCLUSION

This paper attempts to review, synthesise and developed an amalgamated model of ITT in Malaysia based on the experience learned from China, Indonesia, and Tanzania. It reinforced issues such as: technology transfer and technological capabilities; numerous channels; projects implementation, the involvement of stakeholders; the benefits and barriers that could emerge out of it. Despite the benefits of ITT, the absorptive capacities of ITT into organisations are depending on various significant variables such as culture, language, policies, political believe, and needs and expectations of the organisations. These could act as barriers of ITT. Therefore, the ambiguous problems of absorptive capacities of ITT in construction require empirical research to be conducted further.

The research presented in this paper is part of an ongoing PhD research at Faculty of Architecture, Planning and Surveying, UiTM to develop a framework of international technology transfer (ITT) and the development of technological capabilities in Malaysian construction industry. The results of the study could provide an insight into the Malaysian construction project development and will hopefully provide valuable guideline, especially to public or private sectors in Malaysia that are looking forward for global construction market.

REFERENCES

Agmon, T., & Glinow V.M. (Eds.).(1991). *Technology Transfer in International Business.* New York: Oxford University Press.

Attewell, P. (1992).Technology Diffusion and Organizational Learning: The Case of Business Computing. *Journal of Organization Science*, **3**, pp.1-19.

Behrman, J. N. and Wallander, H. W. (1976). *Transfer of manufacturing technology within multinational enterprises.* Ballinger, Cambridge: MA.

Bell, M. (1984). *"Learning" and the accumulation of industrial technological capability in the third world.* London: Mcmillan.

Bennett, D., & Zhao, H. (2004). International technology transfer: Perceptions and reality of quality and reliability. *Journal of Manufacturing Technology Management,* vol*. 15*.

Black, C., Akintoye, A. & Fitzgerald, E. (2000). An analysis of success factors and benefits of partnering in construction. *International of Project Management*, **18**(6), pp.423-434.

Byun, H.-Y., & Wang, Y. (1995). Technology transfer and multinational corporations: the case of South Korea. *Journal of Asian Economics,* **6** (2), pp. 201-216.

Calantone, R., Lee, M.T. and Gross, A.C. (1990). Evaluating international technology transfer in a comparative marketing framework. *Journal of Global Marketing*, **3** (3).

Cartlidge, D., (2004). *Procurement of Built Assets.* Oxford: Elsevier Butterworth-Heinemann.

Chee., & Lim, P. (1981). EEC Investment in ASEAN and the transfer of technology: A Malaysian case study, *Paper presented at the First Conference on ASEAN-EEC Economic Relations, 6-8 August,* Singapore.

Cheung, S. O., Tam, C.M., Ndekugri, I., and Harris, F.C. (2000). Factors affecting client's project dispute resolution satisfaction in Hong Kong. *Construction Management and Economics*, **18** (3), pp. 281-294

Construction Industry Development Board. (2007). *Malaysia Venezuela potential cooperation in construction*. Kuala Lumpur: CIDB Printing Office.

Contractor, F., & Sagafi-Nejad, T. (1981). International Technology Transfer: Major Issues and Policy Responses. *Journal of International Business Studies*.

Cohen, G. (2004). *Technology transfer, Strategic management in developing countries.* New Delhi, California, & London: Sage publications.

Devapriya, K.A.K., & Ganesan, S. (2002). Technology transfer through subcontracting in developing countries. *Journal of Building Research and Information*, **30**(3), pp.171-82.

Economic Planning Unit. (2007). *Internationalization of construction*. Kuala Lumpur: EPU Printing Office.

Farhang, M. (1996). Managing technology transfer to China. *Journal of International Marketing Review,* **14**, (2), pp. 92-106.

Ford, D. (1980). The development of buyer-seller relationships in industrial markets. *Journal of Marketing,* **14** (5/6), pp. 339-54.

Harris, D., & Harris, F.J. (2004). Evaluating the transfer of technology between application domains: a critical evaluation of the human component in the system. *Journal of technology in Society* , pp.551-565.

Kedia, B.L., & Bhagat, R.S (1988). Cultural constraints on transfer of technology across nations: implications for research in international and comparative management. *Academy of Management Review*, **13**, pp.559-71.

Kim, & Linsu. (1997). *Imitation to innovation-The dynamics of Korea's technological learning*. Boston, Maccahussetts: Harvard Business School Press.

Lall, S. (1996). *Learning from the Asian tigers: studies in technology and industrial policy*. Basingstoke: Macmillan.

Li-Hua, R. (2004). *Technology and knowledge transfer in China.* England & USA: Ashgate Publishing limited.

Lin, B.W., & Berg D. (2001). Effects of cultural difference on technology transfer projects: an empirical study of Taiwanese manufacturing companies. *International Journal of Project Management,* **19**, pp.287-293.

Malik, K. (2002). Aiding the technology manager: a conceptual model for intra-firm technology transfer. *Journal of Technovation*, **22**(7), pp.427-436.

Mansfield, N. R., & Sasillo, S.-M. I. (1990). International construction contracts in Tanzania. *Journal of Journal of Project Management*, pp 90-94.

Marton, K. (1986). *Multinationals, Technology and Industrialization*. Lexington: Lexington Books.
Mansfield, E. (1995). *Innovation, Technology and Economy*. UK & US: Edward Elgar Publishing Limited.

Master Builders Association Malaysia. (2007). *Malaysia going global.* Kuala Lumpur: MBAM Printing Office.

Ming, W. X., & Xing, Z. (1999). A new strategy of technology transfer to China. *International Journal of Operations & Production Management,* pp.527-537.

Perlmutter, H., & Sagafi-Nejad, T. (1981). International Technology Transfer: Codes, Guidelines, and a Muffled Quadrilogue, in Technology Transfer Trilogy. *Pergamon, New York.*

Putranto, K., Stewart, D., & Moore, G. (2003). International technology transfer and distribution. *Journal of Technology in Society*, **25**, pp.43-53.

Rogers, E.M. (1962). *Diffusion of innovations*. New York: Free Press.

Rosenberg, N., & Frischtak, C. (Eds.). (1985). *International Technology Transfer: Concepts, measures, and comparisons*. New York: Praeger.

Saad, M., Cicmil, S., & Greenwood, M. (2002). Technology transfer projects in developing. *International journal of Project Management*, **20**, pp.617-625.

Schnepp, O., Glinow V.M.A., & Bhambri, A. (1990). *United States-China Technology Transfer*. Englewood Cliffs: Prectice-Hall.

Simkoko, E.E. (1992). Managing international construction projects for competence development within local firms. *International Journal of Project Management,* **10**(1), pp.12-22.

Simon, D. (1991). International Business and the Transborder Movement of Technology: A Dialectic Perspective, in Agmon, T., & Glinow, V.M. (Eds), *Technogy Transfer in Internatiol Business.* Oxford: Oxford University Press.

Stobaugh, R., & Wells, L. (Eds.).(1984). *Technology Crossing Borders.* Boston: Harvard Business School Press.

Stock, G.N., & Tatikonda, M.V. (2000). A typology of project-level technology transfer processes. *Journal of Operations Management* , pp.719-737.

Takim, R. (2005). A Framework for successful construction project performance (Doctoral Dissertation, Glasgow Caledonian University, 2005).

Teece, D. (1976). *The multinational corporation and the resource cost of international technology transfer*. Cambridge,MA: Ballinger.

Thunman, C. G. (1987). Technology licensing in distant markets, interaction between Swedish and Indian firms, (Doctoral Dissertation, Uppsala University, 1987)

Wie, T.K. (2003). The major channels of International Technology Transfer to Indonesia: An Assessment. *Conference on Catch-Up Growth and Technology Transfer,* University of Groningen, Groningen

Young, T. (2000). *Successful Project management*. London: Kogan Page Limited

PROJECTS: WHERE STRATEGIES COLLIDE

Amos Haniff
School of Management and Languages, Heriot Watt University, Edinburgh, UK
a.haniff@hw.ac.uk
Scott Fernie
School of the Built Environment, Heriot Watt University, Edinburgh, UK
s.fernie@hw.ac.uk

Projectification of the organisational world has resulted in apparent agreement that projects and project management are an efficient means of implementing organisational strategy. By way of a significant critique of the literature, this paper seeks to explore the content, limitations and inherent problems of strategic alignment, particularly within the construction sector. The paper is presented in three main sections. The first section attempts to bring clarity to how projects and project management are defined. This is complimented with an exploration of the connections between projects, project management and organisational strategy. The second section explores and deconstructs the assumptions underpinning the concept of strategic alignment. The final section of the paper presents a discussion and a number of research propositions regarding strategic alignment in the context of the construction sector. The paper concludes with a model of strategic collision that contradicts and challenges the current assumptions and orthodox view presented in the literature.

KEYWORDS: Strategic Alignment, Project Strategy, Project Management Strategy.

INTRODUCTION

Since the 1990's the growth in project management practices outside the traditional heartland of construction and engineering into mainstream management has been rapid. Both industry and academic reports confirm that the major adoption in project management practices is set to continue as firms begin to focus more of their operations in the form of projects (KPMG, 2002, KPMG, 2005, Smith and Winter, 2005). Significantly, the UK government have placed project implementation as a key strategic directive by creating centres of excellence to improve programme and project delivery within the Civil Service (OPSR, 2003). No longer is project management confined to product creation, rather business transformation, continuous improvement, organisational change, value creation and strategy implementation (Winter et al., 2006b, Winter et al., 2006a, Maylor, 2001). As a consequence, the concept of project management has become so widespread that commentators have began to speak of the *"projectification of society"* (Lundin and Soderholm, 1998, Midler, 1995), defined as 'the growing colonisation of all quarters of life by project-related principles, rules, techniques and procedures to form a new 'iron cage' of project rationality' (Cicmil and Hodgson, 2006).

Despite this, researchers appear to agree that projects are an efficient means of implementing strategy (Cicmil and Hodgson, 2006, Gareis, 1991, Cleland and Ireland, 2006, Roberts and Gardiner, 1998, Turner and Keegan, 1999). By employing a project management approach to delivering the broad organisational strategies, businesses are able to partially eradicate the traditional bureaucratic, mechanistic structures, which according to Burns & Stalker (1994) are inherently resistant strategic change. One perspective in literature assumes that the project management approach enables organisational strategy to be implemented efficiently and effectively, thus shorting the time from strategy formulation to strategy implementation (Hauc and Kovac, 2000, Gareis, 1989, Partington, 1996). Central to this perspective is the concept of strategic alignment. This concept ensures that projects accurately reflect the organisations long-term investment and aspirations articulated in their organisational strategies. However, projects represent a context within which numerous organisations simultaneously seek to ensure that their broad organisational investments and aspirations are realised. This paper therefore seeks to explore the use of projects and indeed project management as a way to implement organisational strategies. The paper also identifies the content and limitations of strategic alignment and the problems inherent in connecting this concept to how organisational strategies can be realised within the context of construction projects.

The paper is broken down into three main sections. The first part of the paper attempts to bring clarity to how projects and project management are defined. This is complimented with an exploration of the connections between project management *per se* and organisational strategy. The second part of the paper explores and deconstructs the assumptions underpinning the concept of strategic alignment. The final part presents a discussion and a number of research propositions regarding strategic alignment in the context of the construction sector.

PART 1: PROJECTS AND STRATEGY

Projects as temporary organisations

Most mainstream management text tend to refer to definitions provided by PMI (2004), who define a 'project' as "*a temporary endeavour, undertaken to create a unique product or result"* Within this classic description the role of the project is that of a production function, where projects are characterised as a set of planning and control techniques aimed at delivering project objectives - time, cost quality and scope. However, viewing the project in terms of tools, techniques and outputs makes basic assumptions about the nature of projects and arguably diminishes the complex role of the project manager (Lundin and Soderholm, 1995). This also does not adequately reflect the actuality of projects, in terms of the complex social process, the unpredictability and the collaborative interaction among diverse project participants (Cicmil et al., 2006). Notably, the most basic deficiency within this widely accepted definition is the view that all projects are fundamentally similar, in that they are manageable by a universal set of project management activities (Shenhar and Dvir, 1996). Organisations in the construction sector collectively engaged on a single project may bring multiple interpretations regarding what the *unique product* is meant to be and indeed what constitutes a *result*. This will be arguably heavily influenced by their respective organisational strategies and institutional context.

With respect to organisational strategy, projects are typically viewed as a vehicle for change within an organisation where project objectives are determined by a single parent organisation. In considering the complexities of project management, it is perhaps more appropriate to view a project as an 'organisation' rather than a 'tool'. By, referring to the project as a 'temporary organisation' introduces many of the elements of project management. These include dealing with the conflict of interest between the various stakeholders; realising the role of the project manager and the implementation of information, communication and monitoring systems (Turner and Muller, 2003). Packendorff (1995) also proposes that a change in metaphor from 'project' to 'temporary organisation' means that traditional concepts of planning and control techniques become less important. Instead, problems with the rationalistic belief that the project tasks are clearly defined and unambiguous by a parent organisation become exposed. The following section begins to explore the dominant rationality inherent in project management. This is highly influential in bringing clarity to Packendorff's (1995) critique and the way in which project management and strategy have been woven together.

Project management: streams of research

It has been suggested that project management research has evolved in two stream (Söderlund, 2002). The first stream focuses on the mathematical approach of planning and control techniques developed in parallel by both the US Department of Defence (DoD) and the chemical industry between 1958 and 1959 (Morris, 1997, Siemens, 1971, Archibald, 1987, Fondahl, 1987). These efforts resulted in two of the most important early contributions to project management research, most notably the development of Programme Evaluation and Review Technique (PERT) by US Navy Special Projects and the Critical Path Method (CPM) by E.I du Pont de Nemours Company. On the apparent successful application of these techniques other systems based tools were introduced by the US DoD, including Work Break Structures and PERT/cost.

However, many of the techniques used at this time were developed on an *ad hoc*, trial and error basis, rather than being a deliberate management activity (Thomas, 2006). It was in fact only due to the efforts of the US DoD themselves, that the concept of Project Management became well publicised, with CPM and PERT being the fundamental models of the concept. In order to ensure a generic method of scheduling the DoD forced its customers and contractors to adopt the newly developed methods by publication of DoD/NASA PERT/cost guide (1962). Despite these efforts and initial plethora of published articles on quantitative approaches, by the mid-60's the reaction of defence contractors to the use of the new techniques was decisively negative (Archibald, 1988). From a financial perspective, customers were beginning to realise that the restrictive systems resulted in expenditure of considerable cost and effort by the contactor (Kerzner, 2003). It would also appear that researchers themselves were beginning to question the underlying contribution of such rational techniques to the success of projects (Avots, 1969, Avots, 1962)

In recognising that managing projects requires more than a toolbox of planning and cost control techniques, a second stream of project management research began to evolve, which considered the human dimension of projects. Cleland and Ireland (2006) identify two seminal papers that were influential to this new stream. Firstly, the much cited paper published in the Harvard Business Review by Gaddis (1959), was the first to introduced the concept of project management as a recognised job description, outlining the leadership and responsibility role of the project manager spanning across organisational boundaries. The second significant contribution, also published in the Harvard Business Review described the growing trend in contemporary organisations towards functional teamwork approaches in organisational design (Fish, 1961). Coincidently, the contingency approach to organisational structures was also being developed during this period (Lawrence and Lorch, 1967), which had an influence on research into temporary organisations, with significant interest paid to the benefits of creating project teams from varied departments to form matrix structures (Knight, 1976) and research into varied leadership styles (Vroom and Yetton, 1977).

Regardless of efforts to focus on the 'softer' aspect of project management through these studies, much of the techniques developed and refined during the latter part of the twentieth century were still rooted in the scientific, systems approach. Mainly driven by the swift developments in computer-based technology, terminology such as project control systems, project risk analysis, and project information and communication networks became synonymous with the practice of managing projects. With reference to the evolution of the discipline, these streams of research have been more or less influential in shaping modern project management thinking and practice. This is further explored in the next section of the paper and helps to locate the underlying epistemological assumptions of project management.

Evolution of a Discipline

It was probably not until the 1980's that Project Management became formalised as a recognised discipline. In reaction to successive project failures in the public sector, authoritative bodies began to standardise project management by following the traditions of The US DoD in the 1960's. The UK Government introduced sophisticated project control methodologies in the form of Projects in Controlled Environments (PRINCE) developed by the Central Communication and Telecommunications Agency (CCTA) in 1989. This was followed by PRINCE2 in 1996 in response to practitioners' criticisms that PRINCE was too demanding, ridged and solely applicable to large projects. However, the most influential movement in terms of establishing a project management discipline came from the formation of the Project Management Institute (PMI) who sought to homogenize the practice by developing generic sets of standards in the form of a Project Management Body of Knowledge (PMI, 1987). The aim of these guides were two fold; firstly to formally standardise the growing discipline of project management by presenting a set guidelines that are deemed to be best-practice; and secondly to accommodate the widening discipline of project management by presenting a generic set of tools and management methods. Although, criticised for its mechanistic process and instrumental rationality (Hodgson and Cicmil, 2006), it is this body of knowledge that underpins project management professionalism today, but more significantly it is the various project management bodies of knowledge and their emphasis on a standardised rational approach that underpin project management teaching across universities.

It should therefore be of little surprise that the discipline of project management detracts little from its rational deterministic origins. This dominant allegiance has survived significant criticism of its '*hard paradigm*' (Pollack, 2007) and recognition that traditional project management discourse lacks relevance to current business practice (Packendorff, 1995, Maylor, 2001). A large number of these concerns have recently been raised by the "Rethinking Project Management: EPSRC Network 2004-2006" (Winter and Smith, 2006), whose main concern is the assumption in main stream project management literature that a single theoretical base exists to adequately explain the actual management of projects (Winter et al., 2006b). Whereas other researchers suggest that project management suffers from the absence of a theoretical framework and lack of epistemological context altogether (Anagnostopoulos, 2004, Kalfakakou and Zapounidis, 2004). Notwithstanding the timely debate and emerging thinking within the field, mainstream project management rhetoric surrounding rational deterministic techniques continues to grow as the field of project management widens.

Without doubt, 'Project Manager' and 'Project Management' have become fashionable terms within most organisations. There also appears to be a misguided belief that loose implementation of project management principles provides a solution to the inherent problems of executing change. Yet without significant research and recognition of the current limitations behind the discipline, project management is in danger of being labelled a 'fad' and interest into the subject following the bell shaped curve of Abrahamson's (1996) management fashion model. According to the theory, many managers appear to believe that constant progress is being made by the adoption of new management techniques, which are fuelled by the growth in business media that markets itself by satisfying management interests in management fashion trends (Bamber, 2000). The influence of popular management press is salient to the problem, as it is suggested that it tends to lead to the dissemination of progressive management rhetoric, with the dissemination of academic research lagging behind (Barley et al., 1988).

The rigid allegiance to the assumptions underpinning the first stream of research and the underlying rationalistic epistemology holds significant consequences for any attempt to connect project management with the wider field of organisational strategy. Similarly, the exploration of attempts to strategically align the formulation of organisational strategies with the implementation through projects and project management is significantly problematic.

Organisational Strategy

Unlike like the term 'project', literature offers no universally accepted definition of the term 'strategy'. In fact, Shirley (1982) deducts that there are almost as many definitions of strategy as there are writers about the subject. A number of authors have attempted to undertake the task to trace the evolution of strategy concepts over time and, nearly all find significant differences between concepts (Bracker, 1980, Hofer and Schendel, 1978, Evered, 1983, Henderson, 1989). Despite the differences, more often, strategy is defined in terms of formation and planning, with little emphasis on implementation. This separation of formation and implementation derives from the influential design school of strategy (Chandler, 1962), where a scholars such as Hoffer & Schendel (1978) and Andrews (1971) present models of strategic formation that purposely exclude an implementation phase. Andrews (1971) proposes that strategic formulation should be a deliberate process of conscious thought, and suggests that it is only once the strategy is fully formulated and made explicit that it can be implemented. Therefore, the assumption within this school, is that implementation frameworks are developed on clear communication of strategic intentions and objectives, against which operational managers devise their own targets and plans (Hrebiniak and Joyce, 1985).

Rather than treating strategy as a deliberate process of formation followed by implementation, Mintzberg and Waters (1985) draw a distinction between deliberate strategies, as those realised as intended, and emergent strategies, which are realised, despite, or in the absence, of intention. In their critique of the Design School of Strategy, Mintzberg et al (1998) argue that most manifestations of strategy are implicit, fragmented and fluid, that evolve from a *'pattern in a stream of decisions'* (Mintzberg, 1978). Within a project environment these stream of decisions derives from a number of internal and external influences, which not only include the parent organisational, but all stakeholders involved in the temporary organisation. As a consequence, organisational strategy is rarely realised in the ridged, formal manner that planners assume. Despite this, there is a growing body of literature that seeks to develop implementation of strategies through projects (Pellegrinelli and Bowman, 1994, Grundy, 1998, Hauc and Kovac, 2000, Artto et al., 2001, McElroy, 1996, Van Der Merwe, 2002). This is supported by the concept of strategic alignment, which in terms of projects, becomes more complex than the traditional model of strategy formation suggests. This concept is explored and critiqued in the next section as a way to understand the rationale and limitations inherent in connecting organisational strategies and project management practice in the construction sector.

PART 2: STRATEGIC ALIGNMENT OF PROJECTS

The objective of project and strategic management integration is to essentially increase the efficiency of the processes of strategy formulation to strategy implementation. Strategic management assists managers to formulate and implement strategy in a complex and turbulent environment. Conversely, project management ensures high level of efficiency in implementation of set objectives in general (Hauc and Kovac, 2000). However, Anderson and Merna (2003) postulate that the cause of project failure often originates in poor management at the front-end during strategy formulation, rather than down stream execution. Maylor (2001) goes further to suggest that more than 80 per cent of all problems at the project level are caused by failures at the board level in firms to provide clear policies and priorities. This is regardless of Archibald's (1988) assertion that if senior managers want to manage their organisations strategically, they must provide effective project management practices linked with strategic management practices.

Irrespective of the call from numerous scholars for a deeper understanding into the nature of enquiry, current literature on aligning projects with organisational strategy is not yet comprehensive. A number of scholars focus on the upstream activities of selecting projects for the project portfolio as the critical part of the alignment process (Archer and Ghasemzadeh, 1999, Cooper et al., 2000, Aalto, 2000). Within this stream, strategic alignment relates to the need to select projects for implementation that align with the organisations strategic objectives whilst remaining sensitive to available resources (Archer and Ghasemzadeh, 1999). Other researchers have focused their attention further downstream by proposing that the provision of a managerial framework for grouping projects in the form of programmes. This provides a means to bridge the gap between project delivery and organisational strategy (Maylor et al., 2006, Partington et al., 2005, Thiry, 2002) and requires the deployment of a Programme Manager.

More recently the concept of 'project strategy' has been presented in the literature (Morris and Jamieson, 2005, Shenhar, 2004, Srivannaboon and Milosevic, 2006, Morris and Jamieson, 2004, Artto et al., 2008). Despite, the lack of clarity of the concept, if we accept the argument that all organisations have a strategy (Porter, 1979) the notion of a project having a single unified strategy that satisfies all the organisations involved is problematic. Shenhar (2004) suggests that a project strategy is the specific unique approach the project takes to achieve the organisational strategy and is therefore the “missing link” between the business strategy and the project plans. But this would suggest in the context of multiple organisations involvement in projects that there are numerous missing links! Adapting elements of Shenhars’ (2004) framework, Srivannaboon and Milosevic (2006) also propose that the project strategy present a set of general rules to guide the behavior of the project team towards achieving the organizations competitive advantage. However, it cannot be assumed that a single project can easily facilitate competitive advantage for all organizations engaged in a single project.

Despite the above, Anderson and Merna (2003) draw a distinction between a ‘project management strategy’ and a ‘project strategy’ stating that the latter usually refers to a high level plan for achieving a projects given objectives, whereas a ‘project management strategy’ is used to mean a strategy for the management of a project. However, a review of the literature would suggest that the distinction between ‘project’ and ‘project management’ is ambiguous and terms appear to be used interchangeably. In order to draw clarity to the concepts, we propose that development of a ‘project strategy’ is the direction given to the project manager by senior management. Whereas a ‘project management’ strategy is found in the actual project documentation that directs, plans, executes and closes a project, usually following some form of deterministic project management methodology. It is therefore the responsibility of the project manger to make strategic decisions based on management direction, external influences and his own bounded rationality (Cyert and March, 1963). Indeed, it cannot be assumed that one project has a single project manager. Indeed, in the context of the construction sector, each organization engaged in a project will employ their own project manager. Projects therefore involve multiple project managers at any single point in time, all competing to achieve their separate organizational objectives in a bounded rational way. It is this level of complexity in the context of the construction sector that presents significant challenges to any notion of project strategies, project management strategies and indeed strategic alignment

In considering such complexity, it is difficult to assert how true strategic alignment from the corporate level to the project management level will be achieved. Literature suggests that strategy be set at the at the corporate level and then filtered down to the project level (Archer and Ghasemzadeh, 1999, Morris and Jamieson, 2005). Archibald’s (1988) hierarchy of objectives, strategies and projects propose that objectives and strategies are developed at the policy levels and cascade down through strategic and operational level, thereby ensuring strategic alignment. In recognising the role of strategic business units, Kerzner’s (2001) hierarchy shows how corporate strategic plans flow horizontally across Strategic Business Units (SBU) and vertically to supporting plans and budgets.

.Morris and Jamieson (2004) adapted Turners model (1999) to show how organisations position their programmes and projects to achieve strategic objectives. The critical factor in these models is the assumption that projects are the *obedient servant* (Artto et al., 2008) to a single parent organisation. Therefore, drawing on these frameworks and the discussion above, the following model (Figure 1) exposes a significant number of tensions and ambiguities inherent in strategic alignment.

The model illustrates a process of how the context of the corporate strategy, in terms of defining the industry and market, is communicated to each individual SBU (Grant, 2005), who in turn develop a Project Portfolio designed to deliver the context and competitive advantage of the business strategy (Aalto, 2000). The strategic objectives of the portfolio are then presented as a collection of programmes designed to achieve the competitive directives (Lycett et al., 2004). Responsibility for communication of the project strategy therefore lies with a Programme Manager who must ensure that the programme objectives are achieved (Pellegrinelli, 1997). Thus, leaving the final implementation of the project objectives to Project Manager who will devise his own strategy, based on senior management direction and his own interpretation of project management principles. Although highly prescriptive, the model demonstrates that strategic fit is not a straightforward process of communicating strategies from corporate to operational levels. Within this hierarchy a complex number of interactions, processes, clients and varying objectives exists. Not only do strategies need to be communicated and translated into projects from the top down, but alignment of strategies need to be maintained between each level. Essentially this is a two way process, where circumstances, experiences and capabilities at the operational level impact and effect the strategic objectives at the upper levels (Slack et al., 2006). It is therefore concluded that project and project management strategies are not only formalised by a top-down hierarchy, but also from bottom-up hierarchal influences.

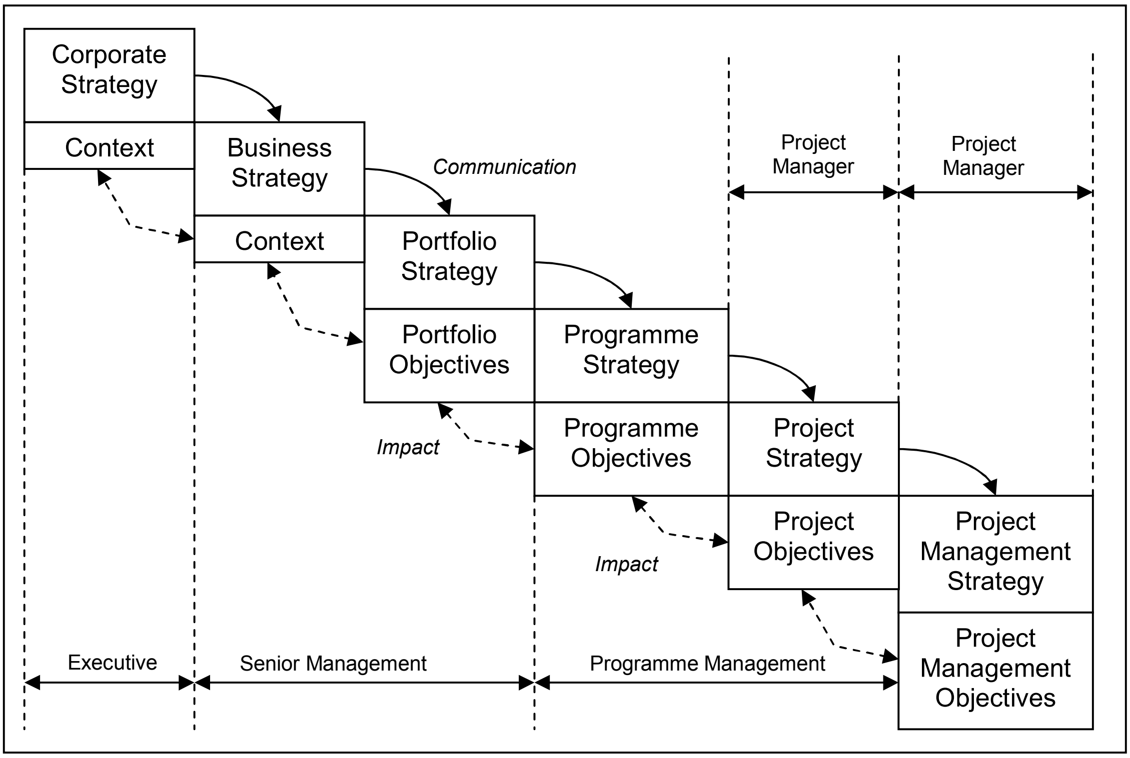


Figure 1: The Hierarchy of Strategic Objectives

DISCUSSION AND RESEARCH PROPOSITION

The notion of a single parent organisation does not readily apply to construction projects. This is because at the operational level of any given construction project there exist a significant number of stakeholders in the form of the project team, who differentiate in terms skills, professional body and loyalty to ones own firm. Within, the construction industry this concept of sentience is particularly strong, especially at professional practitioner level, where each discipline is educated in relative isolation from each other (Walker, 2007, Miller and Rice, 1967). As a consequence, each member of the project team develops a personal conflict of allegiances, not only to the client, but also to their employer, professional body and bounded rationality. As each team member is commonly employed by different organisations there does not exist one single parent organisation as shown in Figure 1, rather there exists a number of organisations who are all attempting to align their own organisational strategy through a particular project management methodology on multiple projects.

It could therefore argued that the nature of the temporary organisation draws questions regarding strategic alignment. In considering the varied influential stakeholders at the operational level of a construction project, it would be difficult to identify how a single organisational strategy could be easily aligned with a single project. In the first instance it is doubtful that project team members, who are not part of the client organisation, would have knowledge of clients organisational strategy, and in many cases even project managers employed by the sponsor have no knowledge of the overall strategic intentions (Crawford, 2005). Instead each organisation relies on the services of their own programme and project managers, albeit under different titles, to construct and implement an individual project strategy that aligns with the individual organisational strategy. Whereas these directives are rarely explicit, individual team members will tacitly attempt to influence decisions to favour their own organisation, thus resulting in a collision of disparate project strategies that create an emergent project management strategy, as shown in Figure 2.

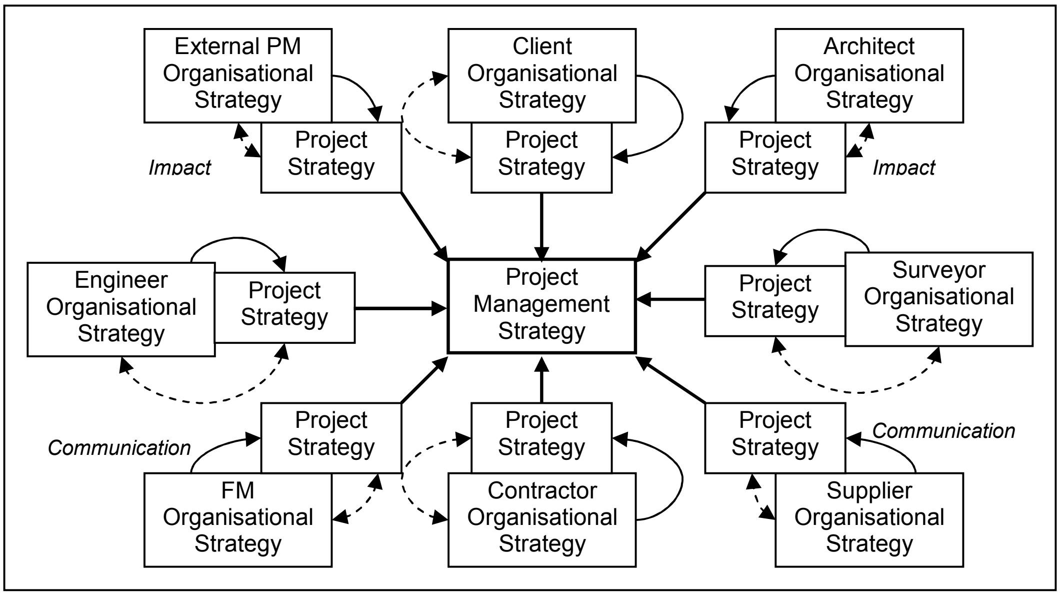


Figure 2: Projects where strategies collide

Figure 2 is therefore central to the argument regarding the collision of strategies on projects and clearly outlines the naivety of assumptions that projects can be anything other than highly contested arenas. The assumption therefore that any pre-determined project management strategy and/or a single set of project plans is therefore questionable if we concede to the argument of an emergent project management strategy developed above. It is naive to assume that any pre-determined project plans can be simplistically implemented. This is because construction projects are implemented in an emergent manner, based on changes, unknowns and the political negotiations with the project team over time. Indeed organisational strategies will also emerge and develop over the same period of time and thus place ongoing challenges to project managers. Organisational strategies are therefore not only emerging over time but are heavily influential in shaping the actions and behaviour of project managers.

Does the argument for strategies colliding on projects support the dominant view of construction projects as a context replete with adversarial and opportunistic behaviour? If so, how can attempts to diffuse initiatives concerned with collaborative working, trust, 'building down barriers', partnering and supply chain management pick their way through such complexity? Indeed is such complexity readily conceded and widely explored by policy makers and researchers embroiled in facilitating, developing and exploring the process of diffusing such initiatives? These questions that have been provoked by this critique are highly relevant for the development of research propositions that can be carried forward by the research team. The following discusses and highlights some of these.

What would perhaps be a good starting point for research into this area would be to explore the arguments put forward through an initial empirical investigation. Such research would explore the arguments that organisational strategies are aligned with project strategies, project managers concerns and interests and indeed, the project management strategy adopted on a project. Indeed, one fundamental question to be initially answered by such research would be to develop an understanding of what a project strategy looks like, how it is developed and how it is diffused in projects. And, perhaps more importantly, who owns the strategy and what interests (or whose) is the strategy developed to defend and pursue. Such research may also be instrumental in helping to make sense of adversarial and opportunistic behaviour in the construction sector.

Another line of inquiry would be to explore the consequences of aligning projects with organisational strategies on project management practice. Does such practice in reality reflect the dominant instrumentally rational rhetoric inherent in the PMBOK and standardised methodologies? In essence are these devices designed to help project managers pick their way through complexity actually useful in practice? Or indeed, are these devices sensitive to the complexity of aligning organisational strategy with projects?

Whilst the complexity described in figure 2 relates to projects in the construction sector there is substantial growth in projects being used to facilitate change and deliver organisational objectives across all sectors. We previously described this as '*projectification*' of the organisational world. If this is the case, then it is highly questionable whether project management, given its significant failings as a method to deliver efficiency in the construction sector over the last 50 years, can prove itself successful in other sectors of the economy. We are not arguing that project management will fail in other sectors but, we would like to highlight the opportunity and argue for research into this growth and cross-sector application of project management.

CONCLUSIONS

This paper has explored the issue of projects providing the context within which organisational strategies collide. Such an argument has been supported by a significant review of projects, project managers, project management and the strategic alignment of organisational strategies with projects. This review has highlighted a number of questionable assumptions in the literature and in some cases highlighted insensitivity to the complexity of alignment and project management practice. We have presented and fully discussed a model of collision that contradicts and challenges the current orthodox view of alignment. This has presented the authors with a number of lines of inquiry to potentially pursue. These have also been discussed. The research is still ongoing and currently negotiating its way through the arguments, models and research propositions presented. Undoubtedly however the paper has proved instrumental in shaping a debate regarding project strategy.

REFERENCES

AALTO, T. (2000) Strategies and methods for Project Portfolio Management. *Tu-22.451 Seminar in Project Management* Helsinki Helsinki University of Technology.

ABRAHAMSON, E. (1996) Management Fashion. *Academey of Management Review,* 21**,** 354-385.

ANAGNOSTOPOULOS, K. P. (2004) Project Management: Epistemological Issues and Standardization of Knowledge. *Operational Research: An International Journal,* 4.

ANDERSON, D. K. & MERNA, T. (2003) Project Management Strategy--project management represented as a process based set of management domains and the consequences for project management strategy. *International Journal of Project Management,* 21**,** 387-393.

ANDREWS, K. (1971) *The Concept of Corporate Strategy,* Homewood, Illinois, Dow Jones Irwin.

ARCHER, N. P. & GHASEMZADEH, F. (1999) An integrated framework for project portfolio selection *International Journal of Project Management,* 17**,** 207-216.

ARCHIBALD, R. D. (1987) Key Milestones in the Early Pert/CPM/PDM days. *Project Management Journal,* 18**,** 29-31.

ARCHIBALD, R. D. (1988) Projects: Vehicles for strategic growth *Project Management Journal,* 19**,** 31-33.

ARTTO, K. A., LEHTONEN, J.-M. & SARANEN, J. (2001) Managing projects front-end: incorporating a strategic early view to project management with simulation. *International Journal of Project Management,* 19**,** 255-264.

ARTTO, K. A., MARTINSUO, M., DIETRICH, P. & KUJALA, J. (2008) Project strategy: strategy types and their contents in innovation projects. *International Journal of Managing Projects in Business* 1**,** 49-70.

AVOTS, I. (1962) The Management Side of Pert *California Management Review,* 4**,** 16-27.

AVOTS, I. (1969) Why does project management fail. *California Management Review,* 12**,** 77-82.

BAMBER, G. J. (2000) Fads, fashion & fantasies: Reflections on management trends and on University Business Schools. *Human Resources and Worklife in the Twentieth Century; International Symposium of the 30th Anniversary of the Japan Society of Human Resource Management* Kobe, Japan, School og Management, Griffith University.

BARLEY, S. R., MEYER, G. W. & GASH, D. C. (1988) Cultures of culture: Academics, practitioners and the pragmatics of normative nontrol. *Administrative Science Quarterly,* 33**,** 24-37.

BRACKER, J. (1980) The Historical Development of the Strategic Management Concept. *The Academy of Management Review,* 5**,** 219-224.

BURNS, T. & STALKER, G. M. (1994) *The management of innovation,* Oxford; New York, Oxford University Press.

CHANDLER, A. D. (1962) *Strategy and Structure: Chapters in the History of the American Industrial Enterprise* Cambridge, MA, MIT Press.

CICMIL, S. & HODGSON, D. (2006) Making projects critical: an introduction IN HODGSON, D. & CICMIL, S. (Eds.) *Making Projects Critical.* New York, Palgrave MacMillan.

CICMIL, S., WILLIAMS, T., THOMAS, J. & HODGSON, D. (2006) Rethinking Project Management: Researching the actuality of projects. *International Journal of Project Management,* 24**,** 675-686.

CLELAND, D. I. & IRELAND, L. R. (2006) *Project Management: Strategic design and implementation* New York, McGraw-Hill, Inc.

COOPER, R. G., EDGETT, S. J. & KLEINSCHMIDT, E. J. (2000) New Problems, New Solutions: Making Portfolio Management More Effective *Research-Technology Management,* 43**,** 18-33.

CRAWFORD, L. (2005) Senior management perceptions of project management competence. *International Journal of Project Management,* 23**,** 7-16.

CYERT, R. M. & MARCH, J. G. (1963) *A Behavioral Theory of the Firm* Englewood Cliffs, N.J., Prentice-Hall

DOD/NASA (1962) *DOD/NASA PERT/ Cost Guide,* Washington, DC, US Govermenet Printing Office.

EVERED, R. (1983) So what is strategy? *Long Range Planning,* 16**,** 57-72.

FISH, G. (1961) Funtional Teamwork. *Harvard Business Review*.

FONDAHL, J. W. (1987) Precedence diagramming methods: Origins and early development *Project Management Journal,* 18**,** 33-36.

GADDIS, P. O. (1959) The Project Manager. *Harvard Business Review,* 37**,** 88-97.

GAREIS, R. (1989) 'Management by projects': the management approach for the future. *International Journal of Project Management,* 7**,** 243-249.

GAREIS, R. (1991) Management by projects: the management strategy of the 'new' project-oriented company. *International Journal of Project Management,* 9.

GRANT, R. M. (2005) *Contemporary Strategy Analysis,* Malden, MA, Blackwell Publishing.

GRUNDY, T. (1998) Strategy implementation and project management. *International Journal of Project Management,* 16**,** 43-50.

HAUC, A. & KOVAC, J. (2000) Project management in strategy implementation--experiences in Slovenia. *International Journal of Project Management,* 18**,** 61-67.

HENDERSON, B. D. (1989) The origin of strategy. *Harvard Business Review,* 67**,** 139-143.

HODGSON, D. & CICMIL, S. (2006) Are projects real? The PMBOK and the legitimation of project management knowledge IN HODGSON, D. & CICMIL, S. (Eds.) *Making Projects Critical.* New York Palgrave MacMillan.

HOFER, C. & SCHENDEL, D. (1978) *Strategy formulation: analytical concepts* West Publishing Company.

HREBINIAK, L. G. & JOYCE, W. F. (1985) *Implementing Stratgy,* New York, Collins McMillan.

KALFAKAKOU, G. & ZAPOUNIDIS, K. (2004) Project management concept: Definitions & Evolution. *3rd Scientific Conference On Project Management (Pm-03). Clustering in Project Management* Thessaloniki, Greece.

KERZNER, H. (2001) *Strategic planning for project management using a project management maturity model,* New York. NY, John Wiley and Sons.

KERZNER, H. (2003) *Project Management: A systems approach to planning, scheduling, and controlling,* Hoboken, New Jersey, John Wiley & Sons Inc.

KNIGHT, K. (1976) Matrix organisation: A review. *Journal of Management Studies,* 17**,** 111-130.

KPMG (2002) Programme Management Survey. *Information Risk Management.* United Kingdom, KPMG.

KPMG (2005) Global IT Project Management Survey. *Information Risk Management.* Australia, KPMG.

LAWRENCE, P. & LORCH, J. (1967) *Organizations and Environment,* Cambridge, MA, Harvard University Press.

LUNDIN, R. & SODERHOLM, A. (1998) Conceptualizing a projectified society: Discussion of an Eco-Institutional approach to theory on temporary organisations. IN LUNDIN, R. & MIDLER, C. (Eds.) *Project as Areanas for Renewal and Learning Processes.* Dordrecht, Kluwer Academic Publishers.

LUNDIN, R. A. & SODERHOLM, A. (1995) A theory of the temporary organization. *Scandinavian Journal of Management,* 11**,** 437-455.

LYCETT, M., RASSAU, A. & DANSON, J. (2004) Programme management: A crtitical review. *International Journal of Project Management,* 22**,** 289-299.

MAYLOR, H. (2001) Beyond the Gantt chart: Project management moving on. *European Management Journal,* 19**,** 92-100.

MAYLOR, H., BRADY, T., COOKE-DAVIES, T. & HODGSON, D. (2006) From projectification to pragrammification. *International Journal of Project Management,* 24**,** 663-674.

MCELROY, W. (1996) Implementing strategic change through projects. *International Journal of Project Management,* 14**,** 325-329.

MIDLER, C. (1995) "Projectification" of the firm: The Renault case. *Scandinavian Journal of Management,* 11**,** 363-375.

MILLER, E. J. & RICE, A. K. (1967) *Systems of Organisations: the Control of Task and Sentient Boundaries,* London, Tavistock Publications.

MINTZBERG, H. (1978) Patterns in Strategy Formation. *Management Science,* 24**,** 934-948.

MINTZBERG, H., AHLSTRAND, B. & LAMPEL, J. (1998) *Strategy Safari,* Harlow UK, Prentice Hall.

MINTZBERG, H. & WATERS, J. A. (1985) Of strategies, deliberate and emergent. *Strategic Management Journal,* 6**,** 257-272.

MORRIS, P. W. G. (1997) *The Management of Projects,* London, Thomas Telford.

MORRIS, P. W. G. & JAMIESON, A. (2004) *Translating corporate strategy into project strategy: realizing corporate strategy through Project Management* Pennsylvania, Project Management Institute Inc.

MORRIS, P. W. G. & JAMIESON, A. (2005) Moving from corporate strategy to project strategy *Project Management Journal,* 36**,** 5-18.

OPSR (2003) Improving Programme and Project Delivery. Whitehall, London, Office of Public Services Reform

PACKENDORFF, J. (1995) Inquiring into the temporary organization: New directions for project management research. *Scandinavian Journal of Management,* 11**,** 319-333.

PARTINGTON, D. (1996) The project management of organizational change. *International Journal of Project Management,* 14**,** 13-21.

PARTINGTON, D., PELLEGRINELLI, S. & YOUNG, M. (2005) Attributes and levels of programme management competence: an interpretive study. *International Journal of Project Management,* 23**,** 87-95.

PELLEGRINELLI, S. (1997) Programme management: organising project-based change. *International Journal of Project Management,* 15**,** 141-149.

PELLEGRINELLI, S. & BOWMAN, C. (1994) Implementing strategy through projects. *Long Range Planning,* 27**,** 125-132.

PMI (1987) Project Management Body of Knowledge of The Project Management Institute (PMI). IN COMMITEE, P. M. I. S. (Ed.) Upper Derby, IL, Project Management Institute.

PMI (2004) *A Guide to the Project Management Body of Knowledge: PMBOK guide,* Pennsylvania Project Management Institute Inc.

POLLACK, J. (2007) The changing paradigms of project management. *International Journal of Project Management,* 25**,** 266-274.

PORTER, M. E. (1979) How Competitive Forces Shape Strategy. *Harvard Business Review,* 52**,** 137 - 145.

ROBERTS, A. & GARDINER, P. D. (1998) Project Management and Strategy Implementation IN HARTMAN, F., JERGEAS, G. & THOMAS, J. (Eds.) *The Nature and Role of Projects in the Next 20 Years: Research Issues and Problems. IRNOP 3.* Calgary, Alberta, IRNOP.

SHENHAR, A. J. (2004) Strategic Project Leadership: Toward a strategic approach to project management. *R&D Management,* 34**,** 569-578.

SHENHAR, A. J. & DVIR, D. (1996) Toward a typological theory of project management. *Research Policy,* 25**,** 607-632.

SHIRLEY, R. C. (1982) Limiting the Scope of Strategy: A Decision Based Approach. *The Academy of Management Review,* 7**,** 262-268.

SIEMENS, N. (1971) A Simple CPM Time-Cost Tradeoff Algorithm. *Management Science,* 17**,** B354-B363.

SLACK, N., CHAMBERS, S., JOHNSTON, R. & BETTS, A. (2006) *Operations and process management: Principles and practice for strategic management,* Harlow, UK, Pearson Education Limited.

SMITH, C. & WINTER, M. (2005) A Critical Review of the Areas of Concern. Report from Making Projects Critical 2 Workshop. *Rethinking PM.* Manchester, EPSRC.

SÖDERLUND, J. (2002) Conceptualizing project management: from optimistic optimization to critical questioning. *EURAM Conference.* Stockholm.

SRIVANNABOON, S. & MILOSEVIC, D. Z. (2006) A two-way influence between business strategy and project management. *International Journal of Project Management,* 24**,** 493-505.

THIRY, M. (2002) Combining value and project management into an effective programme management model. *International Journal of Project Management,* 20**,** 221-227.

THOMAS, J. (2006) Problematising project management IN HODGSON, D. & CICMIL, S. (Eds.) *Making Projects Critical.* New York, Palgrave MacMillan.

TURNER, J. R. (1999) *The Handbook of Project-Based Management: Improving the process for achieving strategic objectives,* Maidenhead, UK, McGraw-Hill.

TURNER, J. R. & KEEGAN, A. (1999) The versatile project-based organization: governance and operational control. *European Management Journal,* 17**,** 296-309.

TURNER, R. J. & MULLER, R. (2003) On the nature of the project as a temporary organization. *International Journal of Project Management,* 21**,** 1-8.

VAN DER MERWE, A. P. (2002) Project management and business development: integrating strategy, structure, processes and projects. *International Journal of Project Management,* 20**,** 401-411.

VROOM, V. H. & YETTON, P. W. (1977) *Leadership and Decision Making,* Pittsburgh, PA, University of Pittsburgh Press.

WALKER, A. (2007) *Project Management in Construction* Oxford, Blackwell Publishing.

WINTER, M., ANDERSEN, E. S., ELVIN, R. & LEVENE, R. (2006a) Focusing on business projects as an area for future research: An exploratory discussion of four different perspectives. *International Journal of Project Management,* 24**,** 699-709.
WINTER, M. & SMITH, C. (2006) Rethinking Project Management: Final report *Rethinking PM.* EPSRC.
WINTER, M., SMITH, C., MORRIS, P. & CICMIL, S. (2006b) Directions for future research in project management: The main findings of a UK government-funded research network. *Project Management Journal,* 24**,** 638-649.

ENACTING COMPETITIVENESS: AN EMPIRICAL INVESTIGATION

Chung-Chin Kao
University of Reading, Reading, UK
c.kao@reading.ac.uk

Stuart D. Green
University of Reading, Reading, UK
s.d.green@reading.ac.uk

Graeme D. Larsen
University of Reading, Reading, UK
g.d.larsen@reading.ac.uk

The paper draws from three case studies of regional construction firms operating in the UK. The case studies provide new insights into the ways in which such firms strive to remain competitive. Empirical data was derived from multiple interactions with senior personnel from with each firm. Data collection methods included semi-structured interviews, informal interactions, archival research, and workshops. The initial research question was informed by existing resource-based theories of competitiveness and an extensive review of construction-specific literature. However, subsequent emergent empirical findings progressively pointed towards the need to mobilise alternative theoretical models that emphasise localised learning and embeddedness. The findings point towards the importance of de-centralised structures that enable multiple business units to become embedded within localised markets. A significant degree of autonomy is essential to facilitate entrepreneurial behaviour. In essence, sustained competitiveness was found to rest on the way de-centralised business units enact ongoing processes of localised learning. Once local business units have become embedded within localised markets, the essential challenge is how to encourage continued entrepreneurial behaviour while maintaining some degree of centralised control and co-ordination. This presents a number of tensions and challenges which play out differently across each of the three case studies.

KEYWORDS: competitiveness, embeddedness, localised learning, organisational structure, regional contractors

INTRODUCTION

Improving the construction industry's competitiveness has long been of interest to the international construction management research community. However, a systemic bias towards positivist and quantitative research approaches has led to a recurring fixation with attempts to define competitiveness and then to measure the underlying determinants as if they were objective characteristics (e.g. Flanagan *et al.*, 2007). Much of the existing literature draws from Porter's (1990) 'diamond framework' to compare and explain different countries' success in the international construction market (e.g. Ofori 2003). Unfortunately, such research is of limited relevance to firms which operate at a regional level within domestic markets. Despite much-heralded trends of globalisation, the vast majority of construction firms remain rooted in localised contexts. Also, there remains a noticeable shortage of empirically-grounded research into the way in which competitiveness is conceptualised and enacted in real world situations. This paper draws from three case studies of medium-sized regional construction firms operating in the UK. The case studies aimed to investigate the ways in which regional construction firms strive to remain competitive. More specifically, on the basis of emergent empirical findings, the research sought to develop fresh insights into the enactment of competitiveness within regional construction firms. Initially, the most popular theories of competitiveness as currently mobilised within construction management are briefly reviewed and critiqued. Attention is also given to an alternative literature which links competitiveness to the notions of 'embeddedness' and 'localised learning'. The adopted case study methodology is then outlined prior to the presentations of three case studies of regional construction firms. Finally, a discussion is offered on the extent to which the research provides both new empirical insights and fresh theoretical perspectives on the competitiveness of construction firms.

UNDERSTANDING COMPETITIVENESS

Competitive advantage

Porter's theory of competitive advantage and his associated 'five-forces analysis' (cf. Porter 1980) are frequently used to discuss the competitive strategy of construction firms (e.g. Betts and Ofori 1992). The adopted perspective tends to view competitiveness in terms of how firms position themselves in the market place. Certainly Porter's competitive positioning school focuses primarily on the importance of exogenous factors. However, numerous commentators have criticised the concept of 'competitive advantage' in terms of its essential ambiguity and imprecision (e.g. Klein 2002). O'Shaughnessy (1996) also criticised Porter's work for its lack of meaningful advice on how firms should implement the adopted strategy. Certainly, Porter's work displays little interest in the contextualised processes through which competitiveness is actually enacted.

Resource-based view and dynamic capabilities

Notwithstanding the recurring focus on the importance of exogenous factors, there is also as need to be familiar with other theories that focus on endogenous factors. Particularly important are the resource-based view (RBV) (e.g. Barney 1991) and the dynamic capabilities school (e.g. Teece *et al.* 1997). The literature on RBV emphasises the firm-specific unique resources that enable firms to become competitive that cannot be replicated by others. De Haan *et al.* (2002) adopted this perspective in arguing that the performance of construction firms is determined by their core capabilities. It is also increasingly popular to focus attention onto the importance 'dynamic capabilities'. As an extension of RBV, the dynamic capabilities literature emphasises the ways in which firms continuously reconfigure their operating routines to enable responses to changing environments. In contrast to the static concept of RBV, the concept of dynamic capabilities is conceived as something a firm *does*, rather than something it *has*. For example, whereas RBV sees knowledge as a source of competitive advantage, the dynamic capabilities literature emphasises the importance of organisational learning. But here again, the RBV and dynamic capabilities literatures have not been exempt from criticism. Both literatures have recurring definitional problems regarding the distinctions between resources, routines, capabilities and competences (cf. Connor 2002; Zahra *et al.* 2006). The underlying arguments are further found to be essentially tautological; the capabilities which make firms successful are those which account for its success. Dynamic capabilities are especially characterised by empirical elusiveness (cf. Green *et al.* 2008). The literature at large once again fails to offer practical advice to practising managers.

Localised learning and embeddedness

The lexicon of dynamics capabilities undoubtedly offers a useful focus in terms of encouraging firms to focus on the need to continuously re-adjust to changing markets, but the existing mainstream literature provides few insights into *how* such capabilities are enacted. During the initial stages of the empirical research, interviewees repeatedly emphasised the importance of relationships and the need to become established in localised markets. This resonated strongly with established concepts of embeddedness and localised learning within the discipline of economic geography. The concept of localised learning is promoted as a central component of regional competitiveness by economic geographers (cf. Maskell *et al.* 1998). Its underlying assumption is built upon the fact that economic and entrepreneurial activities tend to agglomerate at certain places and lead to patterns of national and regional specialisation. The notion of 'agglomerations of related firms' emphasises the importance of interactive learning between firms for the purposes of knowledge creation, which is considered as a key element in enacting competitiveness. Maskell *et al.* (1998) contend that a firm's competitiveness is rooted in its localised capabilities, 'which are difficult to imitate for outsiders, and which are partly based on intense interaction between a limited number of actors within a regional or national industrial system'. In short, localised learning is perceived as a learning activity that is embedded in a local or regional 'milieu', where the interactions between firms, customers, institutions and local authorities take place in a given location (Maskell *et al.* 1998). It is further argued that firms embedded in the right kind of milieu will tend to learn faster than others and hence become more competitive. Localised learning puts a strong emphasis on a collective learning process among a variety of agents, thereby enabling firms to create knowledge and consequently sustain their competitiveness. In other words, competitiveness is highly dependent upon the ways that firms embed themselves in local contexts and develop close relations with other local stakeholders. The localised-learning perspective extends beyond a single-firm focus into a collaborative-network view on the competitiveness of firms.

Similarly the literature on the concept of embeddedness also emphasises the importance of embedding in local contexts and the social networks that sustain competitiveness. Uzzi (1996) describes embeddedness as 'an exchange system with unique opportunities relative to markets' and claims that firms 'organised in networks have a higher survival chance than do firms which maintain arm's-length market relationships'. Jack and Anderson (2002) also contend that embeddedness is a process of becoming part of the structure through knowing players and rules within specific contexts in order to recognise opportunities that are contextual. In short, the central argument of embeddedness is that being embedded in specific local contexts, whether geographical locations or specialist markets, provides opportunities that are not accessible to those outside. The concept of embeddedness discredits generic and de-contextualised recipes for competitiveness. But embeddedness should not be presented as panacea. There are clear dangers in becoming 'over embedded', which can cause too much reliance on a limited number of relational ties with the overall vision becoming too entrenched.

The discourse surrounding localised learning and embeddedness puts a strong emphasis on social networks within local contexts. These are seen to directly shape and influence the competitiveness of firms. Whilst the notions of localised learning and embeddedness can be viewed through different theoretical lenses, it is important to recognise that the two ideas are interconnected. To a large extent, localised learning can be perceived as the process of becoming embedded in local networks. Jack and Anderson (2002) emphasise that there is no ideal end-point for becoming embedded. Localised learning is therefore better understood as an ongoing *process*. In other words, firms remain competitive through a continuous process of localised learning that enables them to become embedded in localised markets.

RESEARCH METHODOLOGY

The adopted research methodology rests on a 'becoming ontology' (cf. Chia 1995) which views reality as something which is fluid and evanescent rather than something which is static. From this perspective, reality never stops in order to actually be, but is in a continuous state of *becoming*. The becoming ontology emphasises the importance of 'action, movement, process and emergence' (Chia 1995). The adopted approach therefore focuses attention on processes of enactment rather than any desired end state of 'being competitive'. It is contended that such an ontological position provides an important fresh perspective on the way in which competitiveness is enacted within construction firms.

The adopted methodology also followed the principles of inductive case-study research, otherwise described as 'iterative grounded theory' (cf. Orton 1997). This comprises an approach whereby emergent findings are interrogated against a succession of theoretical models derived from the literature. In contrast to the conventional view of grounded theory, the iterative grounded theory disregards the possibility of engaging with empirical date in a 'theory free' manner. Emphasis instead is given to the importance of the researchers being *theoretically sensitive* as a result of being steeped in relevant literatures. Knowledge of the accepted literature of competitiveness shaped the initial research design, but emergent empirical findings caused fresh theoretical perspectives to be mobilised. Hence the importance of embeddedness and situated processes of localised learning emerged as the research progressed.

The research comprised three case studies of regional construction firms using multiple sources of evidence. Each case study was initially developed from a series of semi-structured interviews with over fifteen senior managers and directors of the company. The interviews were recorded and transcribed in full. NVivo 7 computer software was used to aid the analysis process. The interview schedule was designed to explore the ways in which individual directors and managers sought to conceptualise how the firm had remained 'competitive' over time. In light of the existing theories of competitiveness, the interviewees were asked specific questions about the firm's evolution over time, current capabilities, competitive strategies, and future plans. Particular interest was given to how the firms responded to changing environments. Data collection was further enhanced by a range of informal interactions with the case study companies (*i.e.* telephone conversation and e-mail exchanges). In addition, each case study made use of archival sources, including the company's annual reports, corporate publicity materials, and public-domain press articles.

CASE STUDIES

Case study 1: Forest Construction

Forest Construction was established in the early 1970s near the south coast of England. The company initially started as a civil engineering contractor working for local water companies. In 2008 Forest operates in nine locations around South England, the Midlands and South Wales. The company currently engages in four sectors: building, civil engineering, railway maintenance, and property development. The company has an annual turnover about £260 million and employs around 1000 staff. Forest has enjoyed three decades of almost uninterrupted continuous growth. In particular, the company has achieved a significant rapid growth over the last ten years during which the turnover has grown nearly five times. The interviewees attributed such success to their long-term investments in building a network of well-located and established regional offices. Forest sees its regional setup to be pivotal in sustaining the company's competitiveness.

By the mid-1990s Forest had established five regional offices. The development of successive regional offices was described to be a 'creeping' process. According to the chief executive, each regional office took nearly fifteen years to grow and establish its own team and client base. The chief executive explained that the slow and stable progress allowed each regional office to gel as a team and to grow its substantial knowledge about local markets, clients and supply chain. The concept of 'organic growth' was further used to describe the progressive development of the regional offices in order to manage a fine balance between workflow and staff growth. Also, each office was required to develop capabilities in both building and civil engineering. This dual capability was seen to provide a source of competitive advantage that Forest's rivals found difficult to imitate. This was also considered important in allowing the company to adapt quickly to the changing markets of building and civil engineering. In addition, the interviewees consistently emphasised the importance of localised networks and staff. The purpose of setting up a regional office was considered to demonstrate a presence and an ongoing commitment to both local clients and staff. The establishment of the regional office ensured clients of localised-based services as well as to attract and retain staff. The ethos of Forest's regional setup was described as 'staff don't have far to travel and thereby achieve a sensible home life'. It was found that most regional directors and managers had been working in local areas for a long period of time and confidently saw themselves as part of local communities. The interviewees were clear that the regional business was primarily built upon the opportunities developed and secured from local people, contacts and reputation. In other words, each regional office was *embedded* within its local market. This was seen to provide the key source of competitive advantage in comparison to national contractors who did not maintain a local presence.

It was considered significant that each regional office has its own team and resources to operate as an autonomous unit led by a regional director. Once the regional office's annual turnover target and business plan had been approved by the group board, the regional director was then fully responsible for delivering the plan with minimum interference from the board. The chief executive admitted that the regional directors are much more knowledgeable about local markets and supply chain than the group directors. The role of the group board was described as being limited to basic strategic guidance and to monitoring the regions' progress against agreed targets. Forest currently put a strong emphasis on the importance of controlled growth. They are also concerned to limit the extent of risk exposure. The group board sets a limit on the maximum contract value that the regional offices are allowed to tender for. They also control the annual growth rate of each region. The overall picture is one of continuous transformation. In 2000 two of the oldest regional offices set up their own small satellite offices. These were originally set up for delivering major projects won by the regional office, but they were also encouraged to explore new opportunities in the surrounding area. Geographical expansion therefore tended to be achieved organically through satellite offices. However, the board recognised that a particular market niche developed within a region could usefully be projected nationally For example, Forest currently established two specialist divisions – railway and civil engineering infrastructure – for the purpose of positioning against national procurement frameworks. The company's business structure therefore combines a regional structure with two specialist divisions (see Figure 1). The specialist divisions were born from the regional structure, but provide the opportunity for the company to *embed* themselves in niche markets. Particular emphasise was give to the need to build relationships with clients and the supply chain to sustain continuous innovation. In other words, Forest enacts *localised learning* within both regional markets and specialist sectors.

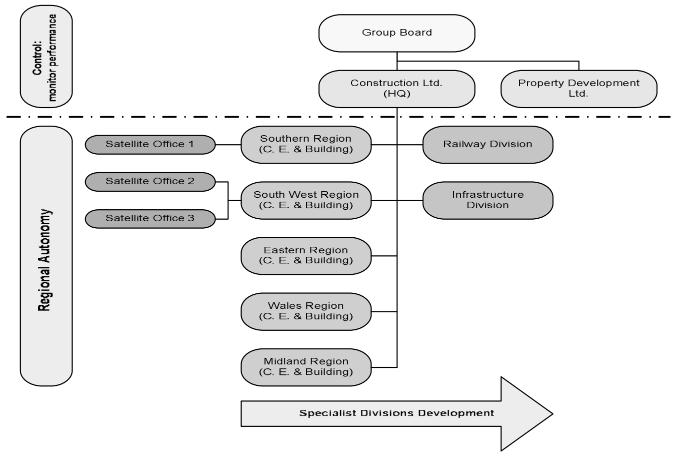


Figure 1 Forest's Evolving Business Structure

Case study 2: Southern Construction

Southern Construction was established as a small civil engineering contractor in the mid-1960s in the South of England. The company currently operates four specialist businesses: building, civil engineering, social housing, and property services in nine locations in the South and Midlands of England. Southern currently has an annual turnover about £250 million and employs around 1,000 staff. They have achieved three decades of continuous growth. The annual turnover more than doubled over the last ten years. In particular, the social housing business has been a significant area of growth and is seen to be a strong area for future expansion. The interviewees were clear that moving into the social housing sector was pivotal in shaping the company's development over the past ten years.

The story of how Southern diversified into the social housing sector was repeated by several interviewees. Southern originally started with speculative housing during the mid-to-late 1980s boom. The company established a speculative housing division with an entirely new core team and invested heavily in acquiring land for potential developments. However, a sudden and deep recession in the early 1990s left Southern with a large land bank and residual demand for houses. Releasing the financial burden of the accumulated land was critical to the survival of the firm. Southern was fortunate in finding a potential buyer for some of its land bank in the form of a local social housing association (HA). Through the relationship established during the sale of land to the HA, Southern recognised the potential of the social housing sector. The company therefore formed a vision of redeploying the firm's redundant private housing resources within the developing social housing market. The interviewees suggested that Southern's early engagement with a locally-based HA provided the company with an opportunity to *learn* what was required in the sector, and to develop appropriate operations. In order to acquire the necessary expertise, Southern began to recruit experienced people from HAs and local authority housing departments. Particularly important was the need to acquire an understanding of social housing policy and grant regimes, as well as the specifics of HA working procedure and regularity. As a consequence of its early success, Southern began to formalise a social housing division and develop specialist capability. The capability was developed over time into what was described as a 'technical team', including expertise in housing design, building technology, land acquisition and contaminated land development. In consequence, Southern now has the capability to resolve problems for HAs proactively, thereby enabling the company to secure the majority of schemes on the basis of negotiation rather than competitive tendering. The technical team's capabilities are seen as a key source of competitive advantage that Southern's competitors found difficult to emulate. In addition, the interviewees consistently emphasised the importance of preserving the firm's reputation and maintaining close relationships with local HAs. The social housing sector was seen to be an 'incestuous' marketplace which depends on extensive networking. Southern also had to ensure that its senior managers are networked across relevant policy arenas in order to keep abreast of changing policy and procurement trends to better position itself for the future. They have therefore achieved success by becoming *embedded* with the social housing market. However, this success cannot be taken for granted. It can only be maintained through continuous *localised learning*.

Notwithstanding the above, Southern continued to operate profitably in both civil engineering and building sectors throughout the 1990s. Of significance was the way in which civil engineering division expanded into railway maintenance works on the basis of its track record in trackside buildings. In the early 1990 Southern set up a railway maintenance division. The maintenance division also moved into social housing maintenance by winning its first responsive contract in 1999. In contrast to Forest's regional-based structure, Southern operated on a specialist-division structure. The company is currently structured into four specialist divisions which operate across several area offices (see Figure 2). Each area office has its particular specialisation and *modus operandi* that fits the sector it serves. However, there are plans to set up a regional office in London. The interviewees explained the need for geographical expansion into London, which is seen to comprise an entirely different business context. Southern decided that it needs a London office in order to demonstrate presence to London-based clients. The establishment of the London office shows a trend towards adding a regional dimension to its current (see Figure 2).

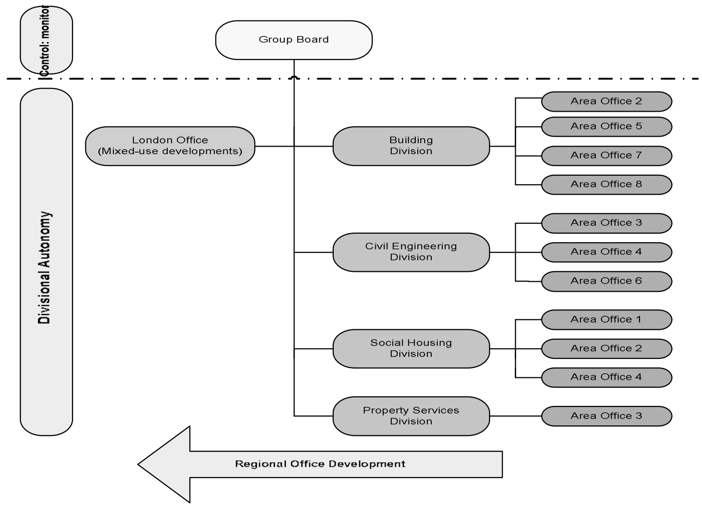


Figure 2 Southern's Evolving Business Structure

Case study 3: Northern Construction

Northern Construction was established nearly seventy years ago in the North of England. The company origins lied in contracting for small works for the steel industry. Construction is one of several businesses within a larger group and accounts for £110 million of the annual group turnover of £140 million. From its initial roots within the steel industry, Northern established itself as a civil engineering contractor working on road works and sea defences on the east coast during the early 1940s. The company has since expanded into building and other infrastructure works. Northern currently operates in four locations in the North and Midland of England, and sees itself as specialising in several specialist sectors: power stations, refinery plants, retail warehouses, water infrastructure, and PFI projects in health and education. The interviewees suggested that the company has accumulated expertise in these specialist sectors which differentiates them from their competitors. One director explained that the company has to be 'adaptable and focused on looking ahead to get into key sectors before everyone else does'. For example, Northern has recognised the waste management sector as a growing market which has been specifically targeted.

Northern was well-positioned to move into waste management as a result of its track record in the process industry. The firm has over ten years' experience in the delivery large complex projects (e.g. incinerators and refinery plants). The interviewee suggested that this specialist capability enabled Northern to move into the developing waste management sector. Both sectors have similar work procedures, liability requirements, and rigorous health and safety standards. In particular, Northern sought to partner with overseas waste technology consultants who were actively seeking local and reliable construction partners. The possibility of developing a partnership between the technology consultant and a local contractor potentially served the interests of both parties. The interviewees described how Northern established a partnering company with one technology consultant, and also were involved in several joint venture schemes with others. This enabled them to position themselves as leading contenders for future work within the sector. They were also clear that Northern's reputation within the process sector enabled them to sign exclusivity agreements with key technology consultants. Northern therefore found itself well placed to move into the waste sector and start building a track record. However, Northern was required to follow their partners nationwide. In the waste sector they were obliged to operate like a national contractor. The interviewees were clear that Northern could not compete out of its region on price; it would therefore only agree to take on commitment outside its normal sphere of operation if the price was negotiated. The key challenge was how to ensure that the firm was invited to negotiate, which reflected the extent to which Northern was *embedded* in the sector. This in term was conditional upon continued *localised learning* relating to the relevant technologies and associated regulatory regimes.

However, the company's annual turnover has fluctuated in recent years. The interviewees explained one of reasons was that the turnover generated from large negotiated projects frequently took time to come to fruition. Within the waste sector, it often took 3-4 years development work before a project began on site. This inevitably caused Northern consistency problems regarding turnover, workflow, and overheads. At the time of interview, Northern was seeking to instigate new strategic plans to resolve the problem. Improving the company's regional business was singled out as one potential solution. Several interviewees suggested that whilst Northern continually focuses on large complex projects in the targeted specialist sectors, the company also has to focus on its regional business for the growth of smaller projects. It was argued that the short lead time of smaller projects would help alleviate the current peaks-and-troughs in turnover and profit. Developing a regionally-based business model was therefore suggested as Northern's medium-term plan for increasing their penetration in local markets.

Northern is currently structured into three specialist divisions: major civil engineering, PFI, and facilities management (FM), all of which are based in head office (see Figure 3). Of significance is the way in which that Northern operates on a centralised-management model. All operations are run centrally from head office under the direct control of the group directors. Northern had previously established three local offices in adjoining areas with an aspiration for geographical expansion. However, these offices had not been accorded any autonomy and therefore were not embedded within their local markets. Indeed, the interviewees openly admitted that the local offices had no real presence in locally-based networks. In this respect, they operate primarily as 'satellite' offices, which are only responsible for delivering simple projects allocated by head office. Given the importance of improving the company's regional business, several interviewees recognised that a greater degree of autonomy would be essential to facilitate greater entrepreneurial behaviour in exploring local markets. In short, Northern Construction is in a process of transition, moving toward to a regionally-based business structure (see Figure 3). However, it was also recognised that the group board needs to maintain some degree of centralised control relating to key performances indicators.

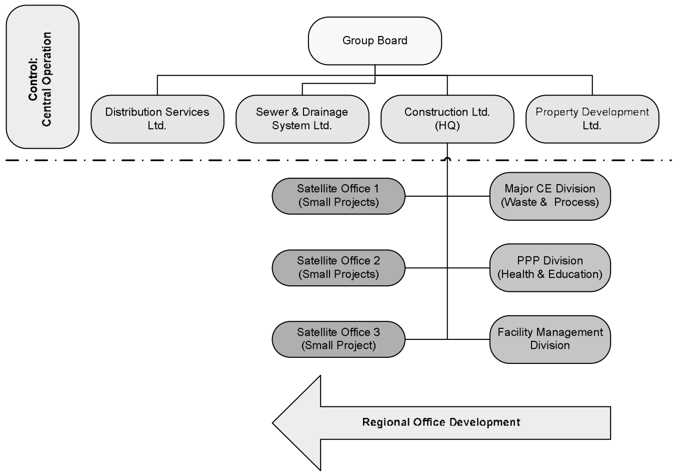


Figure 3 Northern's Evolving Business Structure

DISCUSSION

Localised learning and embeddedness

The preceding three case studies resonate strongly with the notions of localised learning and embeddedness. All three firms emphasised the importance of becoming embedded within close client relationships and localised networks. Further emphasis was given to the need to learn the necessary *modus operandi* for specific sectors and local markets. As a result, they were able to develop the necessary capabilities as well as to secure the majority of their works through negotiation rather than competitive tendering. They were also clear that the company's reputation is essential to sustaining relational ties. It is further evident that in all three cases the firms' unique capabilities are not rooted solely within the company, but are spread across networks of relational ties. Furthermore, the empirical findings demonstrate the ways in which opportunities emerge as a result of being embedded within local contexts and networks.

Tensions: central control vs. local autonomy

Another significant finding was that in all three cases the firms' organisational structures were continuously evolving, and often oscillating between a regionally-based model and one based on specialist division. Indeed, this process of continuous adjustment is, in no small way, the means by which such firms are able to continuously adjust to changing markets. Whilst the regionally-based model was suitable for local markets with a focus on local clients, the specialist-division model was necessary for the purposes of engaging with national clients. Each model brings its own particular challenges in terms of operations and staffing issues. It is also significant that all three firms operated the two business models concurrently in order to make themselves adaptive to market change. They were therefore less constrained by long-term plans and more able to respond opportunistically to emergent markets. Of course, to run both models concurrently also presents a number of challenges and tensions. One such challenge was to maintain the appropriate balance between 'central control' and 'local autonomy'. The empirical findings suggest that a de-centralised structure is essential in enabling multiple business units to become embedded within local markets or specialist sectors. Also, a significant degree of autonomy is required to facilitate entrepreneurial behaviours. But the findings also demonstrate that the group board had to maintain some degree of central control and coordination. In brief, the metaphor of 'constraining the tiger' best portrays the challenge of maintaining some degree of control over highly autonomous regional offices. Interestingly enough, it was found that notions normally held to be engines of competitiveness, such as performance targets, KPIs, and human resource policies, were in fact used by the case-study firms as constraining devices.

CONCLUDING REMARKS

The three case studies described above reveal the ways in which regional construction firms strived to remain competitive in dynamic environments. The insights into how three contracting firms enact competitiveness resonate strongly with notions of localised learning and embeddedness. Certainly these latter concepts provide better explanatory devices than the theories more usually mobilised to explain competitiveness in the construction sector. Certainly the interviewees were resistant to any notion that there could ever be one-size-fits-all approach to competitiveness, or that there was any instrumental recipe that could be followed. They emphasised repeatedly the importance of developing good relationships with local players, and also the crucial importance of company reputation. In both respects, the development and maintenance of situated networks of relational ties is crucial. The overriding storyline focused upon the ways in which different business units seek to embed themselves in local communities or in specialist sectors in order to leverage and secure opportunities. There is little evidence in practice to support the currently accepted discourse of competitiveness in terms of narrowly-construed notions of efficiency and productivity. In contrast, the research identified a new discourse surrounding localised learning and embeddedness which resonates strongly with the *modus operandi* of regional contracting firms. The research further revealed the way in which contracting firms operate in a state of continuous adjustment between a regionally-based structure and a structure based on specialist divisions. Of particular interests are the tensions and challenges involved between autonomy of operation and the need for some degree of centralised control. Maintaining an appropriate balance between responsive entrepreneurship and constrained risk exposure is of central importance to the way in which contracting firms maintain competitiveness.

REFERENCES

Barney, J. (1991) Firm resources and sustained competitive advantage. *Journal of Management,* **17**(1), 99-120.

Betts, M. and Ofori, G. (1992) Strategic planning for competitive advantage in construction. *Construction Management and Economics,* **10**(6), 511-532.

Chia, R. (1995) From modern to postmodern organisational analysis. *Organization Studies,* **16**(4), 579-604.

Connor, T. (2002) The resource-based view of strategy and its value to practising managers. *Strategic Change,* **11** 307-316.

De Haan, J., Voordijk, H. and Joosten, G. J. (2002) Market strategies and core capabilities in the building industry. *Construction Management and Economics,* **20**(2), 109-118.

Flanagan, R., Lu, W. S., Shen, L. and Jewell, C. (2007) Competitiveness in construction: a critical review of research. *Construction Management and Economics,* **25**(9), 989-1000.

Green, S. D., Larsen, G. D. and Kao, C. C. (2008) Competitive strategy revisited: contested concepts and dynamic capabilities. *Construction Management and Economics,* **26**(1), 63-78.

Jack, S. L. and Anderson, A. R. (2002) The effect of embeddedness on the entrepreneurial process. *Journal of Business Venturing,* **17** 467-487.

Klein, J. (2002) Beyond competitive advantage. *Strategic Change,* **11**(6), 317-327.

Maskell, P., Eskelinen, H., Hannibalsson, I., Malmberg, A. and Vatne, E. (1998) *Competitiveness, localised learning and regional development*, Routledge, London.

O'Shaughnessy, N. (1996) Michael Porter's competitive advantage revisited. *Management Decisions,* **34**(6), 12-20.

Ofori, G. (2003) Framework for analysing international construction. *Construction Management and Economics,* **21**(4), 379-391.

Orton, J. D. (1997) From inductive to iterative grounded theory: zipping the gap between process theory and process data. *Scandinavian Journal of Management,* **13**(4), 419-439.

Porter, M. E. (1980) *Competitive Strategy - Techniques for Analysing Industries and Competitors*, Free Press, New York.

Porter, M. E. (1990) *The competitive advantage of nations*, The Free Press, New York.

Teece, D. J., Pisano, G. and Shuen, A. (1997) Dynamic capabilities and strategic management. *Strategic Management Journal,* **18**(7), 509-533.

Uzzi, B. (1996) The sources and consequences of embeddedness for the economic performance of organizations: the network effect. *American Sociological Review,* **61**(4), 674-698.

Zahra, S. A., Sapienza, H. J. and Davidsson, P. (2006) Entrepreneurship and dynamic capabilities: a review, model and research agenda. Journal of Management Studies, **43**(4), 917-955.

PERFORMANCE SPECIFICATION AND TECHNOLOGICAL DEVELOPMENTS OF CONSTRUCTION COMPANY

Masamitsu Onishi
Kyoto University, Kyoto, JAPAN
masa@psa.mbox.media.kyoto-u.ac.jp

Kiyoshi Kobayashi
Kyoto University, Kyoto, JAPAN
kkoba@psa.mbox.media.kyoto-u.ac.jp

In this paper, a theoretical model is developed to analyze the effect of the performance specification scheme in a public procurement problem on the contractors' incentives for technological development and for moral hazard. Considering the variety of technical needs in construction projects, we have pointed out that the performance specification fosters the matching the technical needs of each work with a contractor endowed with the relevant professional expertise who can deal with those needs most efficiently. We have proven that such a matching mechanism motivates contractors to develop new technologies. Moreover, we have pointed out that the role of performance tests in alleviating the contractors' moral hazard for excess cost saving by adopting unreliable new technology.

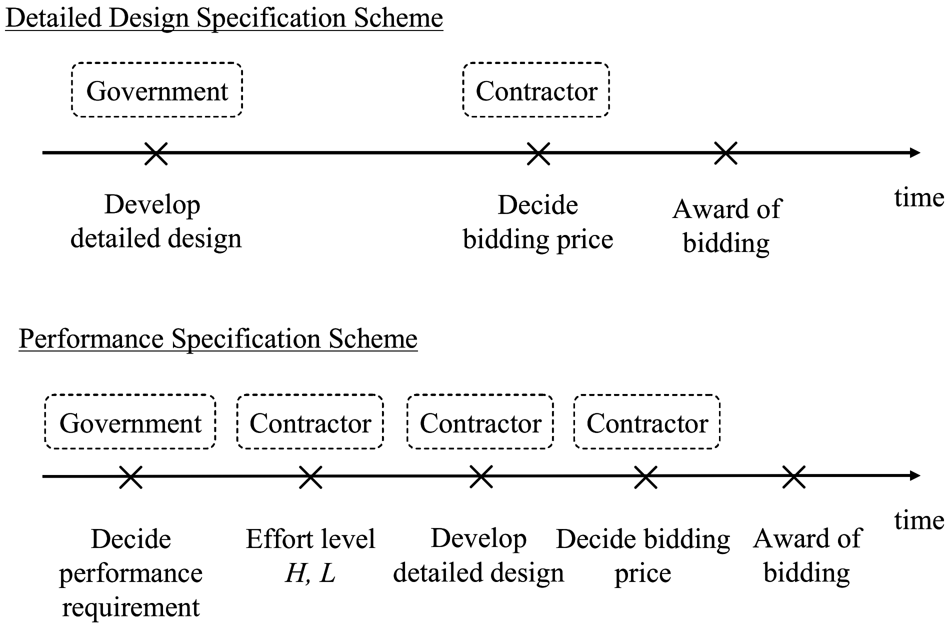
KEYWORDS: performance specification, technological matching

INTRODUCTION

In the Japanese conventional public procurement scheme, the government is supposed to provide detailed specifications of facilities to be constructed. However, the number of the public construction projects adopted a performance specification scheme has been increasing since a decade ago. Under the performance specification scheme, the government prepares the requirements of facilities to be constructed. And, contractors are endowed with the discretion to develop detailed design by themselves. Introduction of the performance specification is expected to foster technological development activities in the construction industry. It has been pointed out, however, that private firms' motives for technological development activities are dependent on the market environment they are facing. Therefore, it is not obvious that the introduction of performance specification scheme really motivates contractors' technological development. In order to analyze contractors' incentive for technological development, we have to clarify the contractors' technological characteristics and the market environment. Based on the research motivation above, we develop a model of the bidding process in the construction market with two contractors and analyze allocating structure of profit by technological development. Moreover, we analyze how the structure of profit allocating affects on the contractors' incentive for technological development. Although there are a variety of definitions for construction innovation, According to Na et al. (2006), there are two distinct forms of innovation depending on the level of importance that authors ascribe to technology innovation.

One of the definitions of innovation emphasizes on the application of technology (Pederson, 1996; Toole, 1998), whereas the other emphasizes on the exploitation of an idea, new to a

Figure 1: Timeline of the Basic Model



particular enterprise or its processes that must take place for innovation to be deemed to have occurred (CRISP, 1997). The definition of innovation in this paper is more related to the latter, because we are interested in the procurement schemes to exploit construction companies' potential knowledge.

As referred in Na et al. (2006), the root problem of poor growth in any industry or nation in is the failure to understand the economic system. For business investments to increase there must be an adequate incentive to invest. Incentive to invest inevitably depends on the market competition environment. Depending on the public procurement schemes, the competitive environment in construction markets varies. There are several papers on the effects of market conditions on the motivation of private firms' technological development (Dasgpta et al., 1980; Loury et al, 1979; Lee et al., 1980; Reinganam, 1981; Scotchmer, 2004). Those papers have developed dynamic competitive models to focus on the firms' behaviour to seek temporal monopolistic benefits protected by patents. Seaden et al. (2003) analyzes the strategic decision-making process in a construction firm based on the empirical data. However, in construction markets, the structure of benefit allocation through bidding process is more critical to firms' motivation rather than the dynamic aspect for technological development. Such a focus has not been noted so far in the previous literature. Na et al. (2006) analyzes a model to stimulate construction innovation in Singapore through the National System of Innovation (NSI). Although there is no agreement on the key elements of NSI, there are three elements can be highlighted; 1) firms and dynamic factors that shape innovation within the firms, 2) common innovation infrastructure and 3) governmental factors (OECD, 1997; Porter and Stern, 2001; Stern et al., 2000). This paper is more related to the governmental factor which facilitates construction companies' incentive to invest for innovation.

The structure of this paper is as follows. First of all, a basic model is proposed to clarify the substantial economic effect of performance specification scheme. In the next step, we extend the basic model to consider the possibility of contractors' moral hazard behaviour. And then, given this setting, the role of performance test is clearly conceptualized. Finally, conclusions of this paper are summarized and some remaining issues are noted.

BASIC MODEL

Basic settings of the model

The government solicits competitive bidders according to the procedure shown in Fig. 1, for procuring two construction works whose types of the design condition are different from each other. These types of design condition are represented by α and β respectively for descriptive purpose. There assumed to be only two risk-neutral contractors *A* and *B* in the construction Under the detailed design specification scheme, the government solicits the bids after preparing detailed specifications for two projects. The obligation of the contractors is only to construct facilities according to the detailed design specified by the government. In this case, the contractors cannot adopt new technologies at all. Then, both contractors spend the cost $\overline{C}$ for construction for each project, adopting the conventional technology. On the contrary, the government solicits the bids with required performance levels of facilities under a performance specification scheme. In this case, as long as the required performance level is satisfied, the contractors can make detailed design which enables them to exploit their technical advantages. Because the contractors are allowed to make detailed design by themselves, they can adopt new technologies. In order that the contractors come up with new technologies, they must make technological development by spending their private funds. To simplify the model, the contractor *i* (*i*=*A*,*B*) chooses an effort level denoted by e_i={*H, L*}, where $e_i = H$ represents that contractor *i* chooses the high effort level and $e_i = L$ the low effort level. Because the environments where construction work implemented are different respectively, the contractors have to make effort for each construction work. Denote the effort cost for contractor *i* whose effort level $e_i = H$ as ξ_i. The cost for effort level $e_i = L$ is assumed to be 0. Let assume that the both contractors bear the same effort cost, that is,

$$\xi_A = \xi_B = \xi \,. \tag{1}$$

If the contractor *i* chooses $e_i = H$, he can save the construction cost ΔC_i^j for construction with design condition *j* for sure compared to the cost when the conventional technology adopted. Assume that Contractor *A* has superior professional expertise for the construction work with the type of design condition α compared to Contractor *B* and for the work with the type β, and vice versa. In this case, Contractor *A* can develop more efficient technology for construction work with design condition α compared to Contractor *B* with the same effort cost. For the design condition type β, Contractor *B* is more efficient. Therefore, following two conditions

$$\Delta C_A^\alpha > \Delta C_B^\alpha \,, \tag{2a}$$

$$\Delta C_B^\beta > \Delta C_A^\beta \tag{2b}$$

are assumed. The game where the contractors choose their effort level is formulated by the strategic-form game which is played before the government solicits biddings. After the contractors choose an effort level, the information on the contractors' technologies, i.e. construction cost, is assumed to be common knowledge between them. By conducting competitive bidding, the contractor who bids lowest price is awarded as successful bidder. If the multiple bidders bid same lowest price, those bidders are awarded stochastically with same probability respectively.

Detailed design specification scheme

As a benchmark to evaluate the effect of the performance specification scheme, we derive the equilibrium bidding strategies. Under the detailed design specification scheme, the contractors cannot adopt new technologies. Therefore, both of Contractors *A* and *B* bear construction cost $\overline{C}$. In this case, the both bids the same price $\overline{C}$, which brings zero profit to them. If Contractors bid the same price, one of contractors is awarded with the probability 1/2. The expected profit of Contractor *i* π_i^s is derived as

$$\pi_A^s = \pi_B^s = 0\,. \tag{3}$$

Performance specification scheme

First of all, we analyze the bidding and technological development effort strategies in the bidding process for construction work with the type of design condition α. Contractors decide the technological developing effort taking the expected payoff through the bidding into consideration. Next, we derive Contractors' expected payoffs for the following four cases given the Contractors' effort level combination.

a) Given $(e_A, e_B) = (L, L)$, both Contractors bear the same amount of construction cost $\overline{C}$. In this case, the Contractors bid the same bidding price $b_A^\alpha = b_B^\alpha = \overline{C}$. Each contractor is awarded with the probability 1/2. Therefore, Contractor *i*'s expected payoffs are

$$\pi_A^\alpha = \pi_B^\alpha = 0\,. \tag{4}$$

b) Given $(e_A, e_B) = (H, L)$, Contractor *A* bears the construction cost $\overline{C} - \Delta C_A^\alpha$, and Contractor *B* bears $\overline{C}$. In this case, the Contractor *A* is surely awarded by bidding price $b_A^\alpha = \overline{C} - \varepsilon$. Therefore, Contractor *i*'s expected payoffs are

$$\begin{aligned}\pi_A^\alpha(H, L) &= b_A^\alpha - (C - \Delta C_A^\alpha) - \xi \\ &= \Delta C_A^\alpha - \varepsilon - \xi\end{aligned} \tag{5a}$$

$$\pi_B^\alpha(H, L) = 0\,. \tag{5b}$$

where ε is a variable with arbitrary small positive value.

c) Given $(e_A, e_B) = (L, H)$, Contractor *A* bears the construction cost $\overline{C}$, and Contractor *B* bears $\overline{C} - \Delta C_B^\alpha$. In this case, the Contractor *B* is surely awarded by bidding price $b_B^\alpha = \overline{C} - \varepsilon$. Therefore, Contractor *i*'s expected payoffs are

$$\pi_A^\alpha(L, H) = 0 \tag{6a}$$

$$\begin{aligned}\pi_B^{\alpha}(H,L) &= b_B^{\alpha} - (\overline{C} - \Delta C_B^{\alpha}) - \xi \\ &= \Delta C_B^{\alpha} - \varepsilon - \xi\end{aligned} \tag{6b}$$

d) Given $(e_A, e_B) = (H, H)$, Contractor *A* bears the construction cost $\overline{C} - \Delta C_A^{\alpha}$, and Contractor *B* bears $\overline{C} - \Delta C_B^{\alpha}$. In this case, the Contractor *A* is surely awarded by bidding price $b_A^{\alpha} = \overline{C} - \Delta C_B^{\alpha} - \varepsilon$. Therefore, Contractor *i*'s expected payoffs are

$$\begin{aligned}\pi_A^{\alpha}(H,L) &= b_A^{\alpha} - (C - \Delta C_A^{\alpha}) - \xi \\ &= \Delta C_A^{\alpha} - \Delta C_B^{\alpha} - \varepsilon - \xi\end{aligned} \tag{7a}$$

$$\pi_B^{\alpha}(H,L) = -\xi\ . \tag{7b}$$

Table 1: Payoff Matrix (Design Condition α)

Design Cond. α		Contractor *B*	
		H	*L*
Contra-ctor *A*	*H*	$(\Delta C_A^{\alpha} - \Delta C_B^{\alpha} - \varepsilon - \xi, -\xi)$	$(\Delta C_A^{\alpha} - \varepsilon - \xi, 0)$
	L	$(0, \Delta C_B^{\alpha} - \varepsilon - \xi)$	$(0,0)$

Table 2: Payoff Matrix (Design Condition β)

Design Cond. β		Contractor *B*	
		H	*L*
Contra-ctor *A*	*H*	$(-\xi, \Delta C_B^{\beta} - \Delta C_A^{\beta} - \varepsilon - \xi)$	$(0, \Delta C_B^{\beta} - \varepsilon - \xi)$
	L	$(\Delta C_A^{\beta} - \varepsilon - \xi, 0)$	$(0,0)$

Table 1 and Table 2 indicate the payoff matrices of this strategic form game in deciding the technological developing effort for the construction work with design condition α and β respectively. The Nash equilibrium of this game for the construction work the type α (e_A^*, e_B^*) is

$$(e_A^*, e_B^*) = (H, L)\,. \tag{8}$$

We can obtain the following Nash equilibrium of the technological developing effort for work with the type β as well.

$$(e_A^*, e_B^*) = (L, H)\,. \tag{9}$$

As a conclusion for this basic model, we obtain **Proposition 1**.

Proposition 1: Under the performance specification scheme, Contractor A exerts the technological development effort for construction work with design condition α and Contractor B does not. Contrary, for construction works with design condition β, Contractor B exerts the effort and Contractor A does not.

The detailed design specification scheme does not entice the contractors to adopt new technologies, because the government makes all decisions related to the materials and technologies. In this case, the Contractors cannot make use of his professional expertise which may be reflected on the construction cost. Finally, the bidding prices proposed by the Contractors are likely to come very close, and success of each Contractor's bid may be uncertain. On the contrary, performance specification scheme enables the Contractors to adopt new technologies which save the construction costs. A noteworthy conclusion of Proposition 1 is that the Contractor is surely awarded by making technological development efforts specializing in his advantageous technical field. In practice, the design conditions vary depending on construction work sites and facilities. The different types of construction works require various kinds of professional expertise. By introducing the performance specification scheme, the contractor with the most appropriate professional expertise should be awarded the contract for a construction work with a certain type of design condition. In other words, the performance specification scheme is blessed with technological matching mechanism. If this technological matching mechanism works, contractors are sure to be awarded for bids the construction works they are best at. This technological matching also has a positive effect that gives the incentive for making technological development efforts.

Rationale of detailed design specification scheme

We have pointed out that the performance specification scheme is superior to the detailed design specification scheme in terms of economic efficiency. However, the detailed design specification scheme has been the standard for public procurement until now. Under the detailed design specification scheme, the government is supposed to select technologies. They are not selected in a competitive market environment. In this case, the most important obligation of the government is achieving accountability on the amount of money to be spent for each construction project. To achieve this accountability, it is most reasonable for the government to estimate the construction cost for each work based on a predetermined rule. This predetermined rule is regarded as the current quantity survey rule in Japan, where adopted technologies have been regulated as standard. Because the adopted technologies have been used for a number of actual projects, reliability of them has already proven. As a result, if budgetary constraint is not so sever different from the current situation, the government can implement all works to be needed by demanding budget estimated based on the adoption of conventional technologies. Of course, benevolent governments may make the effort to develop new technologies and decide to adopt them as well. However, it is not realistic that public officers in the government are familiar with all new technologies in construction industry. In this case, it may be difficult for them to adopt the most appropriate technology among a number of technologies. Therefore, as far as the government is demanded to achieve accountability on technological choice, it is reasonable to predetermine standard technologies.

ROLE OF PERFORMANCE TEST

Basic settings of the model

In the above section, the performance specification scheme fosters the technological development effort of the contractors because they can focus their efforts on their advantageous technical fields. Experience and knowledge related to the conventional technologies which may be adopted by the government has already sufficiently accumulated, whereas knowledge related to new technologies can be insufficient to be convinced of its successful in practice. Such uncertainty is inherent in new technology. If new technologies do not work as expected, realized performance level can not reach the performance requirement specified in the contract. In this case, social costs due to the risk of performance failure arise. Therefore, once we take such a technological uncertainty into consideration, we have to analyze the both of construction cost reduction and expected social costs due to performance failure. Moreover, if contractors have private information related to the reliability of new technologies, they could be motivated to adopt unreliable new technology for excess cost saving. Such a moral hazard behavior by contractors might be alleviated by internalizing those social costs into the payoff of contractors by claiming a damage remedy. However, considering that facilities play as a role of infrastructure, social costs of performance failure could expand in various ways. Therefore, it is practically difficult for private firms to cover social costs due to a project's performance failure. In this case, there is a functional limitation of economic incentive schemes such as damage remedy to alleviate the moral hazard behavior. In this section, the uncertainty of technological reliability is introduced into the performance specification scheme model established in the previous section. Moreover, the assumption of contractor's limited liability is introduced in order to analyze contractor's moral hazard behavior.

In this section, the uncertainty of technological reliability is introduced into the performance specification scheme model established in the previous section. Moreover, the assumption of contractor's limited liability is introduced in order to analyze contractor's moral hazard behavior.

Contractor *A* can develop a new technology by spending ξ which realizes the decrease of $\Delta C_A^{\beta M}$ in construction cost. However, this new technology may fail to attain the performance requirements with a probability $\lambda_A^{\beta M}$. Herein, we call such a Contractor's behavior as moral hazard and represents by $e_A = M$. Failure of performance requirement brings this social cost of *D*. Next, the following inequalities are assumed;

$$\Delta C_B^{\beta} < \Delta C_A^{\beta M} \tag{10a}$$

$$\Delta C_B^{\beta} > \Delta C_A^{\beta M} - \lambda_A^{\beta M} D \,, \tag{10b}$$

where (10a) assumes the condition that Contractor *A* can construct the facility by lower cost than Contractor *B*, and (10b) assumes that considering the expected social costs due to the performance failure, the new technology developed by Contractor *B* is socially more efficient than that of Contractor *A*. The maximum amount that the Contractor can remedy for damage as *T*, and

$$D > T \ . \tag{11}$$

In this case, Contractor cannot remedy all social costs due to the performance failure.

Nash Equilibrium

Here we derive the Nash equilibrium within the strategic form of the game where Contractors' choosing technological development strategies considering the bidding process for construction work with the type of design condition β. In this model, Contractor *A*'s moral hazard strategy is added to the model. Therefore, we derive the Contractors' expected payoffs for the following two cases given the Contractors' strategies combination.

a) Given $(e_A, e_B) = (M, L)$, if Contractor *A* is successful in bidding, Contract *A* bears the total cost including the construction cost and expected remedy $\overline{C} - \Delta C_A^{\beta M} + \lambda_A^{\beta M} T$, and Contractor *B* bears $\overline{C} - \Delta C_B^{\beta}$. In the case that the following inequality

$$\begin{aligned} &\overline{C} - \Delta C_A^{\beta M} + \lambda_A^{\beta M} T < \overline{C} - \Delta C_B^{\beta} \\ \Leftrightarrow\ &\Delta C_B^{\beta} < \Delta C_A^{\beta M} - \lambda_A^{\beta M} T \end{aligned} \tag{12}$$

is satisfied, Contractor *A* is awarded by bidding price $b_A^{\beta} = \overline{C} - \Delta C_B^{\beta} - \varepsilon$ and gains a positive payoff. Contractor *i*'s expected payoffs are thus;

$$\begin{aligned} \pi_A^{\beta}(M, H) &= b_A^{\beta} - (\overline{C} - \Delta C_A^{\beta M} + \lambda_A^{\beta M} T) - \xi \\ &= \Delta C_A^{\beta M} - \Delta C_B^{\beta} - \varepsilon - \lambda_A^{\beta M} T \end{aligned} \tag{13a}$$

$$\pi_B^{\beta}(M, H) = -\xi \ . \tag{13b}$$

b) Given $(e_A, e_B) = (M, L)$, if Contractor *A* bids successfully, Contractor *A* bears the total cost including the construction cost and expected remedy $\overline{C} - \Delta C_A^{\beta M} + \lambda_A^{\beta M} T$, and Contractor *B* bears $\overline{C}$. In the case that (12) is satisfied, Contractor *A* is awarded the contract at a bidding price $b_A^{\beta} = \overline{C} - \varepsilon$ and gains a positive payoff. Contractor *i*'s expected payoffs are

$$\begin{aligned} \pi_A^{\beta}(M, L) &= b_A^{\beta} - (\overline{C} - \Delta C_A^{\beta M} + \lambda_A^{\beta M} T) - \xi \\ &= \Delta C_A^{\beta M} - \varepsilon - \lambda_A^{\beta M} T \end{aligned} \tag{14a}$$

$$\pi_B^{\beta}(M, L) = 0 \ . \tag{14b}$$

Table 3 indicates the payoff matrix of this strategic form of the game in deciding the technological development strategy for the construction work with the design condition type β. The Nash equilibrium of this game (e_A^*, e_B^*) is (M, L).

Proposition 2: If Contractor A can adopt unreliable new technology for the construction works with design condition β, a performance specification scheme may not motivate Contractor B's socially efficient effort level for technological development.

Contractors know the detailed characteristics of the new technologies they develop. It is difficult for the government to acquire correct information on the reliability of these new technologies. Even though informational asymmetricity exists, contractors may not adopt unreliable technologies under the rule that they bare all of the social costs. However, if we consider the case that the contractor cannot bear all the social costs incurred by performance failure due to the protection of limited liability, he could adopt new technology which may cause performance failure with excess high probability to be awarded as successful bid. Such a moral hazard behavior of the contractor may remove the contractor's motivation of the contractor for technological development.

Role of Performance Test

Without any countermeasure to alleviate informational asymmetricity, the performance

Table 3: Payoff Matrix (Moral Hazard Model)

Design Cond. β		Contractor B	
		H	L
Contractor A	H	$(-\xi, \Delta C_B^\beta - \Delta C_A^\beta - \varepsilon - \xi)$	$(0, \Delta C_B^\beta - \varepsilon - \xi)$
	L	$(\Delta C_A^\beta - \varepsilon - \xi, 0)$	$(0,0)$
	M	$(\Delta C_A^{\beta M} - \Delta C_B^\beta - \varepsilon - \lambda_A^{\beta M} T, -\xi)$	$(\Delta C_A^{\beta M} - \varepsilon - \lambda_A^{\beta M} T, 0)$

specification scheme could fail to function as shown in the basic model. Extending the moral hazard model, we analyze the role of performance testing conducted by the government or the third-party agencies (certifier).

Final performance of a facility constructed adopting a new technology depends on the environmental condition (state of nature) realized during the in-service period which cannot be forecast during the construction period. This state of nature is denoted by a stochastic variable θ which is defined on the interval [0,1]. θ is assumed to distributed on [0,1] according to a uniform distribution (See Figure 2). θ close to 1 represents that the state of environment is severe. New technologies developed by Contractor B satisfy the performance requirement for any state of nature on [0,1]. However, new technology developed by Contractor A satisfies the performance requirement for realized $\theta \in [0, \theta_A^{\beta M}]$, but not for $\theta \in (\theta_A^{\beta M}, 1]$. In this case, the probability that the required performance is not attained by new technology developed by Contractor A is represented by

$$\lambda_A^{\beta M} = 1 - \theta_A^{\beta M} . \tag{15}$$

The threshold $\theta_A^{\beta M}$ is known by both Contractor A and B, but not by the government.

The certifier conducts performance tests in a certain state of environment $\hat{\theta}$. If $\theta_A^{\beta M} \geq \hat{\theta}$, new technology developed by Contractor A passes the tests, and if $\theta_A^{\beta M} < \hat{\theta}$, it does not pass the testing. Contractors know this environment assumed in performance test. Therefore, Contractor A which has developed a new technology whose reliability is $1 - \lambda_A^{\beta M} \geq \hat{\theta}$, knows whether his technology will pass the performance test or not. Equation (10b) and (12) can be rewrite as

$$\frac{\Delta C_A^{\beta M} - \Delta C_B^{\beta}}{D} < \lambda_A^{\beta M} < \frac{\Delta C_A^{\beta M} - \Delta C_B^{\beta}}{L} . \tag{16}$$

Table 4: Payoff Matrix (Performance Test Model)

Design Cond. β		Contractor B	
		H	L
Contra-ctor A	H	$(-\xi, \Delta C_B^{\beta} - \Delta C_A^{\beta} - \varepsilon - \xi)$	$(0, \Delta C_B^{\beta} - \varepsilon - \xi)$
	L	$(\Delta C_A^{\beta} - \varepsilon - \xi, 0)$	$(0,0)$
	M	$(-\xi, \Delta C_B^{\beta} - \varepsilon - \xi)$	$(0, \Delta C_B^{\beta} - \varepsilon - \xi)$

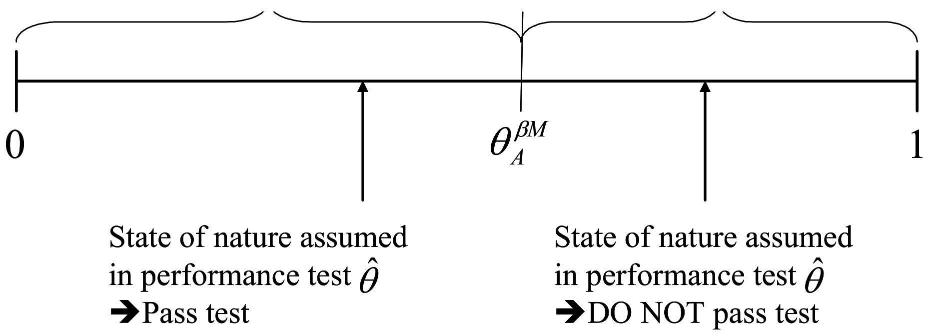


Figure 2: Technological uncertainty and performance test

Therefore moral hazard can be alleviated by excluding Contractor A through the performance test. Now let $\hat{\theta}$ be

$$\lambda_A^{\beta M} < \frac{\Delta C_A^{\beta M} - \Delta C_B^{\beta}}{D}$$

$$\Leftrightarrow \theta_A^{\beta M} > 1 - \frac{\Delta C_A^{\beta M} - \Delta C_B^{\beta}}{D} = \hat{\theta}. \tag{17}$$

In this case, a new technology developed by Contractor A cannot pass the tests. Performance testing can exclude contractors who have developed unreliable technologies from competitive bidding. However, let assume that Contractor A can participate in competitive bidding if he adopt a conventional technology whose reliability has already been proven. Payoff matrix of this strategic form game with performance tests in deciding the technological development strategy is shown in Table 4. The Nash equilibrium of this game is (H, L).

Proposition 3: If the certifier conducts performance testing under some appropriate state of nature $\hat{\theta}$, Contractor with unreliable technology can be excluded. This exclusion motivates Contractor with professional expertise to develop new technologies that satisfy the certifier's criteria.

Performance testing plays a role not only in alleviating the risk of performance failure but also in motivating contractors to develop new technologies in their technical field. According to (17), the appropriate threshold $\hat{\theta}$ depends on 1) the social cost due to performance failure, 2) the amount of cost savings when unreliable technology is adopted and 3) the amount of cost savings when reliable technology is adopted. However, it is impossible for the certifier to know the construction costs of contractors. Therefore in practical works, the certifier determines the standard level of performance test based on the certifier's subjective probability of moral hazard risk and social cost.

Policy Implications

When the government prepares complete specifications of facility to be constructed, it is difficult for the government to achieve accountability about the reason why new technology should be adopted for each project. Therefore, it can be reasonable for the government to employ conventional standard technology whose reliability has already guaranteed for all types of projects. This means that contractors cannot adopt new technologies. Even if a contractor developed a new technology, this technology may not be adopted. Therefore, contractors are not motivated to develop new technologies under the detailed design specification scheme.

On the other hand, the performance specification scheme is nothing more than the government determining a rule to select a technology to be adopted for each project based on the information revealed through the bidding or market mechanism. Therefore, the performance specification scheme relieves the government of accountability with respect to technological adoption. According to the results analyzed in this paper, this scheme guarantees that a contractor who deals with a specific type of design condition most efficiently will be the successful bidder. However, technologies of contractors are evaluated only in terms of cost information under the general competitive bidding scheme. There is a possibility of moral hazard where contractors bid low prices by employing unreliable technology, performance tests based on the appropriate state of environment should play an important role in excluding such contractors from competitive bidding.

In this paper, we have pointed out the economic value of the matching between the technical needs which vary by projects and contractors with their advantageous technical expertise. The function of this matching mechanism will provide a differentiation of technologies among contractors and increase technological variety in the construction markets.

To assure this matching between projects and contractors, the government should develop an information sharing system which identify types of required professional expertise in each project so that contractors know which projects they should participate in among vast amount of construction projects in the market. To develop such an information system, a classification system of construction technologies is necessary. Ministry of Land, Infrastructure and Transportation in Japan has operated NETIS (New Technology Information System) since 2006 where new construction technologies are publicly introduced on a website by sorting according to a classification system. This information system could contribute to the improvement of the economic efficiency of the performance specification scheme by fostering matching between projects and contractors.

However in practice, it is difficult to confirm the reliability of a new technology by the only once performance test. Usefulness of a new technology can be confirmed only in its practical works. By introducing performance specification scheme, results of adopting new technologies in practical works should be evaluated.

CONCLUSION

In this paper, we proposed a technological development game under the detailed design specification scheme and performance specification scheme in order to analyze the effects of those procurement schemes on contractors' incentives for developing new technologies. Construction is not a single production as design conditions vary by projects. The performance specification scheme endows contractors with the discretion to decide detailed specifications of projects, which enable them to adopt new technologies. As a conclusion, the performance specification scheme has a mechanism to realize matching between contractors the technical needs which vary by projects and contractors with their advantageous technical expertise. However, if there is a possibility of moral hazard that contractors bid an excessively low price by employing unreliable technology, performance tests should play an important role in excluding such contractors from competitive bidding. The above conclusions are derived based on the settings assumed in this paper. We are still leaving an important feature of the performance specification scheme, and need to contemplate appropriate risk sharing concepts between the government and a contractor more deeply. Upon the settings in this paper, the contractor should bear all social costs that arise due to performance failure to alleviate moral hazard. Also, bearing excess risk bearing by contractors may not motivate them to adopt new technologies, because even if the reliability of technical uncertainty is quite small, they cannot eliminate the risk of bankruptcy totally. Moreover, results of performance tests are uncertain. Also, a technical uncertainty is different from the assumption in the model we have proposed. Therefore, it is difficult to know the reliability of new technologies by performance tests. Information on the reliability of new technologies should be accumulated through experiences in practical works. In this case, we have to focus experimental values. That is, the value of acquiring information on the reliability of new technology through actual works to contemplating risk sharing between the government and a contractor.

REFERENCES

Construction Research an Innovation Strategy Panal (CRISP) (1997) *Creating Climate of Innovation in Construction,* CRISP Motivation Group, London.

Dasgupta, P. and Stiglitz, J. (1980) Uncertainty, industrial structure and innovation and the speed of R&D, *Bell Journal of Economics*, vol. 11, pp. 1–28, 1980.

Lee, T. and Wilde, L.L. (1980) Market structure and innovation; a reformulation, *Quarterly Journal of Economics*., Vol. 93, pp. 429-436.

Loury, G. C. (1979) Market structure and innovation, *Quarterly Journal of Economics*, Vol. 93, pp. 395-410.

Na, L. J., Ofori, G. and Park, M. (2006) Stimulating construction innovation in Singapore through the national system of innovation, *Journal of Construction Engineering and Management, American Society of Civil Engineering*, Vol. 132, No. 10, pp. 1069-1082.

Organization for Economic Co-operation and Development (OECD) (1997) *Oslo manual: Proposed guideline for collecting and interpreting technological innovation data.* France.

Pederson, D. O. (1996) The economics of innovation in construction, *Economic Management of Innovation, Productivity and Quality in Construction: CIB W55 Building Economics 7th International Symposium,* Katavic, M., ed., Croatia.

Porter, M. E., Stern, S. (2001) Innovation: location matters, *MIT Sloan Managemetn Review,* Vol. 42, No. 4, pp. 28-37.

Reinganam. J. F. (1981) Dynamic games of innovation, *Journal of Economic Theory*, Vol. 25, pp. 21-41.

Scotchmer, S. (2004) *Innovation and Incentives*, MIT Press.

Seaden, G., Guolla, M., Doutriaux, J. and Nash, J. (2003) Strategic decisions and innovation in construction firms, Construction Management and Economics., Vol. 21, p.p. 603-612.

Stern, S., Porter, M. E. and Furman, J.L. (2000) *The determinants of natinal innovation capacity*, National Bureau of Economic Research, Cambridge, Mass.

Toole, T. M. (1998) Uncertainty and home builders' adoption of technological innovations, *Journal of Construction Engineering Management*, Vol. 124, No. 4, pp. 323- 332.

THE IMPACT OF PROCUREMENT OPTIONS ON RISK MANAGEMENT

Ekaterina Osipova
Luleå University of Technology, Luleå, Sweden
ekaterina.osipova@ltu.se

Per Erik Eriksson
Luleå University of Technology, Luleå, Sweden
pererik.eriksson@ltu.se

In order to achieve an expected final result of construction activities, professional risk management as well as conscious risk allocation among the project actors are required. Various procurement options imply different risk allocation and different degree of actors' involvement in risk management. This paper investigates the impact of the chosen procurement option on risk management in construction projects. Three major options currently used in Sweden are analysed: design-bid-build contracts, design-build contracts and collaboration through partnering. A questionnaire survey and a series of interviews with clients, contractors and consultants involved in nine construction projects were conducted. The major finding of the study is that there is a clear connection between the procurement option and risk management. The options that support early involvement of the actors, their participation throughout the project and opportunities for open dialogue and collaboration result in a more effective risk management process and a better final result.

KEYWORDS: risk management, risk allocation, procurement, construction.

INTRODUCTION

In recent years, the Swedish construction industry has been criticized for increasing costs, low productivity, quality problems and project delays (SOU, 2002). As construction projects are characterized by many uncertainties and increasing size and complexity, an ability to manage risks throughout the project is an important element preventing unwanted consequences. There are many examples of construction projects where occurred risks have caused significant deviations in the project performance in terms of time, cost and quality.

How risks are allocated among project actors is to a large extent affected by the choice of procurement option. As different options imply different ranges of responsibilities and liabilities in the project, selecting an appropriate procurement option is a key issue for the project manager. Two procurement options that are mostly used in Sweden are design-bid-build (DBB) and design-build (DB) contracts. However, it has been argued that these traditional options do not support effective collaboration in construction projects (Kadefors, 2004) and, therefore, do not contribute to a better final result. Positive experiences of collaboration through partnering in the US, UK, Norway and Denmark have resulted in the partnering concept being adopted in Sweden.

The aim of the study is to investigate the impact of the chosen procurement option on risk management in Swedish construction projects. The research results are based on a questionnaire survey and a series of interviews with the project actors involved in nine construction projects recently performed in Sweden. The results are expected to increase the understanding of risk management in the different procurement options and, therefore, assist industry practitioners in choosing an appropriate option taking risk aspects into account.

LITERATURE REVIEW

Risk and risk management

Project risks are uncertain events or conditions that may have an impact on project objectives. Risk management is a formal process of identifying, assessing and responding to project risk (PMI, 2000). *Risk identification* is aimed at determining potential risks, i.e. those that may affect the project. There are a number of tools and techniques for identifying the project risks, both quantitative and qualitative. Empirical studies show that qualitative techniques (e.g. brainstorming and checklists) relying on individual judgments are most common among the construction practitioners (Akintoye and MacLeod, 1997, Lyons and Skitmore, 2004, Uher and Toakley, 1999). During *risk assessment,* identified risks are evaluated and ranked. Empirical research (Akintoye and MacLeod, 1997, Simu, 2006, Tang et al., 2007, Wood and Ellis, 2003) shows that the construction practitioners rely mostly on qualitative techniques such as professional judgment, intuition and experience. The *risk response* process is directed at identifying a way of dealing with project risks and consists of four main techniques: risk avoidance, risk reduction, risk transfer and risk retention. The results of a questionnaire surveys (Akintoye and MacLeod, 1997) show that risk transfer is the most preferable strategy among the UK practitioners. However, several later studies (Baker et al., 1999, Lyons and Skitmore, 2004, Tang et al., 2007) have identified risk reduction as the most frequently used technique within the construction industry.

Risk allocation in construction contracts

An appropriate allocation of risks among project actors is important because it is impossible to avoid all potential risks. One of the main problems identified in the literature is the actors' different perceptions of to whom a specific risk should be allocated. Usually, contractors indicate that they have to bear the majority of project risks and price these risks through adding a contingency to the bid price (Andi, 2006, Dagenais, 2007). Using contingency funds has been identified by the researchers and practitioners as a significant source of the project's cost increase (Zaghloul and Hartman, 2003). Conscious allocation of risks results in decreased contingency funds and, therefore, lower total cost (Zack, 1996).

Risk allocation strategy in construction projects is defined through the contractual arrangements. Many countries have developed standardized conditions of contract to be used in construction projects. In Sweden, the majority of contracts are based on the general conditions of contract that formalise risk allocation in projects adopting different procurement options. Two options that are mostly used in Sweden are DBB and DB contracts. Partnering has become popular in Sweden during the last decade. In contrast with the UK, partnering does not have the status of a contractual form in Sweden. As a form of project implementation, partnering is intended to create effective collaboration between the project's actors and result in a better project performance.

Design-bid-build and Design-build contracts

DBB contracts are characterised by a separate appointment of a design team and a construction firm. The client is responsible for the planning, design and function of a construction and the contractor is responsible for the job execution. The DBB procurement is the most widely used procurement option in many countries, e.g. the UK, US, Sweden and Singapore (Eriksson and Laan, 2007, Ling et al., 2004).

In DB contracts the contractor is responsible for both design and construction. Due to a single point of responsibility, the popularity of DB contracts has increased in recent years. A study by Ernzen and Schexnayder (2000) shows that the average profit margin for contractors is higher in DB projects than that in DBB. Konchar and Sanvido (1998) confirm that DB projects on average show a better performance than DBB in terms of unit cost, construction speed, delivery speed, cost growth and schedule growth. From the risk allocation perspective, DB contracts are more attractive for the client as the responsibility for design implies that more risk is allocated to the contractor. On the other hand, the DB alternative may be more expensive compared with DBB contracts. Furthermore, the quality of the final product may be lower if the contractor uses cheaper solutions, trying to decrease his own costs (Gransberg and Molenaar, 2004). This problem is especially relevant in contracts with a lump sum payment mechanism. In terms of time, the DB system arguably provides an earlier start for project execution than is the case for other forms. From the contractor’s point of view, DB construction projects can be very risky when the contractor lacks knowledge and experience of the DB system. Håkansson et al. (2007) highlight that the competence requirements are higher in DB contracts, and hence structured risk analysis should be made very early in the project. Simu (2006) shows that smaller contractors in Sweden prefer DBB to DB contracts. In the case where a DB contract is used, contractors increase their price by including insurance for the extra risks involved.

Partnering

Over the last decade, researchers and practitioners have recognised that relationships between clients and contractors play a significant role for successful project implementation. Partnering is a concept that concentrates on mutual benefits and win-win scenarios through cooperative relationship (Rahman and Kumaraswamy, 2002). Effective cooperation is claimed to lead to fewer disputes, lower construction costs and a better quality product. Based on trustful relationships, partnering results in a more effective risk allocation process, decrease of contingency funds and, finally, in project cost reduction (Zaghloul and Hartman, 2003). A study by Akintoye and Main (2007) shows that UK contractors are positive about cooperative relationships and believe they lead to cost and risk reduction. The three largest construction companies in Sweden, Skanska, NCC and Peab, actively work with partnering projects and report positive results. However, the partnering concept demands high professionalism and very good knowledge of the project on the part of the client *and* the contractor.

RESEARCH METHOD

The study involves nine construction projects recently undertaken in Sweden. To find out how risks were managed in the project, a questionnaire survey was conducted. The survey sample comprised clients, contractors and consultants. Within each group those who were working with risk management in a particular project were identified. The respondents from the client’s side were a representative signing the contract and a project manager. From the contractor's side, they were a representative signing the contract, a site manager and an estimator. The respondent from the consultant's side was an architect or a design manager. The questionnaire was sent in electronic form to the 54 intended respondents in nine construction projects. In total, 36 usable responses were received and formed the response rate of 67%. In a second stage 20 interviews across the nine projects were conducted, based on the compiled results of the questionnaire survey. The objective was to make a deeper analysis of the risk management process. From the client side, it was a project manager, from the contractor side a site manager and from the consultant side an architect or design manager. Each interview took approximately one and a half hours. The results presented below are based on the analysis of both questionnaire and interviews. Despite a set of quantitative data, a sample of 36 responses was not enough for a statistical analysis. Therefore, description of the results is based on the qualitative analysis of the data. The results are grouped according to the different procurement options adopted in the projects.

RESULTS

Design-bid-build projects

Project 1 comprised the rebuilding, refurbishment and additional construction of university premises, located in the northern part of Sweden. The contract sum was 18 MSEK and the final cost of the project was 20 MSEK. The technical characteristics and functionality of the final product were evaluated as high by all actors. However, the project implementation in terms of cost was unsatisfactory from the contractor's perspective. The contractor's costs increased significantly due to the poor quality of design documents. Time constraints for project execution were kept and the project was finished earlier than planned. The client was involved in all four phases of the project: programme, design, procurement and production. The architect participated in the programme and design phase, but was not involved in the production phase. From the perspective of dealing with risks, non-participation of the architect in the production phase created problems and conflicts because there was a need for design changes during the project execution. The contractor joined the project in the procurement phase, which is the traditional approach for DBB contracts. The actors noted that the risk identification and risk response processes were carried out systematically in the project. Risk assessment, however, was not performed by the client. The contractor assessed risks systematically in the production phase using quality management software. During the design phase, the client cooperated with the consultant in the risk identification process. However, the identified risks occurred in the project and their financial impact was fairly large. Unforeseen risks occurred as well, but had a smaller effect on the project's financial position. The client had the largest influence on the risk management process according to all actors. The influence of the contractor and, especially, the architect was significantly lower. A serious problem identified by the actors is that no collaboration in the risk management process existed between the client and the contractor. Moreover, both the client and the contractor communicated known risks, as if they were of a low priority, during the procurement phase. This created conflicts during the implementation of the project.

Project 2 comprised construction of a new road in the north of Sweden. The contract sum was 19.7 MSEK and the final cost of the project was 24.5 MSEK. The contractor explained the cost increase by mistakes in design, which resulted in a re-design during the project implementation. The quality of the final product was evaluated as fairly good and no delays occurred. The client was involved in the design, procurement and production phases. Non-participation in the programme phase can be generally explained by the absence of this phase in some civil engineering projects, road projects in particular. The design manager participated in the design and production phases. The contractor joined the project in the procurement phase. Risk identification, assessment and response were not carried out systematically by the client. On the contrary, the contractor stated that risk management was performed systematically in the project. As mentioned above, unforeseen design risks occurred in the project and had a fairly large financial impact. The contractor had the largest influence on the risk management process according to all actors. The influence of the client and, especially, the consultant was significantly lower. The client felt that no collaboration in the risk management process existed between the project actors. However, the contractor and the consultant evaluated the collaboration as good. Communication of the known risks in the procurement phase did not work well, both the client and the contractor communicated known risks on a low level.

Project 3 comprised construction of a new road in the north of Sweden. The contract sum was 4.9 MSEK and the final cost of the project was 4.7 MSEK. The project execution was fairly good in terms of function and cost and fairly bad in terms of time. The client was involved in the design, procurement and production and the contractor participated in the procurement and production phases. Risk identification, assessment and response were carried out systematically by the contractor in the procurement and production phase. The client said that no risk management was performed in the design phase and explained that this was due to the simplicity of the project. However, the contractor noted that an insufficient geotechnical survey in the beginning of the project led to identified risks occurring in the project, but their effect on the project cost was fairly small. No unforeseen risks occurred in the project. The client argued that all actors had the same degrees of influence on risk management. In contrast, the contractor mentioned that the client had a lower degree of influence and that the consultant had fairly small influence. Both the client and the contractor evaluated the collaboration in risk management as very good. Like other projects, communication of the known risks in the procurement phase was not on a very detailed level.

Project 4 comprised the reconstruction of infrastructure facilities in Stockholm. The contract amount was 95 MSEK. The quality of the final product was fairly good. In terms of cost, the project implementation was very good for the contractor and very bad for the client. Incompleteness and inaccuracy in design documents led to many changes during the project execution, which were paid by the client as he was responsible for the design. Unforeseen risks occurred in the project and caused significant delays and high costs for the client. Identified risks occurred as well and had a fairly large impact on the total cost. The client was involved in the design, procurement and production phases. Risk management was performed from the very beginning. The client carried out risk identification and risk response, but consciously skipped risk assessment. The contractor joined the project in the procurement phase, and systematically performed risk identification, assessment and response in the production phase. The client mentioned that he had the largest influence on risk management. The contractor, in turn, said that his influence was the largest. Both the client and the contractor were agreed that the influence of the project manager was significantly lower. A serious problem identified by the client is that no collaboration existed between the client and the project manager. Moreover, conflicts between them resulted in a dispute. As mentioned above, incomplete design documents led to significant problems in the project. The collaboration between the client and the contractor was evaluated as very good. The extent to which known risks were communicated in the procurement phase was fairly great from the perspective of the client, and fairly limited from the perspective of the contractor.

The impact of design-bid-build contracts on risk management

During a discussion about a connection between the chosen procurement option and risk management, the contractors argued that traditional options like DBB do not create an opportunity for open dialogue and collaboration in risk management between the client and the contractor. Each actor is focused on his own part of the project and tries to manage the associated risks. From the contractors' point of view, in DBB projects the quality of documents and drawings is often insufficient with many inaccuracies involved. This brings additional risks to the projects: "Conflicts come up very often, especially about technical solutions and associated costs" (Client). The general conditions of contract are well-developed documents, which assign responsibilities and liabilities to each party. However, the client often deviates from them by trying to transfer more risk to the contractor. The clients agreed that in the DBB contract, joint risk management is impossible because the contractor follows the client's instruction and executes the project according to the client's requirements: "There is no room for discussions in the DBB projects" (Client). On the other hand, with a DBB contract the client has more opportunities to influence the project, and some clients find this reason significant enough to sacrifice early involvement of the contractor. The architects were positive about risk management in the DBB projects. They argued that the architect has more flexibility and cooperation with the client in such projects than in DB ones. In the latter, the contractor is a 'filter' between the client and the architect. He is focused on short-term financial results rather than on the life cycle cost and, therefore, may use cheaper technical solutions, which are not always optimal. However, DBB contracts assign more responsibility to the architect, while in a DB project the architect shares risks with the contractor. On the other hand, collaboration with the contractor is worse in DBB projects, because the consultant usually does not participate in the production phase.

Design-build projects

Project 5 comprised the construction of a new house for meetings at the university campus in the northern part of Sweden. The contract sum was 41.1 MSEK and the final cost was 43.5 MSEK. The project implementation was very good in terms of time and fairly good in terms of quality. In terms of budget, the project was very good for the client and fairly bad for the contractor. Identified risks occurred in the project, but their effect on the project cost was fairly small. The unforeseen risks during the project execution led to a fairly large increase in project cost. The client participated in all four phases: programme, design, procurement and production. However, risk management was not performed systematically in the project. The clients carried out risk identification and response, but not risk assessment. The collaboration between the project actors was evaluated as very good by the client, and the collaboration in risk management was fairly good. The contractor joined the project in the design phase and carried out risk identification and assessment in this phase and risk response in the production phase. In spite of the fact that the client evaluated general collaboration in the project as very good, the contractor assessed collaboration as fairly bad. The contractor argued that the client's decisions took a very long time, which led to delays in design. However, the collaboration in risk management was evaluated as fairly good by the contractor. Both parties communicated known risks in the procurement phase on a detailed level.

Project 6 comprised the construction of infrastructure in the north of Sweden. The contract sum was 53 MSEK and remained unchanged during the project. The project execution in terms of function, time and cost was fairly good. Both identified and unforeseen risks occurred in the project but had a fairly small effect on the project cost. The client participated in all project phases and the contractor joined the project in the design phase. The client did not perform risk management systematically in the project but the contractor carried out risk identification, assessment and response in the design, procurement and production phases. The contractor had the largest influence on risk management according to all actors. Very good collaboration between the parties resulted in a dialogue about the technical solutions and a good final result. The actors had a joint database, where each actor could find the documents about the project.

Project 7 comprised reconstruction of a residential building in Stockholm. The contract sum was 47 MSEK and remained unchanged during the project. The project implementation in terms of function, cost and time was very good for both the client and the contractor. Risk identification, assessment and response were carried out systematically in the project. Moreover, these processes were performed in the form of joint risk management in all project phases; neither identified nor unforeseen risks occurred during the project implementation. All actors evaluated the collaboration in risk management as very good. As the contractor was responsible for the project design, he had the largest influence on risk management in the project. The client's influence on risk management was therefore lower. The design and production phases were identified as the most important in risk management. Both the client and the contractor communicated known risk in the procurement phase on a very detailed level. This resulted in a low contingency fund in the contract (2.5%).

Project 8 comprised the construction of a residential building in Stockholm. The contract sum was 81 MSEK and the final sum was 84 MSEK. The quality of the final product was evaluated as very good, and the time constraints were kept at a fairly good level. In terms of cost, the client evaluated the project execution as very good while the contractor's evaluation was fairly bad. Both identified and unforeseen risks occurred in the project, but had a fairly small effect on the project cost. Both the client and the contractor were involved in all four phases. The client performed risk identification in the design phase and risk assessment in the procurement phase. Risk response was not performed by the client. The contractor mentioned that risk management was performed systematically in the project. However, it was difficult to assess risks in the programme phase since the project was very abstract. The contractor had the largest influence on risk management, while the client's influence was fairly large. The overall collaboration between the project actors and in particular the collaboration in risk management was evaluated as high by both the client and the contractor. The collaboration was the most intensive in risk identification and assessment during the programme and design phases. In the risk response process during the production phase no collaboration existed.

The impact of design-build contracts on risk management

From the perspective of dealing with risks, early involvement of the contractor in DB projects is considered to be the main advantage of this option. Moreover, contractors' risk management is more thorough in the DB contract due to assigned responsibilities for design. The actors stated that the DB contract might lead to deviations in the quality of the final product because of the client's inability to control the technical solutions chosen by the contractor. To avoid this situation, continual discussion of technical solutions between the actors is required. Therefore, personal commitment of the clients is argued to be the most important factor for securing a final result. "The client is always responsible for commitment of other actors. I do not believe in 'good' contractors and consultants, they adapt to the clients' requirements" (Client). When the client is an active party, the DB form is claimed to create conditions conducive to better collaboration because the clients and contractors are forced to have a dialogue. Cooperative work of the architects and contractors is argued to result in better technical solutions and help in avoiding many design and technical risks. Many actors are positive about more fruitful risk management in DB contracts. Cooperation and trust were identified as the most important factors for successful risk management.

Partnering

Project 9 comprised the reconstruction of a residential building, located in Stockholm. The project was implemented in the form of partnering with a cost reimbursable payment mechanism. The project implementation in terms of function, cost and time was good. Jointly the client and the contractor succeeded in decreasing project costs. As there were important time constraints, the project execution had to start when the design was incomplete. This resulted in low degree of communication of known risks in the procurement phase and in re-design of some parts of the project. All actors participated in the early phases of the project and were involved in risk management. Even though the contractor was not responsible for the design, he participated in the design phase. This phase played, according to the actors, the most important role in risk management. Risk identification, assessment and response were performed systematically in the project. At the beginning of the project the client organised workshops, where all actors identified risks and decided who was better qualified to deal with them. In contrast to other projects, in project 9 the client, the contractor and the architect had equal influence on risk management. Despite the fact that identified risks occurred in the project and their financial effect was large, the actors succeeded in cooperating to find the best solution to the problem. They were all agreed that this was possible due to the partnering form: they evaluated their collaboration in risk management as good.

The impact of partnering on risk management

Great expectations in partnering were found among the project actors. It was argued that partnering allows the actors to see the project as a whole and influence risk management throughout the construction process. An advantage of partnering is that risk management processes are carried out from the earliest stages of the project: “Partnering means that we organise a small enterprise Project X and work together to get a good final product; we share both risks and opportunities and have close collaboration” (Contractor). The fact that the contractor is involved in the programme phase makes risk management more effective and easier in terms of better collaboration. Factors that characterise partnering projects, such as open dialogue, trust and cooperation help to manage risks effectively: “I don’t believe the client can gain something by concealing known risks, because in reality that would result in loss for all partners” (Client). The consultant has an opportunity to assess technical solutions together with the client and the contractor, which results in better solutions and fewer risks involved in the production phase. Moreover, the actors deal with indistinctness before signing the contract. However, a successful partnering project requires greater professionalism and open attitudes from all partners.

CONCLUDING DISCUSSION

A stronger focus on how risks are managed in the different procurement options seems necessary in order to decrease the construction cost, quality problems and time overruns for both the client and contractor. The aim of this study was to investigate the impact of the chosen procurement option on risk management in nine construction projects. The paper focuses on three options that are typically used in Sweden: design-bid-build contracts, design-build contracts and collaboration through partnering.

The major finding of the study is that there is a clear connection between the procurement option and risk management. Different procurement options imply different degrees of the actors' involvement and provide different opportunities for open dialogue and collaboration in the project. From the perspective of dealing with risks, the design-bid-build contracts give no space for discussion about technical solutions between the client and the contractor. On the other hand, the client's responsibility for design forces the actors to have a dialogue when problems appear during the project implementation. The design-build contracts offer early involvement of the contractor and opportunity to influence risk management in the early phases. On the other hand, design-build demands an active engagement of the client for ensuring the quality of the final product. The combination of the professional client and the contractor, continuously discussing technical solutions, offers more fruitful risk management of the project. There is an indication that the newer procurement options like partnering, which creates opportunities for the actors' involvement in all phases of a construction project, can result in a better project performance. The partnering project in this study is a very good example of an effective project organisation with very good cooperation likely to occur in risk management. Collaboration between the actors during all project phases resulted in successful problem solving and cost savings for both the client and the contractor. Trust and commitment were argued to be the most important factors that influence joint risk management in the project. The lack of trust is an important obstacle for intensive communication of known risks in the procurement phase. An economically-executed design-build project (Project 7) can be partially explained by the engagement of a very professional and enthusiastic client, who created cooperative and trustful relationships between the project actors. This resulted in a low contingency fund (2.5%) and, therefore, lower project cost. In comparison, contingency funds in Canadian contracts are between 8 and 20% (Zaghloul and Hartman, 2003).

The overall conclusion is that the procurement options that support early involvement of the actors and create opportunities for an open dialogue and collaboration result in a more effective risk management process.

REFERENCES

Akintoye, A. & Main, J. (2007) Collaborative relationships in construction: The UK contractors' perception. Engineering, Construction and Architectural Management, 14 (6), 597-617.

Akintoye, A. S. & MacLeod, M. J. (1997) Risk analysis and management in construction. International Journal of Project Management, 15 (1), 31-38.

Andi (2006) The importance and allocation of risks in Indonesian construction projects. Construction Management and Economics, 24 (1), 69-80.

Baker, S., Ponniah, D. & Smith, S. (1999) Risk response techniques employed currently for major projects. Construction Management & Economics, 17 (2), 205-213.

Dagenais, D. A. (2007) Introduction to good faith in construction contracts. Construction Management and Economics, 25 (7), 715-721.

Eriksson, P. E. & Laan, A. (2007) Procurement effects on trust and control in client-contractor relationships. Engineering, construction, and architectural management, 14 (4), 387-399.

Ernzen, J. J. & Schexnayder, C. (2000) One company's experience with design/build: labor cost risk and profit potential. Journal of construction engineering and management, 126 (1), 10-14.

Gransberg, D. D. & Molenaar, K. (2004) Analysis of owner's design and construction quality management approaches in design/build projects. Journal of management in engineering, 20 (4), 162-169.

Håkansson, U., Hässler, L. & Bröchner, J. (2007) Risk exposure in design-build contracts. Byggteknik, 1 33-34.

Kadefors, A. (2004) Trust in project relationships - inside the black box. International Journal of Project Management, 22 (3), 175-182.

Konchar, M. & Sanvido, V. (1998) Comparison of U.S. project delivery systems. Journal of construction engineering and management, 124 (6), 435-444.

Ling, F. Y. Y., Chan, S. L., Chong, E. & Ee, L. P. (2004) Predicting performance of design-build and design-bid-build projects. Journal of construction engineering and management, 130 (1), 75-83.

Lyons, T. & Skitmore, M. (2004) Project risk management in the Queensland engineering construction industry: a survey. International Journal of Project Management, 22 (1), 51-61.

PMI (2000) A guide to the project management body of knowledge, Newton Square, Project Management Institute.

Rahman, M. & Kumaraswamy, M. (2002) Joint risk management through transactionally efficient relational contracting. Construction Management & Economics, 20 (1), 45-54.

Simu, K. (2006) Risk management in small construction projects. Department of Civil, Mining and Environmental Engineering. Luleå, Luleå University of Technology.

SOU (2002) Skärpning, gubbar! About competition, quality cost and competence in the construction sector. Stockholm, Construction commission.

Tang, W., Qiang, M., Duffield, C., Young, D. M. & Lu, Y. (2007) Risk management in the Chinese construction industry. Journal of construction engineering and management, 133 (12), 944-956.

Uher, T. E. & Toakley, A. R. (1999) Risk management in the conceptual phase of a project. International Journal of Project Management, 17 (3), 161-169.

Wood, G. D. & Ellis, R. S. T. (2003) Risk management practices of leading UK cost consultants. Engineering, construction, and architectural management, 10 (4), 254-62.

Zack, J. G., Jr. (1996) 'Risk-sharing' - good concept, bad name. Cost engineering, 38 (7), 26-31.

Zaghloul, R. & Hartman, F. (2003) Construction contracts: the cost of mistrust. International Journal of Project Management, 21 (6), 419-424.

SYSTEM DYNAMICS FOR CONTROLLING SUSTAINABLE PROJECTS

Dr. Ibrahim Motawa
School of the Built Environment, Heriot-Watt University, Edinburgh, EH14 4AS, UK
i.a.motawa@hw.ac.uk

Abstract
Traditional construction projects are widely seen as unpredictable in terms of delivery on time, within budget and to the quality standards. The introduction of the concept of sustainability in construction has added more pressures on the control systems of these projects. Typically, managing time and cost has always been investigated in isolation of other qualitative measures such as quality, safety, and environmental impacts. However, the later were also researched in isolation of the former. Projects actually work as a system, whose elements highly affect each other. While the typical project control methodologies usefully guide project team to better control the major performance measures of projects, they do not provide a complete response to the need to characterize project performance in an integrated view as a system-based approach. The integration of qualitative and quantitative measures in project control was always seen as a challenge in this field. This research will help overcoming this challenge and investigate and make explicit the advantages of applying control mechanisms by developing a system dynamic tool that links the behaviour of both qualitative and quantitative project characteristics with the target levels of performance. The main conclusion drawn in this paper is that system dynamics concepts and tools can be integrated into project management practices for better understanding of the system in which project management operates to construct sustainable projects. This will enable the industry to rethink the A/E/C construction processes and provide the project manager with a set of robust methods for planning and controlling today's construction projects.

KEYWORDS: Project Management; System Dynamics, Sustainable Construction

Introduction

The introduction of the concept of sustainability in construction has added more pressures on the control systems of construction projects. Construction development agencies are now tasked with promoting sustainable development to meet an environmental standard such as: EcoHomes or BREEAM. A sustainable approach is a dynamic process through which organisations can achieve a balance between the economic, environmental and social accountability.

Construction industry always comprises many influencing variables that make projects highly complex to achieve sustainable performance in terms of Time, Cost, Quality, Safety and Environmental impacts. As projects get more complex, as chances to meet project goals are likely to become more critical. This makes project management concepts and tools operate on too complex and volatile systems. These systems contain too much apparent randomness to be managed effectively by the linear and deterministic tools that focus on one part of the system at a time (Rodrigues and Bowers 1996, Williams 1999, Love et al 2002). When investigating a project system to improve project performance, there is always a need to identify and implement suitable project policies to deal with any undesirable variances to the performance measures. Project managers are monitoring these measures, defining the variances, and managing the cause and effect relationships of the influencing variables to meet project goals. However, the cause and effect relationships in this situation are more complicated than assumed by the use of traditional project management tools, (Pena-Mora and Parks 2001). Managers are often faced with the difficult task of forecasting the dynamic effects of implementing these policies on projects. The existence of numerous interconnected variables, which are internal and external to a unique and complex project, contributes to this difficulty. This difficulty highlighted the need to use an advanced technique to control sustainable projects in their dynamic behaviour. Project's dynamic behaviour means that the relationships between variables and their impact are changing over time. Stoner et al (1995) used the term dynamic engagement to describe the modern construction project management system. Dynamic engagement emphasises how managers react to change over time considering that activities are performed in the face of unprecedented changes. System dynamics concepts and tools can help in this respect for better understanding of the system in which project management operates to construct sustainable projects.

Despite the need to integrate system dynamics principles and tools into project management, integration of system dynamics into project management has progressed slowly, Toole (2005). Therefore, this research will investigate the dynamic behaviour of the sustainable performance measures and how the reaction of managers can improve these measures when projects are subjected to errors and/or changes. The research will focus on approaches that will encourage best practice and help facilitate project stakeholder satisfaction.

This paper summarizes the available examples that integrate project management and system dynamics in construction, and introduces the system dynamics principles and tools followed by a project causal diagram. The paper concludes by developing basic multiple feedback loops within project management systems that can be used to develop an advanced system dynamics tool for controlling sustainable construction projects.

Background/Context

Project management tools vary from the basic tools of CPM/PERT to the most advanced simulation-based methods. The traditional CPM/PERT (Critical Path Method/Program Evaluation and Review Technique) - based scheduling methods have been the most widely used planning and control methods for construction projects. CPM introduced network scheduling in the 1950's. CPM allows the logical analysis and manipulation of a network to determine the best overall program of operation. PERT was developed to deal with uncertainty in projects by incorporating probabilities into the duration of project activities. Since the development of CPM and PERT, many network-based tools have been developed supplementing CPM and PERT. PDM (Precedence Diagramming Method) added different types of precedence relationships between activities to the traditional CPM. GERT (Graphical Evaluation and Review Technique) made it possible to model 'what-if' conditions by incorporating probabilistic branching and loop structures into network scheduling. Q-GERT (Queue-Graphical Evaluation and Review Technique) based on GERT provided for the management of multiple projects and teams. SLAM (Simulation Language for Alternative Modelling), which was developed based on the concepts of GERT and Q-GERT, demonstrated the possibility of integrating simulation-based methods and the traditional network scheduling by providing a user-friendly graphic interface for easy data input/output and schedule network building.

However, most projects today have demonstrated that CPM/PERT-based scheduling methods usefulness is warranted only when construction is not heavily constrained by either time or resources under a dynamic environment, Hegazy (1999). Since CPM/PERT-based scheduling methods assume that the attributes of project activities are known at the beginning of a project and do not change during the project execution, they are not adequate for representing the actual project progress, which results in frequent manual updates to the schedule to reflect the actual performance, Martinez and Ioannou (1997). Furthermore, the design and construction process is inherently dynamic and complex due to many underlying feedbacks that include many qualitative and quantitative factors.

The contemporary approach for project management considers not only shortest possible completion times but also paying more attention to other qualitative measures such as quality, safety, and environmental impacts. Project managers should avoid putting excessive emphasis on any one goal because of the likely undesirable variances associated with other project goals. For example, crashing project schedule by increasing resources will unlikely result in a proportional reduction in duration and always leads to cost increase. On the other hand, requiring substantial overtime will fatigue the workers, which will result in decreased productivity and poor quality and may necessitate rework. In short, controlling project time should not be dealt with in isolation of other measures of project control. In general, a decision to rectify disruptive consequences in projects based solely on linear assumptions would ignore several important aspects of the underlying project system and result in a less than ideal decision, Toole (2005).

As the quality measures have great impacts on the performance of projects, they should be considered in integration with other quantitative aspects of time and cost. In this respect, the introduction of TQM philosophy has helped improving productivity and customer/employee satisfactions. Quality management to improve the performance of projects has provided solutions to the quality problems and is still one of the challenges to practitioners. The concept and application of Quality Assurance (QA) has helped in this direction. QA is merely a technical inspection and surveillance procedure to monitor activities and mechanisms that aims to prevent quality deviations and to give early warning of poor quality. Failing to abide by the QA standards result in rework, which has substantial consequences on the progress of projects. When dealing with poor quality issues, it is crucial to understand the behaviour of rework as a corrective action to project system. Establishing effective rework prevention strategies require better understanding of the interdependence between a project’s subsystems and other performance measures. For example, rework always results in project delay and cost over runs. It also reduces project team motivation that increases work pressure, which in turn disrupts individuals’ productivity. Rework may also increase the number of parallel activities, which in turn increases the accident rate. Therefore, a holistic approach to deal with quality problems will help when project teams find it difficult to fulfil simultaneous objectives.

On the other hand, dealing with safety problems is always considered when measuring project performance. Developing Safety Programs for projects always requires the identification of the business benefits, roles and responsibilities, hazard identification and control, training and communication, documentation and enforcement of safety rules, maintenance of safe working conditions, setting performance goals, rewarding safety performance, and reviewing circumstances involved in incidents. The benefits expected from such programs include reduced workers’ compensation claims, reduced expenses related to injuries and illnesses, reduced absenteeism, lower employee complaints, improved employee morale and satisfaction, increased productivity, reduction of hidden cost, and reduced insurance cost. Despite the benefits of having a safety program, there are many indirect effects that should be investigated in association with other performance measures; such as: replacement and training cost for new or substitute employee, workers compensation cost, penalties for non-compliance, and the expected decline in project delivery and quality in case of replacement. Maintaining training programs can be debatable if the project is already over budget. This shows the importance of tackling safety problems in a holistic approach with other project performance measures.

In terms of environmental impacts, construction development agencies are now tasked with promoting sustainable development to meet an environmental assessment standard such as: EcoHomes or BREEAM. This creates an additional level of control over all aspects of construction. The key to successful sustainability requirements is to make them specific, achievable, measurable, and controllable. A sustainable approach is a dynamic process through which organisations can achieve a balance between the economic, environmental and social accountability. Despite the expected business benefits like reduced utility bills, increased productivity and staff retention, there are barriers to the wider adoption of more sustainable design and construction solutions. For example, the short-term costs of more sustainable practices are too high to justify their application in a competitive property market.

The applied schemes allow for BREEAM Certificates to be awarded at the design stage of a project, and for a certified post construction review to be carried out ensuring that the project has been constructed in accordance with the design standards and specification. A sustainable approach should also need monitoring the sustainability measures during the construction phase, especially if a change is proposed or an error is detected. It aims to balance the financial, environmental, and operational aspects of every decision, material and system in the development.

The above discussion shows that the success of a sustainable project requires the integration of effective management of qualitative and quantitative measures for both tasks and teams, which can only be achieved if projects are managed controlled as a system of interdependent components. This responds to the ongoing demand of fulfilling the expectations of project teams to create high quality performance and deliver value. This also complies with the ambition of modern research efforts which emphasis that 'system-based approaches which consider products and their effects throughout the complete product life cycle will become more common', A Vision for Research (2003). While the above control methodologies usefully guide project team to better control the major processes of projects, they do not provide a complete response to the need to characterize project performance in an integrated way as a system-based approach. In reality, projects will deviate from the ideal process model. What practitioners need is guidance or systems which help them to get back to good process quickly and without compromising any performance measure widely. Construction practitioners require methods of observing, understanding, and investigating the conflict often present among project variables due to competing value systems, internal complexity, and changing relative importance over the project life cycle. Therefore, a generic and dynamic project management system to provide sufficient insights into the complex systems that underlie project management is timely needed. This system needs to capture the "soft" variables associated with people and tasks as well as the "hard" variables, which together have a significant influence on the progress and quality of projects and sometimes in a very counterintuitive manner. In this sense, system dynamics concepts and tools can be integrated into project management practices for better understanding of the system in which project management operates. This will enable the industry to rethink the A/E/C construction processes and provide the project manager with a set of robust methods for planning and controlling today's construction projects.

The general aim of this research is to develop a more holistic approach to investigate projects performance during project life cycle in order to increase the likelihood of their success. Although many other performance measures can exist, the proposed research will focus on the major ones; Time, Cost, Quality, Safety, and Environmental (TCQSE) measures. This research will capture the dynamics involved in construction activities as projects evolve, focusing on the effects of errors and changes that may lead to variances in these measures. The research will help project team manage the dynamic behaviour of projects when variances in control measures are observed. The main challenge to achieve this objective is how the qualitative and quantitative measures can be integrated. Therefore, System Dynamics (SD) methodology is adopted.

In this paper, an attempt is made to investigate the dynamics of construction projects when variances in TCQSE measures caused by errors and/or changes are observed. A Project Causal

Diagram (PCD) will be introduced to integrate the most significant parties to construction projects, and to incorporate the important construction sub-systems in order to better understand the relationships among the work progress in projects.

System perspective of project management

To understand the internal mechanisms of project control, project activities should be investigated from a systems perspective. Such a perspective provides a fundamental shift in managing projects and explores control problems in a holistic manner where links amongst different components of a system can be studied.

In general, a 'System' can be defined as 'A collection of operations and procedures, people and machinery by which any business activity is carried out'. As shown in Figure 1, a system generally consists of: resources (input such as labour, materials, data, etc.) that go through a regulated change process (assembly, construction, etc.) in order to produce an output (a building, a profit, information, etc.). The feedback forms all learning and corrective actions within the system.

System components are always affected by the surrounding environment, which can be defined in a number of sub-systems. Each sub-system describes the behaviour of related elements and all sub-systems are integrated. For example, elements that may affect the system technical/operational behaviour may include: the operating environment, technical support and the technology. These elements also influence quality-related issues. Other elements of a human resources sub-system may include: manpower availability, skill levels, communication procedures, and employee morale. These elements determine training needs, employee motivation, and the decision-making process in project organization. The introduction of the SD principles will investigate how one element relates or causes a change to another.

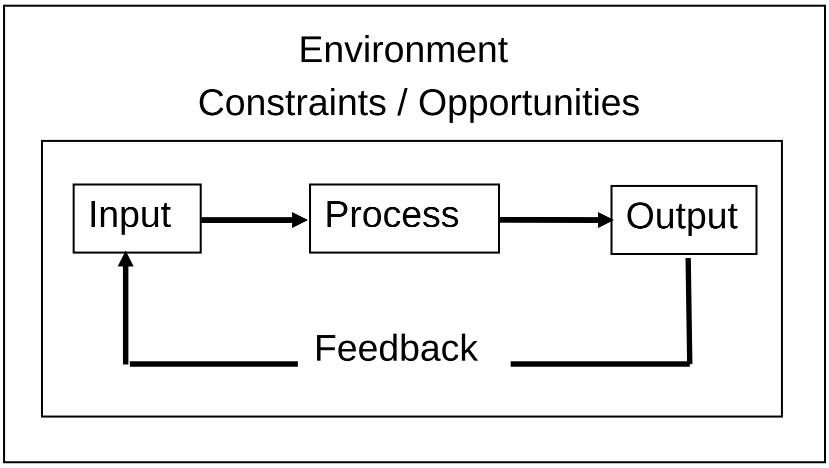


Figure 1: System perspective of project management

Fundamentals of System Dynamics

SD is both a methodological approach and set of analytical tools which have the potential to alleviate several deficiencies in current project management analytical techniques. Coyle (1997) defines SD as a method that 'deals with the time-dependent behaviour of managed systems with the aim of describing the system and understanding through qualitative and quantitative model, how information feedback governs its behaviour, and designing robust information feedback structures and control policies through simulation and optimisation'. The key aspect of SD is that all elements within a system are related. As noted by Rodrigues and Bowers (1996), the application of system dynamics to project management has been motivated:

- the need to take holistic approach (recognizing that the whole is greater than sum of the parts);
- the need to understand non-linear behaviour; and
- the need for a learning laboratory tool.

SD initially used to model electromechanical processes, and then extensively used to model organizational, social, economic, biological and other types of systems (Sterman 2000). Richardson and Pugh (1981) developed a simple SD model for project management. Other SD models were developed such as software project staffing (Hamid, 1989), parallel activities and project duration (William *et al.*, 1995), the impact of client behavior on project development (Rodrigues and Williams, 1998), rework error in a project system (Love et al, 1999), and design error induced rework in construction (Love *et al.*, 2000). Pena-Mora and Park (2001) used causal loop diagrams and a detailed computer tool to model the effect of concurrent design and construction on building completion time and cost. Love et al (2002) used causal loop diagrams to gain insight into the effect of scope changes on construction projects. Chritamara and Ogunlana (2002) developed a SD model of design and build projects, focusing on policies to achieve improvement in time and cost. Gelbard et al (2002) discussed the integration of systems analysis computer tools and project management tools, but systems analysis tools were not based on system dynamics. Ogunlana et al (2003) used system dynamics to model the performance of construction organisations. Park et al (2004) used system dynamics to model construction innovation on a project level. In this research, SD will be used to simulate the control mechanism of sustainable construction projects.

For a SD model, the system structure and the underlying relationships can be depicted graphically using causal loop diagrams. To create a causal loop diagram, one needs to identify the variables associated with a system, identify the causal relationships among these variables, and decide on the type of this relationship. A positive relationship indicates that when one variable increases, the other linked variable also increases. A negative relationship indicates that when one variable increases, the other variable decreases. The structure of system variables and relationships may create feedback loops, which can be positive or negative as well. The polarity of a feedback loop (i.e., positive or negative) is identified by summing the polarities of the individual relationships between the variables within the loop. Loops with an odd number of negative relationships are negative. Loops with an even number of negative relationships are positive. Variables within positive loops will continue to increase indefinitely, therefore positive loops are self-reinforcing. Variables within negative loops will stabilize over time, therefore negative loops are self-balancing. Feedback loop structures, once identified, are translated into stock-flow diagrams to enable simulation. The simulation part is beyond the scope of this paper.

SD can be used simultaneously with traditional project management techniques, serving as an analysis tool for decision making by practitioners, thus complementing the planning technique. The following section presents a set of project causal diagrams (PCD) that represent different aspects of project control.

Project Causal Diagram

Variances in control measures at a specific point in time represent the difference between the actual and the planned project goals. For this research, detailed causes and effects of these variances when an error or change occurs are to be defined at more detailed levels. This section of the paper presents a PCD for a generic project management system. It includes the key variables and their relationships to represent how projects behave when subjected to errors and changes. The PCD at this level does not depict the system underlying all project contexts. This PCD introduces a generic model that can be used to develop understanding of project systems where project management operates, and to create customized PCDs that best represent individual project management systems.

As construction projects are highly affected by the accuracy and clarity of project brief and program, Figure 2 shows a generic PCD that represents the positive relationship of this accuracy with the satisfactory production rate and the negative relationship with the uncertainty level. Increases in the level of uncertainty mean more errors and/or changes are expected. Following on the increases in errors and/or changes, the satisfactory production rate is going to decrease. The generic PCD also shows the associated relationship when a change is proposed to the initial scope of the project. It is worth to emphasis that this research aims to investigate the disruptive effects on the projects due to errors and changes. This means that changes can bring constructive impact to projects. However, re-work, as the main consequence of errors and changes whether at the design or construction stage, is usually pure waste and should be avoided. Therefore, the main concern is on the unproductive and non-value-adding activities.

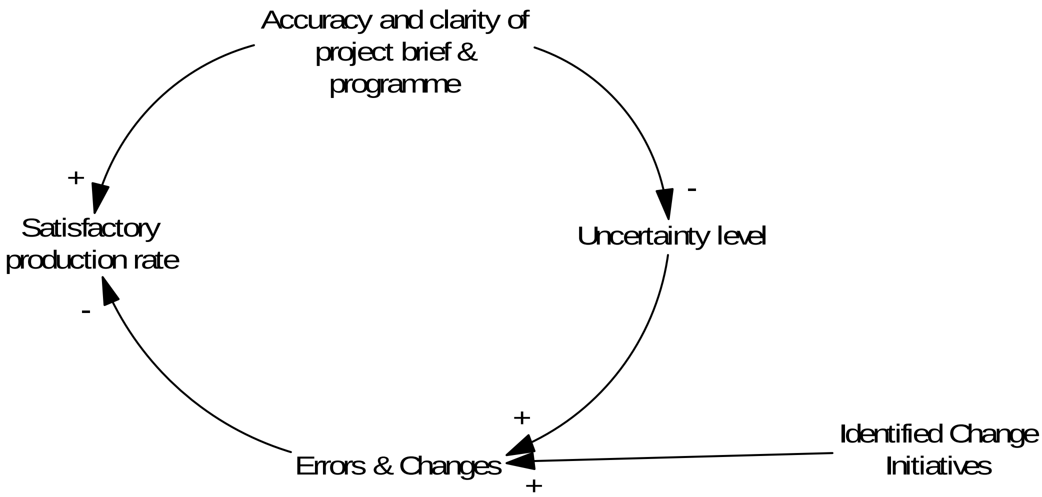


Figure 2 Generic Project Causal Diagram (PCD)

Figure 3 shows a generic example of how errors and/or changes can affect the variances in costs, quality and safety. The most important variable is the rework and/or additional work, which represents the quality measures in this model. Having such variance in quality will increase the variance in cost. Figure 3 also shows how a programme for training and skills development, set to minimise the accident rate probability as a safety measure, can be affected if cost variance is observed. When a project is already over budget, it will be difficult to maintain a training programme. As a result, the PCD develops two positive (self-reinforcing) feedback loops; inner and outer loops. These feedback loops demonstrate the complexity of considering the cost, quality, and safety measures of a project system.

Figure 4 shows how project team can tackle time variance by using additional resources or overtime. Different consequences can be detected that may lead to negative (self-balancing) feedback loops, such as the one developed because of establishing the training program [Time variance, additional resources, training, knowledge, satisfactory production rate]. It may also lead to positive loops, such as [Time variance, overtime, project fatigue, satisfactory production rate]. The outer loop illustrates the case of adopting another policy to tackle the time variance problem using additional resources [Time variance, additional resources, number of parallel activities, work complexity, satisfactory production rate].

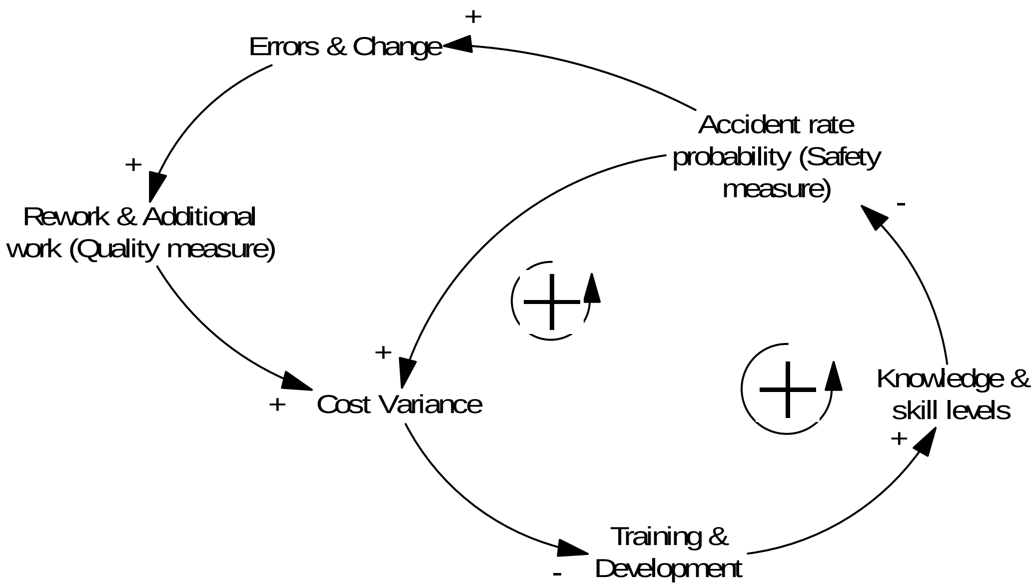


Figure 3 Cost & Quality & Safety variances PCD

The PCD in Figure 4 does not include all variables underlying a project management system. For example, satisfactory production rate is certainly affected by other variables, such as site conditions and weather. Time variance results not just from rework, but also from other variables, such as unforeseen conditions and delay in decision making. Although the PCD does not provide a rigorous diagram in its current development, it will depict the feedback loops within the system that can lead to counterintuitive behaviour.

Figure 5 reflects on the variables of morale and motivation level. The principles underlying these relationships are that personnel motivation can substantially influence task's progress and that work pressure can cause progress to be slower than originally estimated.

The PCD in Figure 6 is produced by integrating all the illustrated PCDs to visualize a holistic view of project systems. It shows a number of important feedback loops that cause instability to the project behaviour. As the positive feedback loops are self-reinforcing, the values of variables within these loops can be rapidly increased or decreased. The main benefit of studying these diagrams is to identify variables within these loops that should be carefully monitored as they inherently result in downward spiral in project performance; such as work pressure. Work pressure is not a desirable variable within a system. When a project has less errors/changes, rework/additional work will not be necessary so work pressure remains minimum and the positive feedback loops involving work pressure will not affect the project performance.

CONCLUSIONS

The need to integrate system dynamics principles and tools into project management has been highlighted by many researchers. In this sense, this paper has presented a project causal diagram and used this PCD to illustrate the importance of incorporating SD in project management systems. The presented PCD will be used to develop a comprehensive SD methodology to model project control when variances in Time, Cost, Quality, Safety, and Environmental measures are observed due to errors/changes occurring in projects.

The integration of system dynamic principles into project management is a step forward approach that has implications on controlling projects. As SD assumes all elements within a system are related, the current drawbacks of focusing only on certain control measures can be dealt with.

The introduced PCD helps determine whether the project system likely develops positive or negative feedback loops. A negative feedback loop in a system will have a systemic resistance to undesirable outcomes within the system. Monitoring errors/changes in such a system may therefore require introducing change to other variables within the system to help balancing the system behaviour. However, a positive feedback loop within a system will cause instability to the system performance. Therefore, implementing changes in a positive feedback system includes monitoring all variables to ensure that undesirable outcomes are under control.

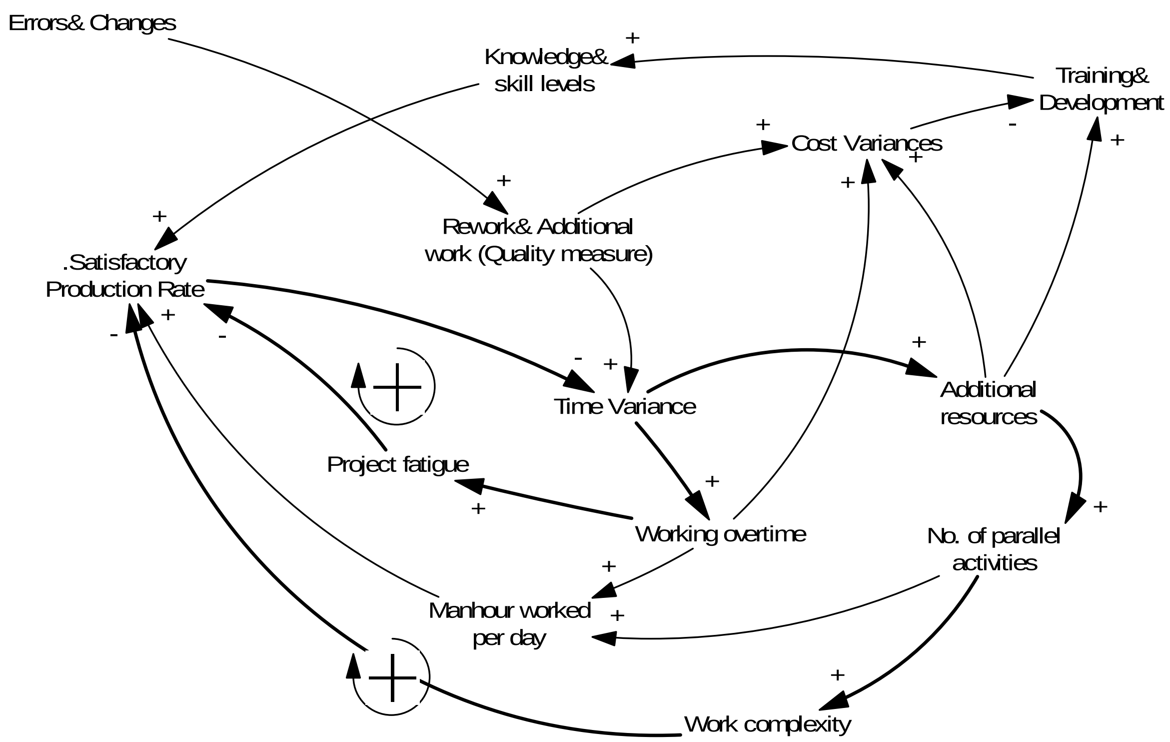


Figure 4 Time & Cost & Quality variances PCD

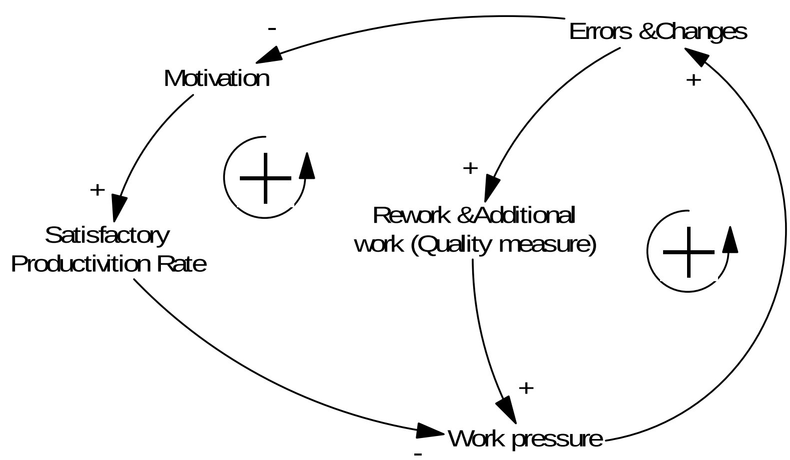


Figure 5 Qualitative variances PCD

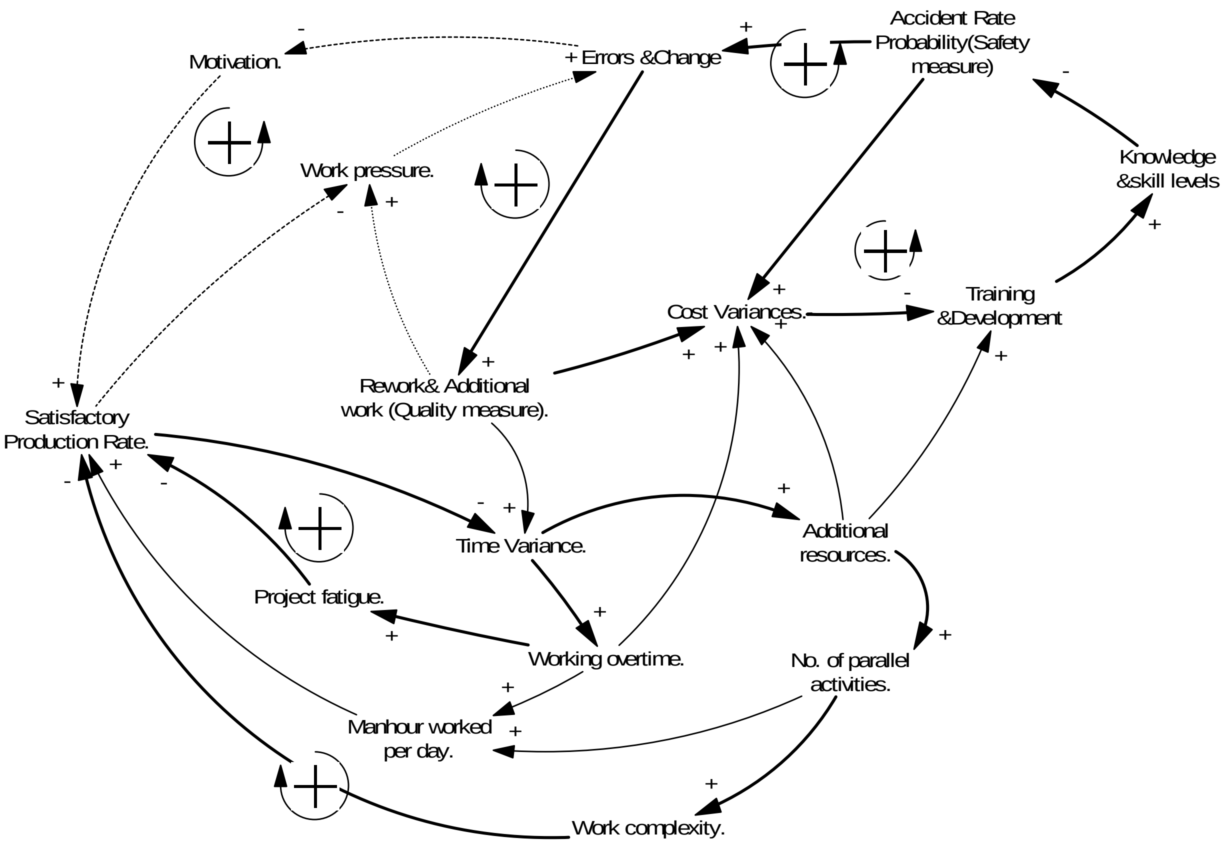


Figure 6 Integrated PCD

References

A vision for research (2003). Swindon: Research Councils UK.

Abdel-Hamid, T. (1989). The dynamics of software project staffing: a system dynamics based simulation approach. IEEE Transaction on Software Engineering 15(2), 109-119.

Coyle, R. G. (1997). System Dynamics Modelling, a practical approach. Chapman & Hall, UK.

Hegazy, T (1999). Optimization of Resource Allocation and Leveling Using Genetic Algorithms. *J. of Construction Engineering and Mgmt,* 125 (3), pp. 167-175

Love, P.E.D., Mandal, P., and Li, H. (1999). Determining the causal structure of rework influences in construction. Construction Management and Economics, 17, 505-517.

Love, P.E.D., Mandal, P., Smith, J.and Li, H. (2000). Modelling the dynamics of design error induced rework in construction. Construction Management and Economics, 18, 567-574.

Love, P.E.D., Holt, G.D., Shen, L.Y., Li, H., and Irani, Z. (2002). Using systems dynamics to better understand change and rework in construction project management systems. International Journal of Project Management 20 (6):425-436.

Chritamara, S. and Ogunlana, S. O. (2002). System dynamics modelling of design and build construction projects. J. of Construction Innovation, 2, 269-295.

Martinez, C. Julio., and Ioannou, G. Photios. (1997) "State-Based Probabilistic Scheduling Using STROBOSCOPE's CPM Add-On" Proceedings, Construction Congress V, ASCE, Stuart D. Anderson, ed, Minneapolis, MN, 438--445.

Ogunlana S.O., Li, H. and Sukhera, F.A. (2003). System dynamics approach to exploring performance enhancement in a construction organization. *J. of Construction Engineering and Mgmt*, 129 (5) 528-536.

Park, M., M. P. Nepal and M. F. Dulaimi (2004). “Dynamic modeling for construction innovation.” ASCE *Journal of Management* 20(4): 170-177.

Pena-Mora, F. and Park, M. (2001). Dynamic planning for fast-tracking building construction projects. ASCE Journal of Construction Engineering and Management 127(6): 445-456.

Rodrigues, A. G. and Pugh, A. L. (1981). Introduction to System Dynamics Modelling with DYNAMO. Cambridge: MIT.

Rodrigues, A. G. and J. Bowers (1996). The role of system dynamics in project management. International Journal of Project Management 14(4): 213-220.

Rodrigues, A. G. and Williams, T.M. (1998). System Dynamics in project management: assessing the impacts of client behaviour on project performance. Journal of the Operational Research Society, 49, p2-15.

Sterman, J.D. (2000). Business dynamics: systems thinking and modelling for a complex world. McGraw-Hill.

Stoner, J., Freeman, A., and Gilbert, D. (1995). Management. Englewood Cliffs, NJ: Prentice Hall.

Toole, T. M. (2005). A project management causal loop diagram. In: Khosrowshahi, F. (Ed.), 21st Annual ARCOM Conference, 7-9 Sep. 2005, SOAS, University of London, Association of Researchers in construction management, Vol. 2, 763-772.

Williams, T., Eden, C., Ackermann, F. and Tait, A. (1995). Vicious circles of parallelism. International J. of Project Management, 13(3), 151-155.

Williams, T.M. (1999). The need for new paradigms for complex projects, International Journal of Project Management 17 (5): 269-273.

MATERIAL WASTE IN THE UAE CONSTRUCTION INDUSTRY: MAIN CAUSES AND MINIMISATION PRACTICES

Assem Al-Hajj
Heriot Watt University, Dubai, UAE
A.Al-Hajj@hw.ac.uk

Karima Hamani
Heriot Watt University, Dubai, UAE
Kh66@hw.ac.uk

Like many countries in the world, the UAE is currently facing a big challenge to manage the increasing amounts of waste generated from the construction activities and dumped in landfills. This research examined the current sources of waste in construction and the recommended measures to minimise this waste. The significance of these sources of waste and the frequency of the implementation of adequate measures were subsequently examined by means of a mixed research method strategy including case studies and a survey. The results revealed that the most significant causes of waste are lack of awareness; off-cuts; and rework and variations; and the most frequent measures practiced are staff training; adequate storage; and just- in time delivery of materials. Moreover, the perceptions of contractors towards the benefits of waste minimisation revealed that waste minimisation is primarily considered as a cutting cost activity. In contrast, the environmental benefits were largely neglected by the surveyed companies.

KEYWORDS: waste, sources, minimisation, UAE.

INTRODUCTION

The UAE construction industry like its counterparts in many other countries is a major and vital sector to the national economy. In spite of the reliance on the oil industry as the main contributor to the GDP, the construction industry still brings a significant input to the economy; it accounts for 8% of the national GDP; and employs around 23% of the civilian population (UAE Interact, 2008). Moreover, the UAE is becoming the land of the world's highest tower, the world's biggest shopping mall, the Middle East's largest airport and many other mega projects. However, according to the 2006 Living Planet report from the World Wildlife Fund, the UAE has also the world's largest ecological footprint (Samari and Qudah, 2007; Puckett, 2008).

In order to improve its eco-credentials, The UAE in general and its construction industry in particular have only one choice to make: 'Going Green'. Going green is about thinking lean and managing the waste resulting from this speedy development. Similarly to its eco-footprint record, the UAE is considered as one of the biggest producers of waste, 75% of which is from construction waste (UAE Interact, 2007) and it is ranked second to USA in waste share per capita among the world countries (Al-Qaydi, 2006). The situation is getting worse every year; for instance, the amount of construction waste dumped in Dubai's landfill for the year 2007 has reached 27.7 million tons which is almost three times the volume generated in 2006 (10.6 million tons). The increase is continuing in 2008 as it is reported that the construction waste from the first half of 2008 is already double that produced in 2007 with 35000 tons of sites' debris discarded daily (Alkhafaf, 2008). These figures show the urgent need for a revolution in the way the country is handling waste; adopting other waste management practices instead of disposal should be the way forward.

This research seeks to contribute to the implementation of this change by investigating the causes of waste in the UAE construction sites and examining the current practices implemented by the contractors to minimise waste.

CONSTRUCTION WASTE

Construction waste has been defined in various ways. Some of these definitions are listed below:

1. Building Research Establishment (1981): any material apart from earth materials, which needed to be transported elsewhere from the construction site or used on the site itself other than the intended specific purpose of the project.
2. Environmental Act 1990 (cited in Cheyne et al., 1995): A scrap material or an effluent or other surplus substance arising from the application of any process.
3. Koskela (1992) and Alarcon (1993): Any activity that takes time, resources or space but does not add value.
4. Formoso et al. (1999): Any losses produced by activities that generate direct or indirect costs but do not add value to the product from the point of view of the client.

After reviewing these definitions the following definition was adopted for this study: *Construction waste is any scrap material generated and removed from sites during the construction process*.

Defining the scope of waste and the identification of its meaning is the first step in dealing with it. The next step is about looking at the sources of waste and analysing the causes behind its generation.

SOURCES OF CONSTRUCTION WASTE

Many factors contribute to the generation of construction waste. These factors have been grouped by Ekanayake & Ofori (2000) under four categories: (1) design; (2) procurement; (3) handling of materials; and (4) operation. They have concluded that most of the causes of waste are due to design issues. This finding has also been reported by a number of studies (Ekanayake and Ofori, 2004; Keys et al., 2000). It is, thus, agreed that the process of waste minimisation must be started at the early stages of the project. However, for the purpose of this study, the focus will be on the construction stage of the project life cycle.

The three aspects investigated in this study are Procurement, Operation and Handling. It is worth noting that waste generation is not only a technical issue but a behaviouristic one as well. Teo et al. (2000) stated that “the labour intensive nature of construction activity suggests that behavioural impediments are likely to influence waste levels significantly”. This statement was supported by Lingard et al. (2000) who pointed out that effective waste minimisation depends on the extent to which participants to the construction process change their behaviour in relation to waste issues. Therefore, sources of waste revolve around four factors namely: procurement, handling, operation and culture. A review of the main origins of construction waste belonging to each category is summarised in table 1. In addition to these direct causes of waste, there are also some indirect factors that contribute to the increasing generation of waste. These are mainly related to the existence of strong drivers for minimising material waste.

Table1: Sources of construction waste

Procurement	Handling	Operation	Culture
Delivery methods Delivery schedules Purchase of inadequate materials Poor quality of materials No take back schemes Poor advice from suppliers Poor supply chain management	Damages due to transportation Inappropriate handling Poor product knowledge Inappropriate storage	Rework and variation Unskilled labour Time restraint Poor coordination between trades Inclement weather	Lack of awareness Lack of incentives Lack of support from senior management Lack of training

DRIVERS FOR WASTE MINIMISATION

According to Osmani et al. (2006), the drivers for waste minimisation can be categorised into four main groups: environmental, industry, economic issues and legislation. From these broad categories, the following can be considered as the key drivers:

•**Government policies and contractual terms**: The reluctance to implement effective waste management has incited many governments to decree waste management laws and policies. The most common regulation is related to the landfill tax which is applied in many countries in the world. In addition to these regulations, contract document can stipulate the required levels of waste segregation and minimisation and also specify some "punitive measures for non-compliance"(Macozoma, 2002: 6).

•**Environmental standards**: The ISO 14001 for Environmental Management System (EMS) is one of the accreditations that improve the image of construction companies as green contractors; and it is considered as a vehicle for organisations to minimise the impact of their activities on the environment. One of the main requirements of the ISO 14001 is waste minimisation and the development of a waste management plan as part of the EMS (Poon et al., 2004; Powell et al., 2001).

•**Financial benefits**: Envirowise (2007) have proved through case studies that the true cost of waste disposal is more than the cost of paying a waste contractor to remove a skip from site and a number of researchers have highlighted the financial benefits of waste minimisation (e.g. Osmani et al., 2006; Begum et al., 2006; Tam et al., 2005; Shen et al., 2005). But, the true cost of waste is still underestimated by contractors (WRAP, 2007b).

WASTE MINIMISATION MEASURES

Waste minimisation is increasingly becoming a topical subject and an important area of research. Many definitions are given to the term; however there is no agreed one amongst researchers. Sometimes, it is used interchangeably with waste management and waste prevention. Jacobsen and Kristofferson (2002) in their report on waste minimisation practices in Europe gave a clear distinction between the three concepts and defined waste minimisation as a set of three options prioritized according to the waste hierarchy. The first priority is waste prevention; the second is waste re-use while the third priority is waste recycle. Reducing the waste generated at source is considered as the first option to be implemented for better protection of the environment, and for better economic savings. A review of the literature suggests the followings measures as the main solutions for efficient prevention of site waste:

- **Logistic management**: It has been the subject of many reports published by the Waste and Resources Action Programme in the UK where they emphasise the importance of implementation of a sophisticated Material Logistics Plan (MLP) on site for better waste reduction. In fact, logistics management is proven to prevent double handling and ensure the adequate handling of equipment to minimise damage to materials on site (WRAP, 2007a).
- **Supply chain management**: It is based on long-term commitment with suppliers and subcontractors and on the win-win arrangements (Ofori, 2000). A good SCM can help to achieve Just-in-Time delivery in order to avoid problems and waste due to long storage or to ordering unneeded materials (DEFRA, 2008; WRAP, 2007a; CIOB, 2004; Mc Donald, 1998).
- **Modern construction methods**: A study published by WRAP in January 2007 shows that "the substitution of some modern methods of construction for traditional building methods does result in a net reduction in waste levels" (WRAP, 2007c, p77). Dainty and Broke (2004) have reported the same finding in their survey of waste minimisation measures implemented in the UK; they stated that there is an increase use of off-site prefabrication to control waste and damage on site.
- **Training and incentivising**: a number of studies and government guides insist on staff training as one of the first steps in dealing with construction waste. Increasing the awareness could be through using toolbox talks or waste posters about the benefits and rules of waste on site (WRAP, 2007b). In addition, incentives for good performers can contribute to meet the waste targets (Lingard et al., 2001).

Reuse and recycling are usually treated together in the literature. Both of these two practices require a separation of waste streams in order to be accomplished (CIRIA, 1995). In fact, the good practice of waste minimisation involves segregation of key waste streams namely: timber, plasterboard, packaging, general waste, inert waste, metal and hazardous by using clearly labelled skips or bins (WRAP, 2007b). Once the waste material is segregated, the possibilities of reuse or recycling on-site must be investigated before considering any off-site recovery or disposal (DEFRA, 2008).

RESEARCH METHODOLOGY

Many surveys and studies have been carried out in different countries to identify the causes of waste and assess current practices. However, no such studies have been found in the literature for the case of the UAE. By building on the findings in other countries and taking into consideration the characteristics of the UAE in terms of culture and legislation, this research aims to fill this gap by means of a carefully selected research method.

In the construction management field, Seymoore and Rooke (1995; 1997) suggest that the rationalistic/quantitative method is not powerful in translating the perceptions and world views of people and they advocate the adoption of the interpretive/qualitative approach for the construction management research. This suggestion has been rejected by Runeson (1997) who criticises this undervaluation of the quantitative method and argues that the positivist rationalistic method which is based on scientific approach is the best way to test bad and good researches. Between these two extremes, many researchers call for "breaking the methodological monopolies"(Rafetery et al., 1996: 293); and argue that a single method cannot be appropriate to all construction research problems (Wing et al., 1998: 101). In fact, Greene et al. (1989: 256) suggest that: "all the methods have inherent biases and limitations". Thus, a mixed method between qualitative and quantitative approaches has been adopted for this study.

In order to achieve the study objectives, the field study was based on two sets of activities. First, four projects with different locations; different sizes, types and different stages of construction were visited for two purposes: observation and semi-structured interviews with contractors. The results obtained from this stage were analysed and combined with the literature findings to design and to analyse the questionnaire survey. In the second stage a non random sampling approach was adopted and only medium and large companies having construction and general contracting as their primary business were targeted. 56 responses were received from 120 questionnaires distributed which gave a response rate of 46%.

The method of analysis adopted for case study interviews was the content analysis based on coding and grouping the text obtained from interviews into different categories for further interpretation.

The analysis of the questionnaire was mainly based on the calculation of weighted average values and the standard deviation according to the following formulas:

$$AS_i = \frac{\sum_{j=1}^{n} X_j N_{ij}}{N}$$

$$\delta_i = \sqrt{\frac{\sum_{j=1}^{N} (X_j - AS_i)^2}{N}}$$

$$IV_i = AS_i + \frac{AS_i}{\delta_i}$$

ASi: the average score of the attribute (i)

Xj: the rank given to the attribute (i)

Nij: the number of respondents who gave the attribute (i) the rank Xj

n: the number of possible ranks given

δi: Standard deviation of the attribute (i)

IVi : Index Value of the attribute (i)

The same method has been used by Begum et al. (2006) in assessing the significance and levels of practice of waste minimisation factors in Malaysia; and by Shen and Tam (2002) in their study of the benefits of and barriers to the implementation of Environmental Management System in Hong Kong.

FINDINGS AND ANALYSIS

Case studies results

The description of case study projects is shown in table 2. The information about causes of waste and waste minimisation practices implemented in each project were obtained from observations during site walks and interviews with main contractors' employees. The results are summarised in table 3.

Table2 : List of case studies

Case study	Type	Location	Project stage	Interviewees
1	Industrial	Abu Dhabi	Foundation	Construction manager
2	Residential	Dubai	Finishing	Project director
3	Office	Dubai	Structure	HSE manager
4	Residential	Dubai	Infrastructure	HSE manager

Table 3 : Summary of case studies results

Case studies	1	2	3	4
Causes of waste				
Off-cuts	✓	✓	✓	✓
Lack of awareness		✓		
Rework and variations		✓		
Poor quality of products	✓	✓		✓
Temporary works	✓			
Waste minimisation measures				
Segregation of waste	✓	✓	✓	✓
Reuse of off-cuts (wood)	✓	✓	✓	✓
Reusable formwork			✓	
Adequate storage	✓			✓
Just in time delivery	✓	✓		✓
Take back schemes			✓	✓
Bar bending lists				✓
Waste Management Plan			✓	✓
Segregation area			✓	✓
Waste minimisation benefits				
Cost savings	✓	✓	✓	✓
Environmental protection		✓	✓	
Health and safety improvement			✓	
Enhancing the corporate image of the company				✓

All the interviewees agreed that most of the waste is due to off-cuts as the sizes of materials in the market are usually different from the sizes in the design drawings. Two of them mentioned the poor quality of products as one of the main sources of damages to materials especially the quality of wood. Two further causes are reported to be the lack of awareness and design errors and variations.

The above opinions show that most of the causes pointed out by interviewees are due to other parties or other stages of the project. Similar findings were reported by Ofori (2000) when he stated that waste on site is directly related to problems "on which the site personnel have very little or no influence"(p.4). However, it was observed during the site walks that there are some problems of storage and handling that can eventually engender material waste. In addition, the waste minimisation measure claimed to be implemented by all the contractors which is the segregation of waste needs more attention. Only two types of materials waste are separated these are: wood and steel. This was justified by interviewees by the fact that these two types of material are valuable and their wastage cannot be allowed. The same idea is supported by the statement of one interviewee that waste minimisation for them is part of their cost control and value management activities.

Survey results

Causes of construction waste

The list of causes was inferred from the literature review and the project cases visited. The respondents were asked to mark each cause of waste according to the level of contribution to the generation of waste in their projects. They had to choose between 4: significant contribution; 3: moderate contribution; 2: minimal contribution; and 1: no contribution.

Table 4 shows that there are three factors that have a mean greater than 3 which means more than a moderate contribution. These factors are namely:

1. Lack of workers' awareness
2. Off-cuts
3. Unskilled labour and rework

Table 4: The ranking of causes of waste

	4	3	2	1	Weighted Average	Standard deviation	Index value	Rank
Lack of workers' awareness	38	18	0	0	3.68	0.47	11.48	1
Off-cuts	17	30	8	1	3.13	0.72	7.50	2
Unskilled labour and rework	17	26	13	0	3.07	0.74	7.25	3
Time Pressure	10	27	16	3	2.79	0.80	6.26	4
Problems of handling	2	26	25	3	2.48	0.66	6.24	5
Inappropriate storage	3	20	30	3	2.41	0.68	5.95	6
Inclement weather	7	22	24	3	2.59	0.78	5.90	7
Damages during delivery	0	5	42	9	1.93	0.50	5.79	8
Poor quality of products	3	10	37	6	2.18	0.69	5.33	9
Purchase of inadequate materials	1	26	17	12	2.29	0.82	5.06	10
Poor advice from suppliers	6	16	25	9	2.34	0.88	5.00	11
Over ordering of materials	3	13	21	19	2.00	0.89	4.24	12
Bad packaging	1	2	3	51	1.13	0.43	3.75	13

It can be seen that these three factors are somehow out of the control of contractors. In fact, awareness is a general issue related to the environmental culture of the industry workforce as a whole; off-cuts are caused by the design problems; unskilled labour is a result of the construction boom in UAE and the increasing demand for workers independently of their level of experience and competence (Smith, 2008); while rework is due to the lack of skills as well as to design errors and variations. On the other hand, it can be seen from the same table that the five factors which are ranked last are all related to the procurement category of sources of waste and they are by order of significance: Damages during delivery and transport; poor quality of products; purchase of inadequate materials; Over-ordering of materials; Poor advice from suppliers; and bad packaging. Seeing these six factors as having minimal contribution can be explained by the fact that all of these problems are related to the procurement of materials; area which can be managed by contractors and which fall under their control. This supports the finding from the survey undertaken by Ekanayake and Ofori who reported that:" The responding contractors did not consider procurement-related factors as major contributors to site waste generation" (2000:5).

In addition to the direct causes of waste, the respondents were asked to give their opinions on the contribution of four indirect causes obtained from the case studies interviews. They were afforded the possibility to strongly agree (5); to agree (4); to be neutral (3); to disagree (2) or to strongly disagree (1).

The results presented in table 5 show that a majority of respondents consider the lack of government legislation and policies as the main obstacle to the reduction of waste in the UAE. In addition, 55% of them agree with the importance of contractual terms as incentives

to minimise waste on site. This reinforces what was stated in the literature review about the necessity of these two drivers to change the current waste culture and behaviour. From the other hand, by ranking high these two factors, most of the contractors show that they are reactive to laws rather than having proactive strategies. Nevertheless, this conclusion is confuted by the disagreement of 63% of the respondents with the lack of support of their companies' managers. This disagreement implies that there is a culture of waste minimisation at the corporate level which is clearly transmitted to the site level within these companies. However, the disparity in the opinions about this factor is clearly illustrated in its standard deviation of 1.33; 38% of the respondents feel a lack of support from their managers.
The results of the thirdly ranked factor show that the lack of local recycling facilities presents a real barrier to the reduction of waste as the mean is 4.30 indicating an agreement of the respondents.

Table 5: Ranking of indirect causes of waste

	5	4	3	2	1	Weighted Average	Standard deviation	Index value	Rank
Lack of government legislation and policies	32	20	4	0	0	4.50	0.63	11.62	1
Lack of contractual incentives	14	31	11	0	0	4.05	0.67	10.09	2
Lack of local recycling facilities	28	19	7	2	0	4.30	0.83	9.49	3
Lack of support from the company managers	4	17	0	22	13	2.59	1.33	4.53	4

Waste minimisation measures

The respondents were asked to specify the frequency with which they implement a Waste Management Plan on site and they had to rank different waste minimisation measures according to the frequency of their implementation. The choices given are: 4: Always, 3: Sometimes, 2: Rarely and 1: Never.

Only 12% of the respondents affirm that they always implement a Site Waste Management Plan (SWMP), while this important tool is never used by 29% of them and rarely by 41%. These results show that there is a large scope for increasing the use of SWMP in UAE projects in order to benefit from its effectiveness in reducing waste on site proved by a number of studies undertaken in different countries (e.g. Poon et al., 2004; Shen and Tam, 2002; Mcdonald and Smithers, 1998). The absence of SWMP, nevertheless, does not prevent the effective use of the waste minimisation measures highlighted in the literature review. In fact, the results presented in table 6 how that the top three ranked measures fall within the first level which is waste prevention. These measures are:

1. Adequate storage of material
2. Ordering just what is needed of materials
3. Staff training and awareness

On the other hand, the three measures that are less frequently implemented by respondents are namely:

1. Recycling on-site
2. Recycling off-site
3. Appointment of waste manager on site

It is normal that the recycling off site is rarely done because of the lack of recycling facilities as it was mentioned earlier. However, about 20% of respondents affirm that they are sometimes recycling waste off site; this can be due to two reasons: these companies are located in Sharjah where a recycling facility exists or they are considering the recycling of metal sold to scrap contractors. On the other hand, the rare implementation of the recycling on site and of the appointment of waste manager can be explained by a the fact that these practices require a financial input from contractors, which means that there must be tangible financial benefit from these activities in order to be implemented.

As a first interpretation, it can be concluded that most of the companies prefer preventing waste rather than handling it after it is produced. However, further analysis need to be undertaken in order to assess whether the preventive measures used aim to reduce waste at source or they are used for other reasons. For this purpose, the existence of relationship between the ranking of causes of waste obtained from table 4 and the ranking of the preventive measures in the table 6 was tested.

Table 6: Frequency of implementation of waste minimisation measures

	4	3	2	1	Weighted average	Standard deviation	Index value	Rank
Adequate storage of material	45	10	0	1	3.77	0.54	10.76	1
Ordering just what is needed of material	11	41	3	1	3.11	0.56	8.64	2
Staff training and awareness	31	17	7	1	3.39	0.78	7.75	3
Recording and measuring different streams of waste	20	26	8	2	3.14	0.80	7.09	4
Using mechanical handling of materials	19	21	13	3	3.00	0.89	6.35	5
Segregation of waste on site	27	11	14	4	3.09	1.01	6.14	6
Prefabrication of components off-site	1	7	38	10	1.98	0.62	5.19	7
Ordering material to size	0	11	20	25	1.75	0.77	4.03	8
take-back arrangement with suppliers	0	7	21	28	1.63	0.70	3.94	9
Reuse on site of off-cut material	0	6	21	29	1.59	0.68	3.92	10
Incentives to site personnel	0	7	19	30	1.59	0.71	3.83	11
Recycling on site	0	3	9	44	1.27	0.56	3.55	12
Recycling off-site	1	11	6	38	1.55	0.87	3.33	13
Appointment of waste manager on site	2	6	9	39	1.48	0.83	3.27	14

According to Naoum (2007), the most appropriate statistical test when assessing ordinal data that are related to more than one attribute is the Spearman Rank Correlation test and; so a critical value for 56 subjects was set at 0.4433 at the level of $p > 0.005$. The value of rho was obtained by using the CORREL statistical function in Excel. The null hypothesis was set as: “there was no significant relationship between the ranking of the preventive waste minimisation measures and the correspondent causes involving these measures". Table 7 shows the results found for the three firstly ranked measures.

Table 7: Correlation test between causes and preventive measures

Cause of waste	Preventive measure	ρ
Waste minimisation training and awareness	Lack of awareness	+0.65
Adequate storage of material	Inappropriate storage	-0.56
Ordering just what is needed of material	Delivery schedules	-0.69

The following conclusions can be drawn from the figures obtained:

- All the coefficients in absolute value exceeded the critical value of 0.4433 and it was concluded that the null hypothesis should be rejected.
- The positive correlation between the ranking of 'Waste minimisation training and awareness' and 'Lack of awareness' can be interpreted in two ways: 1) this measure is frequently used because of the lack of awareness is considered as a high contributor to waste or 2) Lack of awareness is still considered as a significant factor because the training and awareness activities were not sufficiently efficient.
- The negative correlation between the rankings of 'adequate storage on site' and 'inappropriate storage' ; and between 'ordering just what is needed of materials' and 'delivery schedules' indicate that the two factors are considered of minimal contribution to the generation of waste because of the frequent implementation of the appropriate measures.

Benefits of waste minimisation

The respondents were given the possibility to rank each benefit according to its importance to their company. The choices given are: 4: very important; 3: moderately important; 2: slightly important and 1: not at all important.

The most important benefit of waste minimisation according to the results presented in table 8 is related to cost saving and profitability; this supports the findings of many studies mentioned in the literature review and the interviews undertaken. The second important benefit is the cleaner and safe site conditions that can be achieved through waste minimisation. The mean value of this element is 3.30 which indicate that the health and safety issues are more than moderately important for the respondents. This finding is a result of the increasing interest in health and safety issues in the UAE reported by Al-Kaabi et al. (2003) and observed during the site visits. The other financial benefit that is related to saving cost of disposal and transport has only a mean of 2.73 which supports the finding in table 5 that the costs of disposal to landfill are not very high in the UAE and represent a minimal incentive for waste minimisation.

The environmental benefits of waste minimisation are ranked last by respondents, yet the mean of 'enhancing the image of the company as green contractor' is 2.93 indicating that it is almost moderately important for them. In contrast, the mean value of 'protection of the environment' is relatively low and 30% of the respondents perceive this benefit as being not important at all for them. It can be concluded then that while economical and health and safety benefits are strong drivers for waste minimisation, the environmental benefits are still overlooked by most of the contractors.

Table 8: Ranking of waste minimisation benefits

	4	3	2	1	Weighted average	Standard deviation	Index value	Rank
Increased profit	33	20	2	1	3.52	0.66	8.85	**1**
Cleaner and safe site conditions	24	26	5	1	3.30	0.71	7.95	**2**
Saving cost of disposal and transport	8	30	13	5	2.73	0.82	6.06	**4**
Enhancing the image of the company as a green contractor	18	23	8	7	2.93	0.99	5.89	**5**

Protection of the environment	10	17	12	17	2.36	1.10	4.50	**6**

CONCLUSIONS

The main causes of waste in the UAE construction sites are: ‘workers' lack of awareness’; ‘materials off-cuts’; and ‘rework and variations’. In addition, the lack of legal and contractual incentives in the UAE is also considered as a significant contributor to the generation of construction waste.

Contractors consider cost savings and increased profits as the most important benefits of waste minimisation. In contrast, the environmental benefits are neglected and considered less important.

The current practices implemented by the contractors to minimise construction waste are: ‘adequate storage’; ‘staff training and awareness’; and ‘just- in time delivery’. In contrast, recycling waste is found to be rarely practiced by contractors.

The effectiveness of the waste minimisation measures implemented could be further investigated based on the content of this research. In addition, as it was stated in the literature review, construction waste in order to be managed should be integrated and taken into consideration at the planning and design stages of the project. Future research is recommended in order to investigate the extent of such integration in the UAE construction projects.

REFERENCES

Alarcon, L F (1993) Modelling waste and performance in construction. in Alarcon, L. (Ed.) Lean Construction, A.A. Balkema, Rotterdam.

Al-Kaabi, N and Hadipriono, F (2003) Construction safety performance in the United Arab Emirates. Civil Engineering and Environmental Systems, **20**(3),197 — 212.

Alkhafaf, M (2008). Waste problems are shared responsibility between developer, engineer and lead project holders. Alsahara Press. Available at : www.zawya.com (21/07/08).

Al-Qaydi S (2006) Industrial solid waste disposal in Dubai, UAE: A study in economic geography. Cities, 23(2), 140-148.

Begum, R A, Siwar, C, Pereira, J J and Jaafar, A H A (2006) Benefit–cost analysis on the economic feasibility of construction waste minimisation: The case of Malaysia. Resources, Conservation and Recycling **48**, 86–98.

Building Research Establishment. Waste of building materials. Building Research Establishment Digest 1981; 247 (March).

Cheyne, I and Purdue, M (1995) Fitting definition to purpose: the search for a satisfactory definition of waste. J Environmental Law, **7**, 149-168.

CIOB (2004), Sustainability and the Construction Industry. Ascot: Chartered Institute of Building.

CIRIA (1995). Waste Minimisation and Recycling in Construction – A Review. London: Construction Industry Research and Information Association (CIRIA) Special Publication.

Dainty A R J and Brooke R J (2004) Towards improved construction waste minimisation: a need for improved supply chain integration. Structural Survey, **22**(1), 20–29.

DEFRA (2008) Non-statutory guidance for site waste management plans. London: Department for the Environment, Food and Rural Affairs.

Ekanayake, L L and Ofori, G (2000). Construction material waste source evaluation. Proceedings of the 2nd Southern African Conference on Sustainable Development in the Built Environment: Strategies for a Sustainable Built Environment, Pretoria, 2000.

Ekanayake, L L and Ofori G (2004) Building waste assessment score: design based tool. Building and Environment, **39**, 851–61.

Envirowise (2007) [Accessed on 2008]. Benefits of Resource Construction Efficiency, http://www.envirowise.gov.uk/media/attachments/202895/BRE-Construction-resource-efficiency.pdf

Formoso, C T, Isatto, E L and Hirota, E H (1999) Method for waste control in the building industry. Proceedings IGLC-7, 7th Conference of the International Group for Lean Construction, Berkeley, CA, 26-28 July.

Greene, J C, Caracelli, V J and Graham, W F (1989) Toward a conceptual framework for mixed-method evaluation designs. Educational Evaluation and Policy Analysis, **11**, 255–274.

Jacobsen, H, Kristoffersen, M (2002) Case studies on waste minimisation practices in Europe. European Environment Agency: Copenhagen.

Keys A; Baldwin A and AUSTIN S (2000) Designing to encourage waste minimisation in the construction industry. Proceedings of CIBSE National Conference, Dublin, 2000.

Koskela, L (1992) Application of the New Production Philosophy to Construction. Technical Report No. 72, CIFE, Stanford University.

Lingard, H, Gilbert, G and Graham, P (2001) Improving solid waste reduction and recycling performance using goal setting and feedback. Construction Management and Economics, **19** (8), 809-17.

Lingard, H, Graham, P and Smithers, G (2000) Employee perceptions of the solid waste management system operating in a large Australian contracting organization: implications for company policy implementation. Construction Management and Economics, **18** (4), 383-93.

Macozoma, D S (2002) Secondary construction materials: an alternative resource pool for future construction needs. Proceedings of Concrete for the 21st Century Eskom Conference Centre, Midrand, Gauteng. March 2002.

McDonald B (1998) Implementing a waste management plan during the construction phase of a project: a case study. Journal of Construction Management and Economics, **16**(1):71–8.

McDonald, B and Smithers, M (1998) Implementing a waste management plan during the construction phase of a project: a case study. Construction Management and Economics, **16**, 71-8.

Naoum, S (2007) Dissertation Research and Writing for Construction Students, 2nd Ed. Oxford: Butterworth-Heinemann.

Ofori, G (2000) Greening the construction supply chain in Singapore. European Journal of Purchasing & Supply Management, **6** (3–4), 195–206.

Osmani, M, Glass, J and Price, A (2006) Architect and contractor attitudes to waste minimisation. Proceedings of the Institution of Civil Engineers. Waste and Resource Management. 159. May 2006 Issue WR2. Pages 65–72.

Poon, C S, Yu, A T W, Wong, S W and Cheung, E (2004) 'Management of construction waste in public housing projects in Hong Kong. Construction Management and Economics, **22**(7),675 — 689

Powell, J and Craighill, A (2001) The key to sustainability in the building sector. Report presented at the OECD workshop on the Design of Sustainable Building Policies 28-29 June 2001, Paris.

Puckett, K (2008) The middle east green building challenge. Building magazine 29/02/08. Available at: www.building.co.uk (lasr accessed 21/07/08).

Raftery, J, McGeorge, D & Walters, M (1997) Breaking up methodological monopolies: a multi-paradigm approach to construction management. Construction Management and Economics, **15**, 291-297.

Runeson, G (1997) The role of theory in construction management research: comment. Construction Management and Economics, **15**(3), 299- 302.

Samarai, M A and Qudah, L M (2007) Planning Sustainable Mega Projects in UAE. World Housing Congress 2007: Affordable Quality Housing. 1st July-5th July 2007. Malaysia.

Seymour, D E and Rooke, J A (1995) The culture of the industry and the culture of research. Construction Management and Economics, **13**(6), 511± 523.

Seymour, D.E., Crooke, D. and Rooke, J. (1997) The role of theory in construction management: a call for debate. Construction Management and Economics, **15**(1), 117-119.

Shen LY, Tam VWY (2002) Implementation of environmental management in the Hong Kong construction industry. Int. J Project Management, **20**(7):535–43.

Shen, L, Lu, W, Yao, H and Wu, D (2005) A computer-based scoring method for measuring environmental performance of construction activities. Automation in Construction, **14**, 297–309.

Smith, M (2008). Construction sector battles to find skilled employees. Emirates Business (22/06/08) available at :www.zawya.com (01/08/08).

Tam, V W Y, Shen L Y and Tam, CM (2005) Assessing the levels of material wastage affected by sub-contracting relationships and projects types with their correlations. Building and Environment, **42**, 1471–1477

Teo, M M M, Loosemore, M, Masosszeky, M and Karim, K (2000) Operatives attitudes towards waste on a construction project. Annual Conference – ARCOM 2000, **2**, 509-17.

UAE Interact (2007) UAE at a glance. Available at www.uaeinteraact.com, the official website for the Ministry of Information and Culture in the UAE (accessed 5 July 2008).

UAE Interact (2008) United Arab Emirates Yearbook: Economic development available at www.uaeinteraact.com, the official website for the Ministry of Information and Culture in the UAE (accessed 5 July 2008).

Wing, C K, Raftery, J and Walker, A (1998) The baby and the bathwater: research methods in construction management. Construction Management and Economics, **16**(1), 99- 104.

WRAP (2007a) Efficient Construction Logistics. Waste and Resources Action Programme: Banbury.

WRAP (2007b) Reducing Material Wastage in Construction. Waste and Resources Action Programme: Banbury.

WRAP (2007c) Current Practices and Future Potential in Modern Methods of Construction. Waste and Resources Action Programme: Banbury.

Supporting Problem Resolution on Construction Sites with Converged Multimedia, Wireless & Mobile Technologies

Shabbir Ahsan
Myriad Vision Ltd, 58 Regent Road, Leicester LE1 6YJ, England (UK)
(shabbir.ahsan@myriadvision.com)

Ashraf El-Hamalawi, Dino Bouchlaghem
Civil & Building Engineering Department, Loughborough University, Loughborough LE11 3TU, England (UK)
(A.El-Hamalawi@lboro.ac.uk, N.M.Bouchlaghem@lboro.ac.uk)

Salman Ahmad
Myriad Vision Ltd, 58 Regent Road, Leicester LE1 6YJ, England (UK)
(salman.ahmad@myriadvision.com)

ABSTRACT

Construction work is a collaborative effort, with site problems requiring varying levels of attention on an ongoing basis despite the time and effort spent during the planning phase to ensure a smooth build. The project manager or other appropriate personnel such as site engineers would normally attempt to resolve the problem in consultation with the extended project team, whether on the same site or located elsewhere. This process is hindered by difficulties in clearly communicating problems and the tendency to close information links when faced with critical situations.

Research was carried out looking at the role of converged networks to support information flow, in particular the role of voice and multimedia information from the construction site. A survey with nine of the largest international construction companies within the UK was conducted to determine the main problems hindering communication and collaboration within the industry. Voice and verbal instructions/descriptions were considered the most critical when it came to decision-making, with telephones/mobiles being the most common tools used to discuss the problems and agree on a resolution. Difficulties expressed with this method included the ability to clearly express the problem, and the subsequent logging of the agreement and proposed resolution.

This paper presents a prototype solution whereby the PDA is the main communications tool, with software written to allow the exchange, logging, and further dissemination to appropriate parties of voice and/or multimedia information via an onsite wireless network, and VoIP accompanied by various other exchange protocols. Preliminary tests are discussed along with a discussion of the variables involved when deploying such ICT support systems onto the construction site, along with the process required to track any communication involved in a

decision to ensure accountability, and a clearer understanding of the various problems by the different parties onsite.

Keywords: Collaboration, PDA, Wireless Networks, Convergence

INTRODUCTION

There has been a general recognition that the construction industry is slow in adopting change in many areas preventing advancement compared with other industries such as manufacturing. Industry experts (Latham, 1994, Egan 1998, 2002) have consistently highlighted issues such as industry fragmentation, culture and lack of innovation as key factors preventing substantial progress. Amongst the drivers influencing the construction industry within the next 20 years, the knowledge economy and technologies for tomorrow are of key significance (Flanagan, 2004). Research has exposed that despite the extensive planning taking place on any construction project, it is often the case that when work begins on the construction site, all kinds of problems arise which call for immediate attention (Dainty et al., 2006) and where access to up-to-date information is essential. Resolving these frequent problems often requires a lot of communication and collaboration with the project team, be they on or off site resulting in tools to support this collaboration being of upmost importance.

A study of delays in construction projects found causes linked to all parties involved in the project, with the main causes including the inadequacy of sub-contractors, a lack of sufficient resources, incomplete and unclear drawings and deficiencies between consultants and contractors (Noulmanee et al., 1999). The study suggested that delay could be minimized by greater discussion and communication between project members to form greater understanding (ibid). Loosemore (1998) suggests that often the 'crisis situations' which form on the construction site due to unforeseen problems lead to a breakdown of clear and open communication. Project managers must therefore ensure amongst other things that information hoarding (members keeping valuable information between themselves) is minimised, and supporting communication to ensure no bottlenecks (Loosemore, 1998).

Examining ICT within construction Harris and McCaffer (2006) categorise the progression into three stages. The first going up to the late 1970's sees the use of IT to achieve efficiency and cost savings in the processing of information. The second goes from the late 1970's to the late 1980's where the emphasis was to align technology to support the functions of a construction company producing many stand-alone systems from project planning to financial reporting. The last phase which is still evolving is the addressing of the integration of the stand-alone applications and the use of ICT as a communications medium (Harris and McCaffer, 2006).

The emergence of mobile and wireless technologies led to research projects examining applications on the construction site. A variety of applications have emerged with mobile computing, from site diaries and logging of maintenance conditions (Scott and Assadi, 1997, Rojas and Songer, 1997) to the collection of data for defect management (Kim et al., 2008) and site inspections (Kimoto et al., 2005). All the while, the focus has been very much on the collection of data on electronic forms to replace pen and paper, with little focus on examining the use of mobile computing to support general communications such as voice communication with IP telephony (Beyh and Kagioglu, 2004) and further advanced uses. The application of sharing information to improve collaboration is explored in this research.

COMMUNICATION DURING CONSTRUCTION COLLABORATION

A typical project involves a wide range of professionals coming together for a relatively short period of time. Often these participants are geographically dispersed, with communication and coordination problems affecting project performance and productivity resulting in the acute need for effective information and communication technologies (Li et al., 2000, Anumba et al., 2002). Communication has been defined as the transmission of resources (e.g. information and other meanings including ideas, knowledge, specific skills and technology) from one party to another through the use of shared symbols (Cheng et al., 2001). When it comes to partnering and working with the project team, effective communication has been ranked a priority because partnering requires timely communication of information and the maintenance of open and direct lines of communication among all project team members (Larson, 1995). Problems occurring on site require immediate resolution once they occur (Moore et al., 1992) with effective communication requiring the formation of effective channels to motivate participation and cooperation between the team to produce compatible expectations (Mohr and Spekman, 1994). The UK construction industry has defects which cost at least £20 billion to repair or rebuild (BRE, 2005). Poor communication on construction sites is the cause of some of these defects, with poorly detailed drawings, operatives being given incorrect instruction or technical information not being available. Access to project resources such as team members and project data is increasingly important to cut these losses (Ahsan et al., 2008).

The different communication media available include face-to-face meetings, email, telephone, fax, letter, video conferencing and computer collaboration (Cheng et al., 2001, Morrison and Liu Sheng, 1992), the selection of which depend on four major criteria (Cheng et al., 2001):

1. Amount of information required – different communication channels can convey different amounts of information.
2. Instant information required – telephone and fax are described as the most instant, with email, meeting, teleconferencing, letter and visit becoming less instant respectively.
3. Effective communication required – the accuracy of information transmitted. Two-way communication is the most effective as there are more chances to clarify meanings.
4. Efficient communication required – speed of transmission of messages.

Of the tools used for communication, the telephone, fax, and email consistently come out as the most used (Howard and Peterson, 2001, Forcada et al., 2007, Ahsan et al., 2008). One particular case study showed that non-IT based media was used almost 1.8 times more than IT-based communication media (Howard and Peterson, 2001). Communication amongst project members is crucial to ensure successful project completion and as collaboration partners need to be empowered to locate each other, mobility of context (who, what, why, when and using which resources) are essential facets of any collaborative system (Dustdar and Gall, 2003). Research has revealed that despite the extensive planning that takes place on any construction project, it is often the case that when work begins on the construction site, unexpected problems arise which call for immediate attention (Dainty et al, 2006). With Newton (1998) highlighting that 65% of contractor-rework is attributed to insufficient, inappropriate or conflicting information, it can be argued that the timely collection and dissemination of information to project teams would help reduce and resolve the number of unexpected problems, with computing at the construction site an important factor, problems need to surface and be solved on-site whenever possible (Moore et al. 1992; Sanders and Moore 1992).

CONVERGENCE IN CONSTRUCTION

An important advancement in ICT is the emergence of convergence in networks and communication, i.e., enabling the merging of voice, video and other types of data in a single system. Converged networks are being used within various industries to incorporate voice into mainstream data networks using Voice over Internet Protocol (VoIP) which brings cost savings by having a unified infrastructure and integrated data system, which can be of benefit to the construction industry (Ahsan et al., 2005; Beyh and Kagioglu, 2006). Research examining the adoption of VoIP within the construction context has identified several issues that require further investigation (Beyh and Kagioglu, 2004; Ahsan et al, 2005):

- the nature of information to be transmitted such as voice, video and other types of data
- data access by various project teams
- reliability, availability and quality of service
- cost of service including network administration, maintenance and upgrade
- availability of terminals and users' devices such as mobile handsets.

When examining the technical issues of introducing the technology, it was established that many of the barriers, such as reliability and security, can be overcome by adopting tried and tested techniques to solve similar problems adopted by other sectors such as manufacturing and IT (Ahsan et al., 2005).

RESEARCH METHODOLOGY

In order to test the use of convergence within construction and gather requirements for a mobile support tool, two methods were employed: case studies and scenario analysis. A scenario is a description of possible or probable futures (Schwartz, 1991). It is a story about people and their activities (Carroll and Rosson, 1990) that describes human work, human collaboration, or human activity (with or without computers) (Muller, 1999). Muller (1999) identified several uses for scenarios as:

1. Analysis of human work and collaboration with a balance between a focus on technology and a focus on human processes
2. Consumer engagement
3. Design and implementation of systems
4. Usage-guided testing of systems

Rosson and Carroll (2002) note that with respect to scenarios showing interaction with a system or application, user interaction scenarios makes the system's use explicit, and in doing so orients design and analysis towards a broader view of computers. It can help designers and analysts to focus attention on assumptions about people and their tasks. Scenario representations can be elaborated as prototypes, through the use of storyboards, videos, or rapid prototyping tools. For this research, the use of mock screen shots were used (Ahsan et al., 2007) to allow the industry experts to examine the use of mobile technology and to allow the requirements for the user interface to be gathered.

FIGURE 1 MOCK-UP SCREEN SHOTS USED IN THE SCENARIO PROCESS (AHSAN ET AL., 2007)

The formation of the scenario used a mixture of analyst and expert input, with key trends identified in the literature and discussions with ICT industry specialists. The processes which formed the basis of the scenario originated from the methodology within the Chartered Institute of Building (CIOB) manual for project managers (CIOB, 1996). The scenario took a common occurrence of a problem identified by construction workers on site, and on the basis of the procedures from the manual for project managers (CIOB, 1996); several steps were formulated to show the problem resolution process. These processes were then supplemented with the technology displayed in the conceptual model to introduce the concept of unified communications, using the PDA as the main communication and collaboration device on site

The case study is an in-depth investigation which investigates a contemporary phenomenon and in which multiple sources of evidence are used (Yin, 1994). It can employ a mixture of data collection methods, and excels at allowing an understanding of complex issues (Soy, 1996). With respect to construction, it has been found that the case study plays a major role in increasing industry uptake of construction IT solutions (Bloomfield, 1998), and as such is an effective means of identifying correct application of technology. Nine of the largest construction companies within the UK were investigated with site visits examining the problem resolution process, the use of computer technology on site and the views of project managers and site staff with regards to more advanced technologies on site.

After the collection of requirements was complete, a prototype tool was developed and tested. The tests were carried out in a simulated construction environment in order to test the functionality and adherence to requirements. Black-box testing was used to ensure appropriate outputs were produced given a set number of inputs, essentially that the tool would work as it was designed to.

PROBLEM RESOLUTION PROCESS

The scenario explained the problem resolution process according to the CIOB project managers' manual, which was found generally to be true to the process on site; however there were subtle differences in the way problems were handled which had an impact on the communication taking place. These main aspects of the resolution process included:

Role of the Project Manager (PM) – The research found that when it came to problem resolution there were generally two types of managers, the *facilitator* or the *delegator*. The type of role the manager would take would depend on the extent of the problem, with large problems always involving the PM heavily. The facilitator would be involved in the decision process and would act as the intermediary between the experts and the workmen carrying out the jobs. The delegator, though, would assign the engineer on site to speak directly to the expert to come to an acceptable solution.

Role of Project Team –Depending on the problem, the level of involvement from the team varied. One of the companies ensured weekly briefing meetings whereby any problems would be discussed with the project team to ensure maximum awareness.

Documentation – All the sites had official forms to complete due to any cost implications arising from the problem or the resolution (change request, technical query), although these forms were often completed retrospectively with tasks issued verbally using the mobile phone. This did pose a risk of some changes not being documented due to a lack of time, or forgetfulness.

Design Update – Any changes to the design would be agreed upon by the decision makers involved, and since most sites had a document management system in place, updated drawings would be uploaded to the system to ensure staff had the latest copy. Problems included the use of printed drawings, which would be printed out in the morning and used throughout the day. With many changes occurring throughout the day, the printed drawing would often be out of date by the end of the day posing the risk of site staff making mistakes due to incorrect information.

Communication – Almost all the teams relied heavily on the mobile phone to communicate with experts and issue updated tasks. The verbal communication would be supplemented with email and information stored on the project document store but, where possible, face-to-face meetings were desired over the use of telephony and email. Difficulties in explaining problems to the project team were frequent, with time taken in explaining the problem to the wider project team to ensure an adequate resolution.

Duration – Assessing the duration of the problem resolution process was difficult as there are a vast range of problems which can occur on site. In response, average times were stated which ranged from a couple of hours (if it was something which could be sorted out quickly) to weeks or months (if third parties were to be involved and acceptance from the client was requested).

Use of Digital Camera – The digital camera would be used on most sites on a daily basis to document the construction process (which often were saved on a local computer and left). For problem resolution, the digital camera was identified on one site as being used to take an image of the problem which was subsequently emailed to the project team, or placed on the extranet to allow for a more effective resolution.

REQUIREMENTS FOR MOBILE ICT SUPPORT SYSTEM

Examining the findings from the scenario analysis and case studies, the main functions of a support system were identified as:

- Efficient logging and alerting of problems
- Mobility
- Speech recognition
- Use of multimedia content
- Access to latest information

Taking on board the requirements, and leveraging the key technologies of VoIP, speech transcription, mobile devices and multimedia content, a conceptual model and prototype design was developed. The solution, named the Mobile Collaboration Toolkit (MCT), with a deliberately simplified specification list was designed to show that the chosen technologies have a practical application on a construction site. Figure 2 shows the conceptual model of the proposed solution and shows an overview of the various components involved. The MCT makes use of a mobile device to collect information from the site and uses the available network (wireless/GPRS/3G) to send data to a central server where it is published and made available for the rest of the project team to view. The audio is transcribed, allowing data to be collected faster from the site as the construction worker need only record a comment instead of type it into the device. The functionality of VoIP was tested as a separate part of the overall solution and not included as part of the developed prototype. The reason behind this choice was to allow the use of publicly available VoIP tools to allow the investigation of different deployment options.

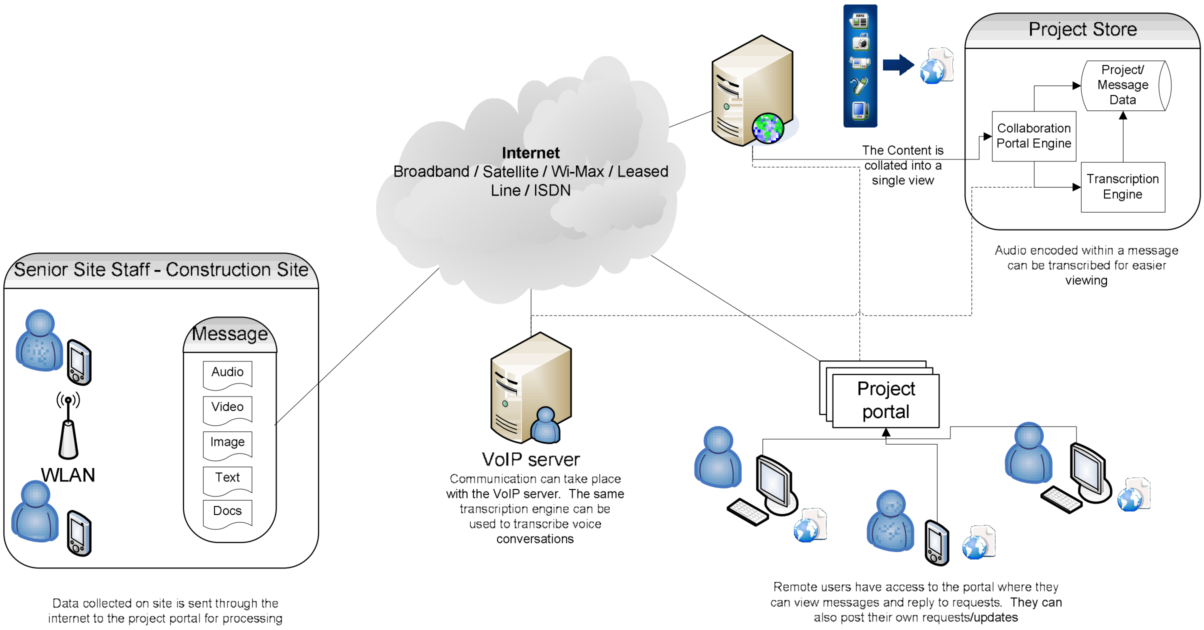


FIGURE 2 OVERVIEW OF PROPOSED SOLUTION (MCT) (AHSAN ET AL., 2007)

PROTOTYPE DEVELOPMENT

Figure 2 shows the overview of the MCT and indicates two aspects of the MCT, the client where data is collected and the server where the data is processed and distributed. The client server architecture was chosen as it gave a central location for data storage and allowed the much greater processing power of a desktop server to be utilised for processing. A mixture of Microsoft C#.NET for the client and Java 2 Standard Edition (J2SE) for the server was used as it offered a good mix of rapid development on the client and the ability to leverage open source modules on the server.

CLIENT ARCHITECTURE

Figure 3 shows a breakdown of the client architecture. The processes are separated into three logical layers; the data layer named the data handler which manages all interaction with the database, the business logic layer, named business services, which manages all the processing of data and the presentation layer, named user services, which manages the input and output of data. The resources available to the client include a pocket database, the device file store, the camera and microphone along with network access via any available network connection (3G, GPRS or Wi-Fi).

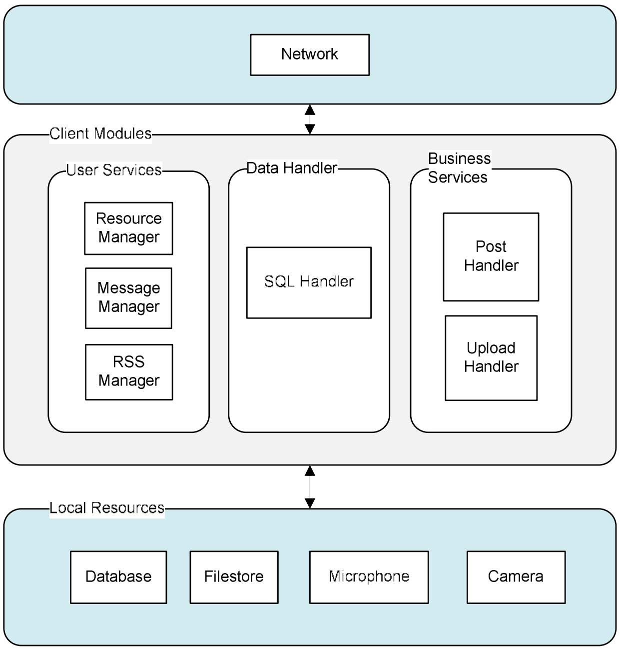


FIGURE 3 MCT CLIENT ARCHITECTURE

SERVER ARCHITECTURE

Figure 4 shows the server application architecture, showing four main servlet classes which are responsible for the uploading and handling of messages from the client, speech recognition and the publishing of messages into RSS format. The local resources consist of Microsoft SQL (MSSQL) server Express and the file store. The library includes (apart from the default modules) a JTDS module which allows connection to MSSQL from Java and Sphinx4.0, the speech recognition library.

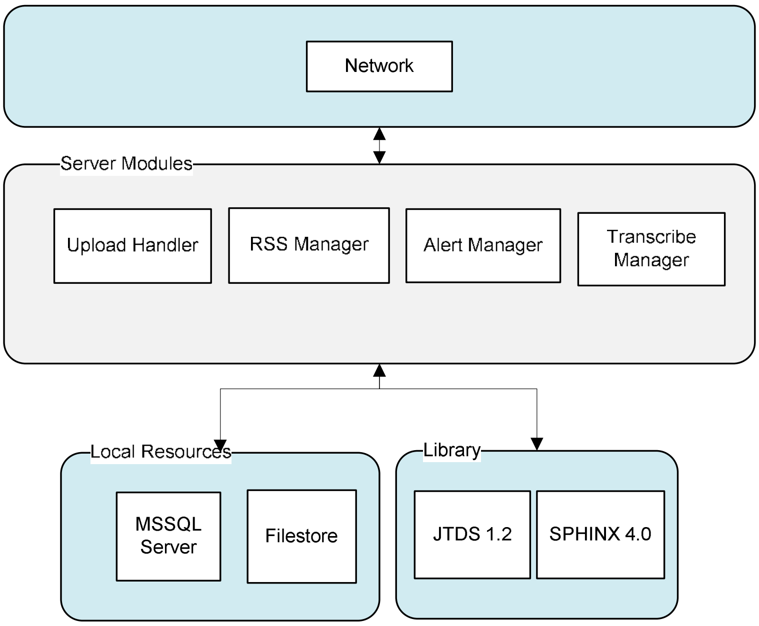


FIGURE 4 SERVER ARCHITECTURE

The HTTP (Hyper Text transfer Protocol) protocol is utilised to push data from the device to the server. The data being sent is a combination of the multimedia data along with meta-data designed to identify the message and subsequent handling options (figure 5). The server application is tasked with separating the content from the meta-data and rebuilding the files.

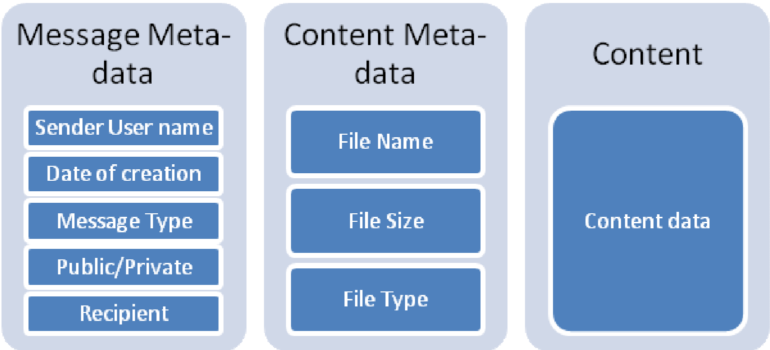


FIGURE 5 COMPONENTS OF A MESSAGE WITHIN MOBILE COLLABORATION TOOLKIT

The processed content is then published in the RSS 2.0 format, which is a dialect of XML and designed by the Berkman Center for Internet & Society at Harvard Law School. The format consists of elements or XML tags which store data. An RSS 2.0 document must contain a '<channel>' element which describes the overall content; in the case of the MCT the project details would be stored within these elements. The channel element may contain any number of '<item>' tags, which represent each message. Table 1 shows a list of elements used within the MCT to store the message contents, including a description and examples.

TABLE 1 ELEMENTS USED TO STORE A MESSAGE IN RSS

Element	Description	Example
title	Title of the message. This also contains the message status	<title>Closed - Status Update</title>
guid	A unique identifier for the message. This requires a URL, however the URL was stripped in the MCT client to give the unique identifier enabling replies to be linked	<guid>http://123.com/46b7bedb-daec-430e-ba7c-cc18f83ec9d2</guid>
link	Link to the message details	<link>http://server/MCT_Alpha_Sphinx/ShowPostList?detail=1&Post_id=46b7bedb-daec-430e-ba7c-cc18f83ec9d2</link>
description	The message contents are stored in HTML	
dc:creator	Author of the message	<dc:creator>Shabbir Ahsan</dc:creator>
pubDate	Date the message was created	<pubDate>Mon, 24 Dec 2007 11:19:00 GMT</pubDate>

PROTOTYPE EVALUATION

Tests were carried out with two mobile devices being used over two separate sites simulating the collaboration taking place between the construction site and the architect's office. The tool was tested to ensure the basic features were functioning and allowing the transfer of multimedia information using a mobile device and a wireless network. The devices used for the test were the HTC Tytn (figure 6) as it came with Windows Mobile and offered full GSM, GPRS and Wi-Fi 802.11g access.

FIGURE 6 HTC TYTN

The functionality tests included:

Collection of multimedia information - This entailed the collection of videos, pictures, audio and text. The multimedia information was collected in real-time when messages were being created simulating the use of the application when on site in a problem situation and recording information to allow other team members to fully understand the problem.

Sending of data from location of problem – Wireless networks were established at both sites enabling the users to send messages direct from their locations. The option of creating messages and storing for later sending was also tested. Messages sent were immediately visible to the user of the second device on the second site allowing the messages to be viewed and appropriate action to be taken.

Viewing of data – New messages were visible using the MCT application on the mobile devices as well as using Microsoft Outlook or a web browser. Viewing the messages on the device allowed the user the option to download the multimedia information in order to view it, thereby allowing information to be reviewed by team members whenever they wished.

Voice over IP Trials

The MCT deployment did not include VoIP functionality as part of the application, but in order to test VoIP, commercially available tools were used. In a review of the commercially available IP telephony PBX (Private Branch Exchange) solutions, the open source software-based PBX called Asterisk was chosen. Asterisk is capable of handling the common PBX functionality including voice mail, conference calling, interactive voice response, and call distribution, as well as the more advanced functions of video conferencing (using a high grade H.264 codec), and call logging and recording. Many versions of Asterisk were available for evaluation, due to the software being an open source model. The version provided by Trixbox (www.trixbox.org) was chosen as it gave access to a greater set of modules built by the open source community and included a web GUI for simple administration. The purpose of evaluating the open source IP PBX was to understand the capabilities and application within the construction sector, focussing on the capability to create an audit trail for communication occurring on site. The testing involved creating three users with different devices to represent the different modes of working which would exist on the construction environment, which are as follows (figure 7):

1) Desk-based IP phone – the trial used a Grandstream GXV-3000 video phone as it supports both the SIP and H264 standards. This phone was used to represent the type of phone which would sit on the desk of the project manager or architect and hardwired to the network.
2) Soft phone – The RE used a freely available piece of software developed by Counterpath, who also develop enterprise IP software. The application used was X-Lite and had advanced features such as call recording, video conferencing (although the free version only accepted the older and more clumsy H263 codec), automatic conference and 2 lines.
3) Mobile Soft phone – To represent the mobile user, a freely available SIP client for Windows Mobile called Fring was used. The clients available for mobile devices were not as advanced as those available on PC, offering only basic calling functionality.

FIGURE 7 GRANDSTREAM GVX-3000, XLITE SOFT PHONE, FRING MOBILE SOFT PHONE (LEFT TO RIGHT)

To establish the functionality of the VoIP deployment, a scenario of a problem occurring on site and the following discussion to work out a resolution was used. The test took place within a lab environment. The scenario had three actors:

Bill:– the site engineer out on site, using the mobile soft client

Tom: – the architect at his office, using the desk-based IP phone

David: – the project manager at his computer, using the PC soft phone

The narrative for the test was:

"Whilst on site Bill got a call from one of the workers as they had come across a problem on site. The workmen found that the piping in the ground was laid differently than what was previously thought. Bill immediately called David using his mobile VoIP client. David was at his desk attending to his emails when he saw the call come in from Bill. Using his wireless headset he accepted the call. Bill explained the problem to David who promptly called Tom on his second line. Tom was in his office

and took the call using his desk-based IP phone. David introduced the problem, then placed Bill on the call via the conferencing facility to discuss options. David placed his call on the speaker and invited his colleagues to join in the discussion. After a quick discussion it was discovered that a small change was required to the drawing, and the go-ahead was given to adjust the task. All three agreed and the call was ended."

The scenario may be possible to enact, in-part, without the use of IP phones, and instead using traditional PBX systems and mobile phones, but the successful enactment of the scenario with IP devices shows that there is conformance among IP devices for what may be considered more advanced functionality such as conferencing and that audio and video communication can occur over infrastructure that is self-established (i.e. the construction companies can have wider choice over communication infrastructure).

With the three devices being placed on a separate LAN infrastructure and behind security firewalls, initial connection proved difficult. This problem was overcome with the use of a STUN (Simple Traversal of UDP through NATs (Network Address Translation)) server, which enabled the connection to get past the firewalls whilst maintaining network integrity. With the problem resolved, the narrative was simple to act out. The devices connected and the call was established with no difficulties. Figure 8 shows a screenshot of the soft client on the PC and the mobile client. The soft client (X-lite) clearly shows that both lines are active and in fact in a conference, with the mobile client connected through Wi-Fi.

FIGURE 8 TEST CONFERENCE CALL

When the accounts were setup, the option to record calls was set to true, and as such all calls going through the IP PBX would therefore be recorded. Trixbox included a simple interface to allow users to log in and track the calls. The test showed the call was recorded (fig 9), and all three audio streams from the three users in the call were also saved.

FIGURE 9 CALL LOGGING AND RECORDING

Running the usability test with the VoIP deployment the following was discovered:

Fast and efficient setup – The test deployment was setup in a short period of time, but it is obvious for a large construction firm, the time to deploy will be much longer and more thought would have to be taken in planning the configuration. The management of the system is achieved through a web interface, offering the in-house IT staff the ability to setup and maintain the application after some training.

Call Logging – The server logged all calls in a database. Using the concept of distributed systems, this information would be available to be used within a unified view of the project whereby data from the various distributed systems would be shared.

Call Recording – The system was setup to record all calls in the WAV format. Trixbox included a web application allowing users to view their own call history and play back files, along with access for admin to view all activity and playback files.

Firewall – The firewall was identified as a problem early on in the trial as it prevented connection. The STUN server was a way of bypassing the problem allowing the network to maintain integrity when running the VoIP server.

Multi-Client – The tests showed a number of different clients in use which highlights the diversity available for the IP market. The Wi-Fi client did have problems with standby mode. When the Tytn handset would go into standby after being idle for some time, the wireless connection would be dropped therefore disconnecting the phone. This would cause problems if these wireless handsets were to be used on site as difficulties in connection would cause engineers to resort to the mobile phone. This can be overcome by preventing the handset from going into standby mode, but the implication is shorter battery life.

CONCLUSION

Examining the process of resolving problems occurring on site it was clear that communicating as much information about the problem played an important part in achieving an effective solution. Initial use of multimedia information in the form of digital images was found to be used on some construction sites, but with the prototype tool, the process of capturing and disseminating this information was streamlined allowing a larger set of multimedia information to be collected and disseminated direct from the problem location. The ability to send a large degree of multimedia information would resolve any ambiguity surrounding a problem, and with information stored in a central location, access to the information would always be available to the project team.

Another important consideration was the tracking of communication and decisions made. The research identified delays in the logging of problems and their subsequent resolutions leading to a risk of changes going undocumented. The use of VoIP and call logging /recording was presented as a possible solution to help keep track of verbal communications and subsequently the decisions being made surrounding problem resolution. The tests showed that calls could be recorded and stored for auditing purposes, and with further improvements in speech recognition, be available to immediate review.

The research presented novel uses of technology linking the various aspects of mobile communications, multimedia content, speech recognition and call logging to enhance the flow of information in order to support the decision-making process and ensure shared understanding amongst the project team. The tests showed that functional support was achievable, with the prototype tools functioning according to their specifications. The tests were carried out in simulated environments, but in order to improve the tool and the processes on site, further tests would have to be carried out in real life situations to ensure adherence to industry requirements.

REFERENCES

Ahsan, S., El-Hamalawi, A., Bouchlaghem, D. and Ahmad, S. (2008) 'Applications of converged networks in construction', Int. J. Product Development, (IN PRINT)

Ahsan, S., El-Hamalawi, A., Bouchlaghem, D. and Ahmad, S. (2007) 'Mobile Technologies for Improved Collaboration on Construction Sites', Journal of Architecture, Engineering and Design Management, Vol. 3, pp257-272.

Ahsan, S., El-Hamalawi, A., Bouchlaghem, D., and Ahmad, S. (2005), 'Using Voice over IP and a Wireless Network to Aid Collaboration in the Construction Industry', Proceedings for CIB-W78, 19-21 July, Dresden, Germany, pp 147-154

Anumba, C. J., Ugwa, O. O., Newnham, L. & Thorpe, A. (2002). 'Collaborative design of structures using intelligent agents', Automation in Construction, 11(1), pp. 89-103.

Beyh, S. and Kagioglu, M. (2004). 'Construction sites communications towards the integration of IP telephony', ITCon, Vol. 9, pp. 325–344

Bloomfield, D. P. (1998). 'The role of case studies in the uptake of innovation in construction IT'. The life-cycle of construction IT innovations - Technology transfer from research to practice. B. C. Bjoerk & A. Jagbeck, eds., Stockholm, pp. 115

BRE. "BRE guidance on construction site communication", BRE Guidance.(http://projects.bre.co.uk/site_communications/pdf/communication-guidance.pdf) [Accessed 03.03.2005]

Carroll, J.M., and Rosson, M.N. (1990). 'Human-computer interaction scenarios as a design representation', proceedings Volume II of HCIS-23: 23rd Hawaii International Conference on Systems Sciences, Software Track, ed. Shriver, B.D., pp. 555-61

Cheng, E.W.L., Li, H., Love, P.E.D, and Irani Z. (2001). 'Network communication in the construction industry', Corporate Communications: An International Journal, 6(2), pp. 61 – 70

CIOB (Chartered Institute of Building). (1996). 'Code of Practice for Project Management for Construction and Development', Addison Wesley Longman. ISBN: 1405103094

Dainty, A., Moore, D. and Murray, M. (2006). 'Communication in Construction: Theory and Practice', Taylor & Francis, Oxon, UK

Dustdar, S. and Gall, H. (2003). 'Architectural concerns in distributed and mobile collaborative systems', Journal of Systems Architecture 49(10-11) , Evolutions in parallel distributed and network-based processing, pp. 457-473

Egan, J. (1998). 'Rethinking Construction, Report of the Construction Task Force in the Scope for Improving Efficiency of the UK Construction Industry', Department of Environment, Transport and the Regions (DETR). London, 1998

Egan, Sir J. (2002). 'Accelerating Change, A report by the Strategic Forum for Construction', Chaired by Sir John Egan, Rethinking Construction, London, UK.

Flanagan, R. (2004). 'The future forces of change for the construction sector - a global perspective', in ECPPM 2004 eWork and eBusiness in Architecture, Engineering and Construction. A. Dikbas & R. Scherer, eds., The Netherlands, A.A. Balkema Publishers, pp. 3-10.

Forcada, N., Casals, M., Roca, X. and Gangolells, M. (2007) 'Adoption of web databases for document management in SMEs of the construction sector in Spain', Automation in Construction, Volume 16, Issue 4, Pages 411-424

Harris & McCaffer (2006). 'Modern Construction Management - 6th Edition', Edited by Edum-Fotwe, F. ISBN: 9781405133258

Howard, R. and Petersen, E. (2001). 'Monitoring Communication in Partnering Projects', ITcon Vol. 6, pp. 1-16, http://www.itcon.org/2001/1

Kim, Y.S., Oh, S.W., Cho, Y.K., and Seo, J.W. (2008). 'A PDA and wireless web-integrated system for quality inspection and defect management of apartment housing projects', Automation in Construction, 17(2), 22nd Symposium on Automation and Robotics in Construction, ISARC 2005, January 2008, pp. 163-179.

Kimoto, K., Kazuyoshi, E., Iwashita, S. and Fujiwara, M. (2005). 'The application of PDA as mobile computing system on construction management', in Automation in Construction, 14(4), pp. 500–511

Larson, E. (1995). 'Project partnering: results of study of 280 construction projects', Journal of Management Engineering, 11(2), pp. 30–35

Latham, Sir M. (1994). 'Constructing the Team', Final Report of the Government / Industry review of Procurement and Contractual Arrangements in the UK Construction Industry, HMSO, London, UK

Li, H., Cheng, W.L., and Love, P. (2000). 'Partnering research in construction engineering', Construction and Architectural Management, 7(1), pp. 76–92

Loosemore, M. (1998). 'The three ironies of crisis management in construction projects', International Journal of Project Management 16(3)

Mohr, J., and Spekman, R. (1994). 'Characteristics of partnering success: partnering attributes, communication behaviour, and conflict resolution techniques', Strategic Manage Journal, 15(2), pp. 135–152

Moore, C., Mosley, D., and Slagle, M. (1992). 'Partnering guidelines for win-win project management', Project Management. Journal, 22(1), pp. 18–21.

Morrison, J., and Liu Sheng, O.R. (1992). 'Communication technologies and collaboration systems : Common domains, problems and solutions', Information & Management, 23(2), pp. 93-112

Muller, M.J. (1999). 'Catalogue of scenario-based methods and methodologies', in Lotus Research Technical Report 99-06, available at http://www.research.ibm.com/cambridge, under 'Papers' [Accessed 15/05/2005]

Newton, P. (1998). 'Diffusion of I.T. in the Building and Construction Industry', in CSIRO, Building for Growth Innovation Forum. Sydney

Noulmanee, A., Wachirathamrojn, J., Tantichattanont, P., Sittivijan, P. (1999). 'Internal causes of delays in highway construction projects in Thailand', July, 1999, available at www.ait.c1et.com [Accessed 10/09/2007]

Rezgui, Y. (2001). 'Review of information and knowledge management practices state of the art in the construction industry'. The Knowledge Engineering Review Journal, 16(3), pp. 241–254.

Rojas, E.M. & Songer, A.D. (1997). 'FIRS: A vision of the future of building inspection', in Proceedings of the Forth Congress in Computing on Civil Engineering, pp. 25-32.

Rosson, M.B., and Carroll, J.M. (2002). 'Usability engineering, scenario-based development of human-computer interaction', Morgan Kaufmann publishers, ISBN: 1558607129

Sanders, S.R., and Moore, M.M. (1992). 'Perceptions on partnering in the public sector.' Project

Management Journal, 22(4), pp.13–19.

Schwartz, P (1991). 'The art of planning: planning for the future in an uncertain world', ISBN: 0385267320

Scott, S. & Assadi, S. (1997). 'Towards an electronic site diary'. Information Technology Support for Construction Process Re-Engineering CIB Proceedings (208), pp. 349-358.

Soy, S. K. (1996). 'The Case Study as a Research Method', Available at http://fiat.gslis.utexas.edu/~ssoy/usesusers/l391d1b.htm [Accessed 10/05/2006]

Yin, R.K. (1994). 'Case study research: design and methods', 2nd ed. London: SAGE, ISBN 0803956622.

RISK AND SUCCESS FACTORS IN CONSTRUCTION COLLABORATIVE RELATIONSHIPS

Akintola Akintoye
University of Central Lancashire, UK
aakintoye@uclan.ac.uk

Jamie Main
Capita Symonds, Glasgow, UK
Jamie.Main@capita.co

ABSTRACT
Collaborative relationships including joint ventures, strategic alliances, project and strategic partnering, partnership are now used in many industries including manufacturing, retailing, construction and service sectors. This has brought many advantages to companies where a balanced collaborative relationship is achieved. This paper presents a result of investigation into the risk and success factors involved in construction collaborative relationships from construction contractors perspective. This is based on a content analysis of open-ended questions in which UK construction contractors are asked to list and rank in order of importance five major risks success factors and assessment criteria for collaborative relationships in construction development. The main risk involved in collaboration for construction development are lack of trust (abuse, breach); complacency (over familiarity, fail to honour agreement, lack of drive); dependence (lost of control, interdependence), exploitations, clash of corporate culture and poor performance of any of the partners. The critical success factors are clear objectives and vision, trust, teamwork, communication and consultation, and joint risk and reward sharing. It is postulated that if these success factors are carefully incorporated, the risk involved in construction collaborative relationships could be reduced.

KEYWORDS: risk factors, success factors, collaborative relationship, communication.

INTRODUCTION

Collaborative relationships are now used in many industries including manufacturing, retailing, construction and service sectors. In the construction industry, this has been encouraged by two major reports produced by Latham (1994) and Egan (1998). These reports do have a recurring theme in that they all suggest the industry would be improved through greater teamwork not only at site level and organisational level but also with clients and suppliers. Recommendations within these reports have led to some construction clients and companies using collaborative arrangements such as long-term/strategic arrangements, project and strategic partnering, joint venture, partnership, prime contracting and supply chain management in order to improve the construction development process.

The usage has brought many advantages to companies where a balanced collaborative relationship is achieved. Despite these benefits, the intensity of the relationship and the central philosophy of commitment embedded in such relationships can lead to a high level of pressure to perform whereby partners under pressure may be encouraged to take unnecessary risks to prove their worth. According to Lorange and Roos (1991), it is overstatement to that that all collaborative relationships are successful. This paper therefore presents a result of investigation into the risk and success factors involved in construction collaborative relationships.

OVERVIEW OF COLLABORATIVE RELATIONSHIP

Collaboration relationship relies on co-operation and teamwork, openness and honesty, trust, equity and equality, if it is to succeed (Bennett and Jayes, 1998). Collaboration can provide a framework for the establishment of mutual objectives among the building team as well as encouraging the principle of continuous improvement. This framework encourages trust, co-operation and teamwork into a fragmented process which enables the combined effort of the participants of the industry to focus upon project objectives (Naoum, 2003). There are some authors (Green, 1999; Taylor, 1999) however, who feel that collaboration is a long way from returning tangible benefits to the contractor because clients still have a deep-rooted cost-driven agenda. As a result they expect to reduce costs, or to pass costs and risks down the supply chain, and thereby do not genuinely adopt a win-win attitude (Wood and Ellis, 2005).

One of the key elements and common feature of collaborative arrangements is a high level of commitment between parties at management level. This was founded in a study by Black et al., (2000) where organisations that had experience of partnering rated management commitment more highly than those without. Communication between stakeholders is essential whenever an organisation is dealing with change and it is equally true when introducing or managing a partnership as communication between parties is vital to understanding each party's expectations, attitudes and limitations. The study by Black et al. (2000) showed that contractors considered this a critical factor for success.

The continuous evaluation of a collaborative relationship is needed in order to ensure that it developed according to the expectations of the parties involved is essential, Bennett and Jayes (1995) highlight that continual performance improvement is necessary in order to deliver the benefits of collaboration. As advocated by Egan (1998) the use of integrated teams is a common feature of collaborative arrangements. By involving the team at the earliest stage in a project improvement can be made in quality, productivity, health and safety and cash flow, and in reducing project durations and risks (Egan, 2002).

A study by Burnes and New (1996) revealed many examples of the ways in which different industries and organisations have sought to use collaborative relationships. Examples of the benefits realised include the minimisation of waste, improvements in operational efficiency and productivity, and improved supply chain co-ordination (Hamza and Hibberd, 1999).

Collaboration encourages openness and communication as according to Cook and Hancher (1990) ''neither side benefits from exploitation of the other, innovation is also encouraged and each partner is aware of the others needs, concerns, and objectives and is interested in helping their partner achieve such". This can therefore lead to better mutual understanding on the needs of each other. Therefore, the working process becomes more efficient, which in turn will reduce wastage (McGeorge and Palmer, 1997). Collaboration can promote organisational flexibility and is beginning to be seen as a means of developing an environment supportive of innovation and learning (Bennet and Jayes 1995).

Litigation is a major problem in most construction projects. It does not help realise potential saving. In a collaborative arrangement, the problems of disputes, claims or litigations are greatly reduced through open communication and improved working relationship (Cook and Hancher, 1990). In a study conducted by Bennet and Jayes (1995) looked into the financial benefits of collaboration and commented that collaborative workshops and other related collaborative efforts can achieve savings up to about 10% of total costs.

Collaboration has potential to improve cost performance as it can reduce the risk of budget overruns through improved cost control by alleviating rework and reducing schedule time through improved communication and clear project goals (Albanese, 1994). By improving communication on projects parties are less likely to be surprised by schedule delays and additional costs, which often lead to disputes and litigation (Moore et al., 1992).

According to Arntzen et al. (1995) collaboration improves project quality by building an atmosphere that fosters a team approach and improves communication. This enables potential problems and quality issues to be recognised earlier (Albanese, 1994). Collaboration can also enhance customer satisfaction as the customer is closer to the construction process and better informed (Nielsen, 1996). There is a general consensus that collaboration has the potential to bring consistently better results than the more traditional approach. Typical benefits from partnering would be (CIIA, 1996): reduced exposure to litigation; improved project outcomes in terms of cost, time and quality; lower administrative and legal costs; increased opportunity for innovation and value engineering; and increased chances of financial success.

Obviously, collaborative relationship has brought many advantages to companies where a balanced collaborative relationship is achieved including: ability to leverage internal investments; focus on core competencies leverage core competencies of other organisations; reduce capital needs, broaden products offerings; gain access or faster entry to new markets; share scarce resources; spread risk and opportunity; improve quality and productivity; having access to alternative technologies; provide competition to in-house developers; use a larger talent pool and satisfy the customer (Crouse, 1991). Lamming, (1993) notes that despite these benefits, the intensity of the relationship and the central philosophy of commitment embedded in such relationships can lead to a high level of pressure to perform whereby partners under pressure may be encouraged to take unnecessary risks to prove their worth. In essence, in spite of the benefits and features associated with collaborative relationship which are particularly useful to address the problems currently facing the construction industry, it is generally recognised that there are associated risks. Apart from this there are success factors that need to be taken into account. It also important to identified some measures of success of collaborative relationship for benchmarking and continuous improvement. These issues (risk, success factors and measures of success in construction collaboration relationships) are addressed by this paper.

RESEARCH METHODS

A four page questionnaire, accompanied by a covering letter, was sent to managing directors of sample firms. The letter indicated the objectives of the research and requested that the questionnaire should be completed by a senior member of staff involved in construction development in the firm. The questionnaire design was based on a combination of an extensive review of literature dealing with collaboration in construction and Leverick and

Littler (1993) survey on the manufacturing industry to establish whether the use of collaboration can be used to improve the construction industry.

The questionnaire was divided into six sections exploring collaboration in construction to address the four objectives of the study: (i) to investigate the reasons for collaboration in construction development; (ii) to identify the role of collaboration in construction development; (iii) to identify the risks of collaboration and the discriminating factors between success; and failure and (iv) to identify The use of Information Technology (IT) for communication within collaboration. Akintoye and Main (2006a and 2006b) have reported the elements of the questionnaire that with reasons, roles and success factors of collaboration in construction development based on the questionnaire's five point Likert scale. The current paper present the three open-ended questions aspect of the questionnaire that deal with risk, success factor and measures of success factors of construction collaborative relationships as follows:

i. *The risks of collaboration: In your experience, what are the five major risks of collaborative relationships in construction development? Rank in order of importance: 1 being the most important*
ii. *In the light of your experience, list five factors that contribute most to the success of collaborations in general? List in order of importance.*
iii. *Assessing collaboration success: In the light of your experience, what do you see as the major criteria for assessing the success or failure of product development collaborations?*

The questionnaires were sent to the managing director of 250 construction companies and requested that the information was provided by a senior management who has had involvement in construction collaborative relationships. Table 1 shows the designation of the staff from the 63 construction companies that completed the questionnaires. These are mainly senior management staff with extensive construction industry experience. Tables 2 and 3 show the grouping of the firms, the number in each group, the mean turnover, the mean number of employees and the standard deviation for each.

Table 1 – Position of the respondents

Respondents Position	Respondents (Total 63)	%
Area Manager	1	1.59
Bid Manager	2	3.17
CEO	2	3.23
Chairman	1	1.59
Construction Manager	9	14.29
Development Manager	1	1.59
Human Resource Manager	1	1.59
Managing Director	37	58.73
Project Manager	5	7.94
Quality Manager	1	1.59
Risk Manager	1	1.59
Supply Chain Manager	1	1.59
Company Secretary	1	1.59

Table 2 - Firms Turnover

Group	Employees	Frequency	%	Mean (£ m)	Std Dev.
SME	Less than 250	32	50.8	52.81	105.15
Large	Greater than 250	31	49.2	555.45	764.3
	Total	63	100	608.26	815.45

Table 3 - Employment

Group	Employees	Frequency	%	Mean (£ m)	Std Dev.
SME	Less than 250	32	50.8	109.53	67.28
Large	Greater than 250	31	49.2	3873.84	9473.41
	Total	63	100	3983.87	9540.69

Table 4 shows the types of collaborative relationships that the companies that the respondents have had involvement. This shows that the contractors are involved in collaborative relationships with construction clients followed by sub-contractors on long term, project and partnering collaborations.

Table 4 Types of Collaborative Relationships

	Long-term / strategic	Project	Innovation	Joint Venture	Partnering
Client	68.25%	69.84%	30.16%	25.40%	63.49%
Contractor	23.81%	38.10%	20.63%	30.16%	33.33%
Sub-contractor	41.27%	63.49%	33.33%	23.81%	55.56%
Supplier	39.70%	38.10%	20.63%	4.76%	28.57%
Consultant	28.57%	57.14%	25.40%	14.30%	49.21%

Content analysis technique was used to analysis the open-ended questions by listing the responses to each question based on the ranking provided. The factor (e.g. risk) that is ranked first is then scored 5, while factor ranked second is scored 4, third is scored three, fourth is scored 2 and fifth is scored 1. There are then added together for each factor to produce the Important Level Score for that factor as shown in Tables 3-5. Based on the importance level score, the factors are then Profiled I, and II to show the relative importance of the factors; these can be interpreted Tier 1 and Tier 2 factors. Tier 1 factors are those responsible for up to 50% of the total Importance Level scores and Tier 2 are those factors responsible the remaining 50%

RISK FACTOR IN COLLOBORATING RELATIONSHIP

Collaboration may not always achieve its original goals. Public sector procedures often work against open relationships and thus can jeopardise the project objectives originally established (Patching, 1994). According to Patching (1994) conflict and failure could be increased by a fundamental deviation in goals, especially in relation to accountability, thus hindering all cooperation that may have been attained by the collaboration process. Failure to achieve open and honest communication and to implement appropriate training and project goals can produce a win-lose attitude of stakeholders (Lendrum, 1998)

Lack of commitment and top level management support for collaboration can lead to the eventual breakdown of the collaborative arrangement. According to Larson (1997) every stakeholder must be committed to project collaboration and must be willing to support all other stakeholders. A lack of 'team approach' and comprise can also be detrimental to a collaborative arrangement where parties are unwilling to determine team solutions to problems that arise can lead to mistrust in one another and destroy the relationship.

By collaborating organisations need to change their ways of working to share basic goals. However, it is well established that it is difficult enough effecting cultural transformation within organisations, let alone between them (Beer et al., 1990). The selection of a competent, experienced partner can significantly affect the effectiveness and performance of collaboration although selecting the wrong partner or one with little experience can be detrimental (Chan et al., 2003).

A study by Black et al. (2000) found that contractor's rated mutual trust as a crucial element for success in a collaborative relationship, therefore without trust there is a risk that the relationship will fail. A study by Chan et al., (2003) also found that commercial pressures, risks and rewards not being shared equally and dealing with large bureaucratic organisations are risks that can impede the effectiveness of collaboration.

Table 5 shows that a list and ranking of the risks that the respondents identified as being involved in construction collaborative relationships. The most important risks involved in construction collaboration are those Profiled I and embraces: lack of trust (abuse, breach); complacency (over familiarity, fail to honour agreement, lack of drive); dependence (lost of control, interdependence), exploitations, clash of corporate culture and poor performance of any of the partners. These six factors represent 50% of the risks from construction collaborative relationships. The risks identified in the open-ended question are similar to those identified in the long term supplier-manufacturer relationships and interdependency which include the risk that sensitive information is abused by a trusted partner, the loss of control over product development programmes and corresponding slippage in timescales; possibility of missing out on new technologies developed by organisations outside the partnership (Leverick and Cooper, 1998)

Table 5: Risk Factors in Collaborating Relationships

	Risk Factors	**RANKING**					**Imp Lev**	**% / Tier**	**Total**
		1	**2**	**3**	**4**	**5**			
1	Lack of Trust: abuse, breach	10	3	4			74	50.15	17
2	Complacency: over familiarity, fail to honour agreement, lack of drive	6	4	3	3	2	63		18
3	Dependence: lost of control, interdependence	2	5	5	3		51		15
4	Exploitations	3	4	3	1	3	45	Tier 1	14
5	Increase cost: overhead, transaction, capital	2	2	3	3	1	34		11
6	Clash of corporate cultures, interference	2	3	1	2		29		8
7	Poor performance: time, cost, profit, reward,	1	3	2	1	3	28		10
8	Different/Shift objectives and business emphasis	3	2		1	1	26	49..85	7
9	Poor Management: lack of senior management/team support, poor decision making		3	1	3	1	22		8
10	Focus: taken off the primary skills, becomes uncompetitive, unprofitable	2		2	2	2	22	Tier 2	8
11	Unfair/Different reward: withdrawn of funding	2	2		1	1	21		6
12	Human factor: staff politics, lack of teamwork, staff changes, loss of key staff	2		2	1	3	21		8
13	Breaking relationship with JV partner /collaboration dissolving	1	1	3		2	20		7
14	Lack of understanding of roles parties involved	1	1	2	2		19		6

15	Poor overall risk management: inappropriate risk sharing/allocation, many eggs in one basket	2		1	2		17	5
16	Exposure/Disclosure: corporate advantages, sensitive information	1	1	2			15	4
17	Choice of partner: inequality of experience and skills, wrong partner	1	2		1		15	4
18	Additional resources: more personnel, meetings, overhead, cost, etc		2	2			14	4
19	Insolvency of a partner company/change in ownership	2		1			13	3
20	Financial: Inability to reach agreement on financial matters, control	1	1	1		1	13	4
21	Lack of innovation: no fresh idea, poor expertise		2	1		1	12	4
22	Corporate identity: change, loss of company individuality / control	1	1			3	12	5
23	Competitive advantage: reduction of opportunities, erosion, uncompetitive	1			3	1	12	5
24	Loss of reputation: error by partner, complications	1		2			11	3
25	Lack of communication: information control and interface management		1	1	2		11	4
26	Health and Safety record of some collaborators	1		1	1		10	3
27	Partners support: buy-in by clients, suppliers			2	1		8	3
28	Dispute: contractual dispute, no remedy if relationship failed			1	1	1	6	3
29	Inflexibility approach - unwilling to change established procures					2	2	

SUCCESS FACTOR IN COLLABORATIVE RELATIONSHIP

Anslinger and Jenk (2004) produced six guidelines that to creating successful alliances as follows: (i) develop clear, common objectives and definition of success; (ii) ensure proper alliance form; (iii) determine appropriate governance model with clear decision making; (iv) anticipates the most likely conflicts; (v) plan for evolution and establish clear metrics to track and measure success. Hoffman and Schlosser (2001) identified the success factors for strategic alliances at the five stages involved in the alliances from strategic analysis *vis a vis* decisions to co-operate; search for a partner and partner selection; designing the partnership, implementation and management of the partnership and termination of the partnership stages. They identified 'Precise definition of rights and duties', 'Contributing specific strengths and looking for complementary resources', 'Establishing required resources', 'Awareness of time requirements' and 'Equal contributions from all partners' as the most significant critical factors that determine the success or failure of an alliance. They concluded from their study that careful strategic planning and good partnership preparation are essential for alliance success. Lorange and Roos (1991) identified two broad factors which are responsible for the success or failure of strategic alliances; these are political considerations (stakeholder blessing and internal support) and analytical considerations (strategic match and delineation of strategic plan). Leverick and Cooper (1998) emphasised how good management practice has a major part to play in increasing the chances of a successful relationship and lessen the risks involved. To this end they identified partner selection, communication, information sharing and external monitoring as four of the issues that need to be placed on agenda in order to develop effective partnering strategies.

Table 6 shows the results of content analysis on the success factors for construction collaboration. The first tier success factors are: clear objectives and vision, trust, teamwork, communication and consultation, and joint risk and reward sharing. These factors are responsible for almost 50% of the success factors for construction collaboration.

Table 6: Success factors for construction collaborative relationship

		RANKING					Imp	% /	
	Success Factor	**1**	**2**	**3**	**4**	**5**	**Lev**	**Tier**	**Sum**
1	Objectives and vision: clear, aligned, achievable, mutual, win-win	6	10	4	2	4	90	46.8	26
2	Trust: honesty, integrity , frankness and openness	6	3	4	3	7	67	Tier 1	23
3	Teamwork: behaviour of key player/ cohesion/ working with like minded people	3	6	2	5	1	56		17
4	Communication and consultation: clear dialogue between parties	4		6	3	1	45		14
5	Joint risk and reward sharing: shared problem		5	3	7		43		15
6	Management style: clear planning/target/milestones and definition of responsibilities	2	4	1	3	1	36	53.2	11
7	Relationship: personal, good, ongoing, long term, strategic	2	4	1	1	3	34		11
8	Financial success: profitability/fair returns/reduced cost, budget control, vfm	1	1	5	2	4	32		13
9	Corporate cultures (and technical) compatible	3	3	1		2	32		9
10	High level commitment (senior management)	3	2	1	1		28	Tier 2	7
11	Commitment (inch .Personal from individuals)	2	1	1	2	1	22		7
12	Programme: , predictable, measurable, result oriented, project focused	2		2	1	3	21		8
13	People: professionalism, right people/team selection, experience	1	2	1	2		20		6
14	Innovation: knowledge transfer, look outside the box, special knowledge	1		3	1		16		5
15	Benchmarking: reliable, predictable, reviewed and appraised regularly	1			5		15		6
16	Timing of collaboration: early involvement and adequate	1	1	1		2	14		5
17	Resources and efforts: joint use, compatible		1	2	1	1	13		5
18	Flexible approach (design/methods/structure/)			3	2		13		5
19	Equality of benefits/Equal split of responsibilities	1	1		1		11		3
20	Leadership: decisive, single point of contact	1			2	1	10		4
21	Management structure: joint, well defined, joint decision			1	1	1	6		3
22	Dispute: lack of claims, resolution procedure		1			2	6		3
23	Quality of end product			1		2	5		3
24	Information Management system: IT resources				1	2	4		3
25	Contract arrangement: simple, sensible				2		4		2

Overall there are 25 factors that the parties should take into account to achieve a successful construction collaboration. The success factors embrace the ten principles of a solid partnership identified by Sonnenbery (1992): both partners gain from the relationship; each party should be treated with respect; promise only what cab be delivered; specific objectives should be defined before the relationship is firmly established; striving for a long-term commitment is important to both parties; each side should take the time to understand the other's culture; each side should develop champions of the relationship; lines of communication should be kept open; the best decision is one made together; and preserve the continuity of the relationship.

CONCLUSIONS

The construction industry has been generally regarded underachieving, both in terms of meeting its own needs and those of its clients. Collaboration has been advocated as a way of improving performance and reducing confrontation within construction development. Collaboration has been used in many other industries in order to reduce the risks and costs of product development. Current research has been undertaken into the risks and rewards of collaboration in construction development. In particular this paper has presented the risks, success factors and assessment criteria for success of collaboration in construction development.

The results of the survey indicate that certain requirements must be met if construction collaboration is to succeed; in particular good communication, commitment, trust, a clear understanding of roles, and flexibility. It can be postulated that if partners in collaborative relationship incorporate these requirements they can benefit from a less adversarial environment, increased client satisfaction and an improved understanding of the difficulties faced by other parties.

Commitment to the relationship by the partners is important. If clients or any other member of the team were unwilling to unconditionally commit themselves to the collaborative arrangement, this can negatively affect the reciprocated commitment of the collaborative partners. In order for collaboration to be a success ever stakeholder must be committed to project collaboration and must be willing to support all other stakeholders. Although it is obvious from the study that there are risks and barriers to collaboration in construction development, these risks can be managed. If all parties in the collaborative relationship work together to control risk events and prevent barriers occurring, then the collaboration relationship should succeed.

In order to ensure that the project goals are met and collaborative arrangements are successful some requirements are imperative. It is important that all collaborative relationship stakeholders are fully committed to the collaboration process. The stakeholders should have a complete understanding of their requirements within the team and there must be clear defined roles for each stakeholder within the arrangement. Organisations must be flexible for the benefit of the collaborative relationship and overall efficiency of the project while there must be must be clear lines of communication. All stakeholders must communicate effectively especially at senior management level. It is important that senior management are seen to be involved in the process; and facilitate and implement a clear problem resolution process and ensure that they are willing to commit to jointly solve problems that arise in the collaborative arrangement.

REFERENCES

Akintoye A and Main J (2006a) Collaborative advantages in construction development. In Andrew Baldwin, Eddie Hui and Francis Wong (Edt) *Construction Sustainability and Innovation*. Proceedings of CIB W89 International Conference on Building Education and Research (BEAR), 10-13 April 2006, Department of Building and Real Estate, Hong Kong Polytechnic University

Akintoye A and Main J (2006b) Perception on success and failure factors for construction collaborative relationships. In Mohammed Dulaimi (Edt) *Sustainable Development through Culture and Innovation*. Proceedings of the Joint International Conference of Construction Culture, Innovation and Management, 26-29 November, The British University of Dubai, 143.

Anslinger P and Jenk J (2004) Creating successful alliances. *Journal of Business Strategy*, Vol. **25**(2), 18-23.

Albanese, R. (1994) *Team-building process: key to better project results*. *Journal of Management in Engineering*, ASCE, **10**(6), 36–44.

Arntzen, B. C., Brown, G. G., Harrison, T. P., & Trafton, L. L. (1995). Global supply chain management at Digital Equipment Corporation. *Interfaces*, 25(1), 69-93.

Beer, M., Eisenstat, R.A. and Spector, B. (1990) Why change programs don't produce change. *Harvard Business Review*, November± December, 158-66.

Bennett, J. and Jayes, S. (1995) *Trusting the Team: the Best Practice Guide to Partnering in Construction*, Centre for Strategic Studies in Construction/Reading Construction Forum, Reading.

Bennett, J. and Jayes, S. (1998) *The Seven Pillars of Partnering*, Reading Construction Forum, Reading.

Black C, Akintoye A, Fitzgerald E. (2000) An analysis of the success factors and benefits of partnering in construction. *International Journal Project Management*, 18(6), 423–34.

Bresnen, M. and Marshall, N. (2000) Partnering in construction: a critical review of issues, problems and dilemmas. *Construction Management and Economics*, 18, 229–37.

Burnes B, New S. (1996) *Strategic advantage and supply chain collaboration.* London: Manchester School of Management, UMIST, AT Kearney; 1996.

Chan A P C, Chan D W M and Ho KSK. (2003) Partnering in construction: critical study of problems for implementation. *Journal of Management in Engineering*, ASCE 2003;19(3):126–35.

Construction Industry Institute Australia (CIIA) (1996): *Partnering: Models for Success.* Research Report No. 8. Sydney

Cook, E.L., and Hancher, D.E. (1990) Partnering: contracting for the future. Journal of Management in Engineering, ASCE, 6(4), 431–47.

Crouse H J (1991) The power of partnerships. *The Journal of Business Strategy*, November/December, 4-8

Egan, Sir J (1998) *Rethinking Construction*. Department of the Environment, London.

Egan J. (2002) *Accelerating change*. Strategic Forum for Construction, Rethinking Construction; London.

Green, S.D. (1999) Partnering: the propaganda of corporatism*?,* in Ogunlana, S.O. (ed.) *Profitable Partnering in Construction Procurement*, CIB W92 and CIB TG23 Joint Symposium, E&FN Spon, London, 3–14.

Hamza A, Djebarnu R, Hibberd P. (1999) The implications of partnership success within the UK construction industry supply chain. In*?,* in Ogunlana, S.O. (ed.): *Profitable partnering in construction procurement* S.O., CIB W92 and CIB TG23 joint symposium, 39–46.

Hoffman and Schlosser (2001) Success factors of strategic alliances in small and medium-sized enterprises – An empirical survey. *Long Range Planning*, 34, 357-381

Lamming (1993) *Beyond Partnership: Strategies for Innovation and Lean Supply*, Prentice Hall International (UK) Limited, pp. 168-175

Leverick F and Littler D (1993) *Risks and rewards of collaboration*. Manchester School of Management, UMIST, ISBN 1-871782-63-5

Leverick F and Cooper R (1998) Partnerships in the motor industry: opportunities and risks for suppliers. *Long Range Planning*, 31(1), 72-81

Larson E (1997). Partnering on construction projects: a study of the relationship between partnering activities and project success. *IEEE Transactions on Engineering Management* 44(2), 188– 95.

Latham, M (1994) *Constructing the Team: Joint review of procurement and contractual arrangements in the United Kingdom construction industry*. HMSO, London.

Lendrum T (1998) . *The strategic partnering handbook*. 2nd ed. Sydney: McGraw and Hill.

Lorange P and Roos J (1991) Why some strategic alliances succeed and others fail. The Journal of Business Strategy. January/February, 25-30.

McGeorge, D., Palmer, A. (1997), *Construction management: new directions*, Oxford, UK: Blackwell Science Ltd.

Moore, C. Mosley, D. and Slagle, M. (1992) Partnering guidelines for win–win project management. *Project Management Journal*, 22(1), 18–21.

Naoum, S. (2003) An overview into the concept of partnering. *International Journal of Project Management*, 21, 71–76

Patching A (1994). *Partnering and personal skills for project management mastery*. Alan Patching and Associates Pty Ltd.

Sonnenbery F K (1992) Partnering: entering the age of cooperation. *Journal of Business Strategy*, 13(3), 49-52.

Taylor, S. (1999) Can partnering work for you*? Contract Journal*, 13 January, 18–19.

Wood, G & Ellis, R. (2005) Main contractor experiences of partnering relationships on UK construction projects. *Construction Management and Economics,* 23, 317–325

THE POTENTIAL OF SECOND LIFE AS A PLATFORM FOR VIRTUAL WORLD RESEARCH IN BUILT ENVIRONMENT

Raju Pathmeswaran, Song Wu, Nick Bakis, Xiaonan Zhang, Ghassan Aouad, Vian Ahmed, Carl Abbott
Salford Centre for Research and Innovation (SCRI)
University of Salford, Manchester, UK
p.raju@salford.ac.uk

The advances in Internet and Web technologies enabled the development of virtual worlds such as Second Life. Second Life allows participants, called residents to interact with each other through motional avatars, providing an advanced level of a social network service combined with general aspects of a metaverse. Second Life is being used as a platform for education by colleges and universities. Many companies are exploring the way to improve communication and collaboration with their customers through Second Life. Architectural firms are also exploring the use of Second Life to enhance their real-world business. Second Life provides scripting and modelling capabilities for developing content and applications, however integration with external databases and applications is required if more advanced applications are to be supported. This paper introduces Second Life and then investigates its potential in the built environment. It then demonstrates how a whole life cycle costing application can be implemented using Second Life.

KEYWORDS: architecture, building design, second life, virtual world

INTRODUCTION

The advances in Internet and the World Wide Web enabled the rise of online computer games and the dominance of networked computers for information transfer and communication. These have enabled a new media form, the virtual worlds. Virtual worlds are similar to the computer games with which they share technology and terminology, virtual worlds take their participants to new places beyond the physical and geographic limitations of the real world (Ondrejka, 2008). Yet virtual worlds go far beyond games in their leveraging of social connections and learning principles (Livingstone and Kemp, 2006).

Salen and Zimmerman define a “game” as “a system in which players engage in an artificial conflict, defined by rules, that results in a quantifiable outcome (Juul, 2003). Virtual worlds are something different. While still massively multiplayer, meaning that thousands of players simultaneously experience the world in a shared space, they possess neither strong fictions nor leveling. Instead, their defining characteristic is the ability of residents to generate creations of value within a shared, simulated, 3D space. Strong, predefined fictions are not appropriate, as they limit the design space available to the residents. Instead, residents create their own fictions and communities, imbuing them with meaning through interaction (Ondrejka, 2008).

Within the possibility space afforded by virtual worlds, residents become engines of creation themselves, working as the producers of content in the world, designing and reshaping the space around their own ideas and interests (Wired Travel Guide, 2006). The emergence of virtual world applications such as Second Life and ActiveWorlds provides potential for supporting learning communities in new ways. Virtual world applications clearly have the potential to support communications between learners, to support problem-based learning opportunity and to support exploratory learning experiences (Saunders, 2007). Virtual world applications, like immersive serious games applications, offer the capacity for using three-dimensional spaces as new learning spaces (de Freitas, 2008). This can support seminar activities, streaming lectures, create cyber campuses and help to support distributed and remotely located learner groups. This may add value to existing educational provision, as well as extending new provision of learning.

Real life architectural firms are also starting to explore the use of Second Life to enhance their real-world business. It is especially appealing for architects looking for feedback on buildings long before construction begins. For example, Crescendo Design showed how it uses its virtual land in Second Life to build virtual models of its design concepts and redesigns the virtual site so that it is similar to the actual site. It then lets clients access this virtual model in Second Life and spend as much time in it as they want, get a sense of the design, and provide their feedback. It conducts meetings in virtual "real time" where both the architect and client meet in the form of their respective avatars at the virtual site and tour it together. It also uses its virtual studio as an educational model which describes the value of several green design features. (Khemlani, 2007)

However, there are number of limitations with Second Life in terms of programming and modelling. This paper first introduces Second Life and then investigates the potential of Second Life in the built environment discipline, with applications in architecture and building design. It then demonstrates how a whole life cycle costing application can be implemented using Second Life as a platform.

SECOND LIFE

Second Life is an Internet-based virtual world launched in 2003, developed by Linden Lab (Second Life, 2008). A downloadable client program called the Second Life Viewer enables its users, called "residents", to interact with each other through motional avatars, providing an advanced level of a social network service combined with general aspects of a metaverse (Wikipedia, 2008). Residents can explore, meet other residents, socialise, participate in individual and group activities, create and trade items (virtual property) and services from one another. Second Life has its own virtual currency, Linden Dollar, which is exchangeable for US Dollars in a marketplace consisting of residents, Linden Lab and real life companies. In all, more than 8.9 million accounts have been registered in the virtual world. (Wikipedia, 2008)

The 3D modelling tool of Second Life allows any Resident with the right skills to build virtual objects: buildings, landscape, vehicles, furniture, and machines to use, trade, or sell. This is a primary source of activity in the economy. Outside Second Life, Residents can use various graphics, animation, and sound tools to create more elaborate objects, and upload them into the world. One of the distinguishing characteristics of Second Life is that the Residents create and own most of the content of the world (Wikipedia, 2008).

Second Life also includes a scripting language called Linden Scripting Language, or LSL. LSL is used to add autonomous behaviour to many of the objects in Second Life, such as doors that open when approached (Wikipedia, 2008). LSL has been used to create relatively advanced systems, such as the artificial life experiment on the island of Svarga, where a complete ecology runs autonomously (including clouds, rain, sunshine, bees, birds, trees and flowers) (Svarga, 2006). Geometric primitives, called prims can be created and manipulated for different purposes by modifying their size and texture. Every item in the Second Life universe is referred to as an asset. Figure 1 shows the Second Life interface with object and script editors. More complex objects can be created linking different prims together. Second Life also allows collaborative design and creation of content where same objects can be simultaneously designed with several other residents.

Figure 1: Second Life Interface with Object and Script Editors

Second Life is being used as a platform for education by major colleges and universities. One example of how Second Life is being used is the use of Teen Second Life (for use by teenagers only) by the Open University. The students from the National Association for Gifted and Talented Youth (NAGTY) are taking lessons in virtual classrooms. The pilot developed under Schome, is a project aimed at developing new education systems in both real and virtual worlds (Schome, 2008). Imperial College, London and the National Physical Laboratory have developed Second Health, a 3D vision that provides a vision of health of the future (Second Health, 2008). Another example is SciLands, the science and technology region of Second Life. The region includes many highlights including the International Spaceflight Museum and Nanotechnology Island.

Within Second Life, the Arch is dedicated to exploring the convergence of virtual architecture with real-world architectural practice. It also describes other examples of classic works being recreated in Second Life, such as Palladio's Villa Venete. If all the architectural masterpieces are recreated online, it will be experienced in a far more interactive manner than photographs or videos alone (Khemlani, 2007). However, there are still limitations in the current form of Second Life. One of the biggest problems is that there is no easy way to transfer building models created in real world practice into the virtual world of Second Life. The building in Second Life has to be created using its internal modelling system. This could be a huge barrier for construction industry to enter this powerful and exciting virtual world. There are attempts by researchers to develop tools to bridge this gap, but it is still at very early stage. It would be terrific if the vendors of modelling tools used in AEC can work with the creators of virtual worlds like Second Life to ensure that building models created in professional practice can be seamlessly published in the virtual world, complete with all details and textures. When that happens, Second Life can really take off in construction industry (Khemlani, 2007).

The next section outlines the potential of using Second Life in architecture and building design. It briefs some of the application areas that can be further researched with the use of Second Life.

SECOND LIFE FOR ARCHITECTURE AND BUILDING DESIGN

Architectural Design and Collaboration

Currently, architectural design uses commercial CAD systems for visualisation and collaboration through exchanging data file or sharing a common database. The virtual world, such as Second Life has the advantage of allowing users to be immersed in the development environment as well as facilitating real-time walkthroughs and collaboration. DesignWorld (2006) take advantage of virtual world to maintain different views of a single design in order to support multidisciplinary collaboration. Second Life also has an internal modelling system, which enable user to manipulate geometric shapes to form more complex objects. It is possible to interface with external data or building model with its internal modelling system. This creates possibilities to the integration of the AEC building model in Second Life. This paper demonstrates an example how the second life model can interact with external database.

User-Centred Design Evaluation

Typically, user design evaluation can be done through post occupancy evaluation, or in a virtual reality environment. The Second Life presents an opportunity to accommodate both requirements. Building can be built in the virtual world, which provides similar immersive virtual reality user experience. Furthermore, the advantage of virtual world provides environment that facilitate creating online experiments that can automatically recruit potentially thousands of research subjects, over a short period of time, and at low cost (Bainbridge, 2007). The Second life design evaluation can take advantage of this feature to attract large number of virtual world residents. Experiments such as accessibility analysis, fire evacuation can be conducted. The challenges will be how to organise and motivate the second life residents to participate the evaluation without comprising the integrity of the research and lack of technology to capture real time user feedback during the evaluation in second life.

Urban Planning and Design

Second Life presents opportunities to city planners, urban designers or members of the community to use virtual worlds to describe, discuss and even co-create design concepts. The second life shows how multiple contributors can work together simultaneously on an architectural design concept. Wikitecture (2008) is exploring Second Life for such collaborative design. Its central aim is to explore that question by applying an open-source paradigm to the design and production of architecture and urban planning. In much the same way Wikipedia enables a loose, self-organizing network of contributors to collaborate on content creation, they have been experimenting with ways to bring together a diverse and geographically disperse community of individuals to create an architecturally noteworthy design that, in the end, is more than the sum of its parts.

User behavioural modelling and simulation

The Second Life can also be used to conduct experiments to capture user behaviour information in a built environment, such as way finding, evacuation, accessibility analysis, etc, to refine and improve simulation environment, Simulation environments are often based on the game Artificial Intelligence (AI) which refers to techniques used in computer and video games to produce the illusion of intelligence in the behaviour of Non-Player Characters (NPCs) (Diller, et al, 2004). The process of producing the intelligence in the behaviour is often referred as behaviour modelling (Nareyek, 2004).

The techniques used typically draw upon existing methods from the academic field of artificial intelligence (AI). Techniques such as navigation, decision making, sensory mechanisms, and learning will be deployed. The key requirement of developing of intelligent behaviour in games and simulation systems is able to describe and specify the desired behaviour accurately for programmers to implement them. However, constructing explicit behavioural or cognitive models can be very challenging and time consuming. Technologies such as AI Implant from Engnunity Technology, Kynapse from Kynogone Technology, have been developed in the game industry to simplify the process. The behaviours defined for the virtual characters in simulation environment are usually translated from the domain experts. The Second Life presents good opportunities to capture and validate the behaviour information with virtual world residents because the virtual character in Second Life is controlled by real human and their behavioural information is probably the closest to the actual human behaviour. Once the behaviours have been validated, the behavioural models can be applied any simulation environment to make simulation more realistic. However, it is important to be aware that the behaviour information in virtual world may not be fully representative for real world. Therefore, the methodology to capture the information has to be carefully designed and real life experts have to be consulted.

Architecture design education

In addition to being an alternate design and presentation medium for architects, Second Life can also emerge as a useful educational tool. In San Francisco, Architecture professor uses second life to teach collaboration, and students develop their design in the virtual world (Wong, 2007). At the Montana State University School of Architecture, students are using Second Life's group creation platform, and they can work in the same interface to manipulate geometric shapes and link them to make a variety of structures. It was found that it is a good tool for showing students how building parts fit together (Kieran, 2007).

The next section demonstrates the second life as a design evaluation platform with an example of integrating external applications with second life.

SECOND LIFE AS A DESIGN EVALUATION PLATFORM – A PRELIMINARY STUDY

While Second Life provides the Linden Scripting Language (LSL) (LSL-Portal, 2008) that allows to control object and avatar behaviour and provide the basis for incorporating additional functionality to the Second Life environment, integration with external databases and applications is required if more advanced applications, such as user behavioural modelling mentioned above, are to be supported. We have used the example of a Whole Life Costing application that we have developed in the past to examine the degree in which integration with external applications can be achieved.

Integrating External Applications with Second Life

The Whole Life Costing application consists of a 'Resource Database' that stores unit based historical performance and cost data of building components and a CAD based application that retrieves these data to calculate the whole life costs of building components based on the components' physical properties (Bakis et al. 2003). We have ported the CAD application to Second Life allowing users (avatars) to select a component of a Second Life building (e.g. an external wall), see the available types for this component defined in the Resource Database (e.g. brick wall, stone wall, etc), see the whole life costs for each type calculated based on the component's physical properties retrieved from Second Life (e.g. wall dimensions), specify the type of each component, and see the whole life costs for the whole building once the type of each component has been specified (figure 2). The following paragraphs highlight the main issues in achieving this integration.

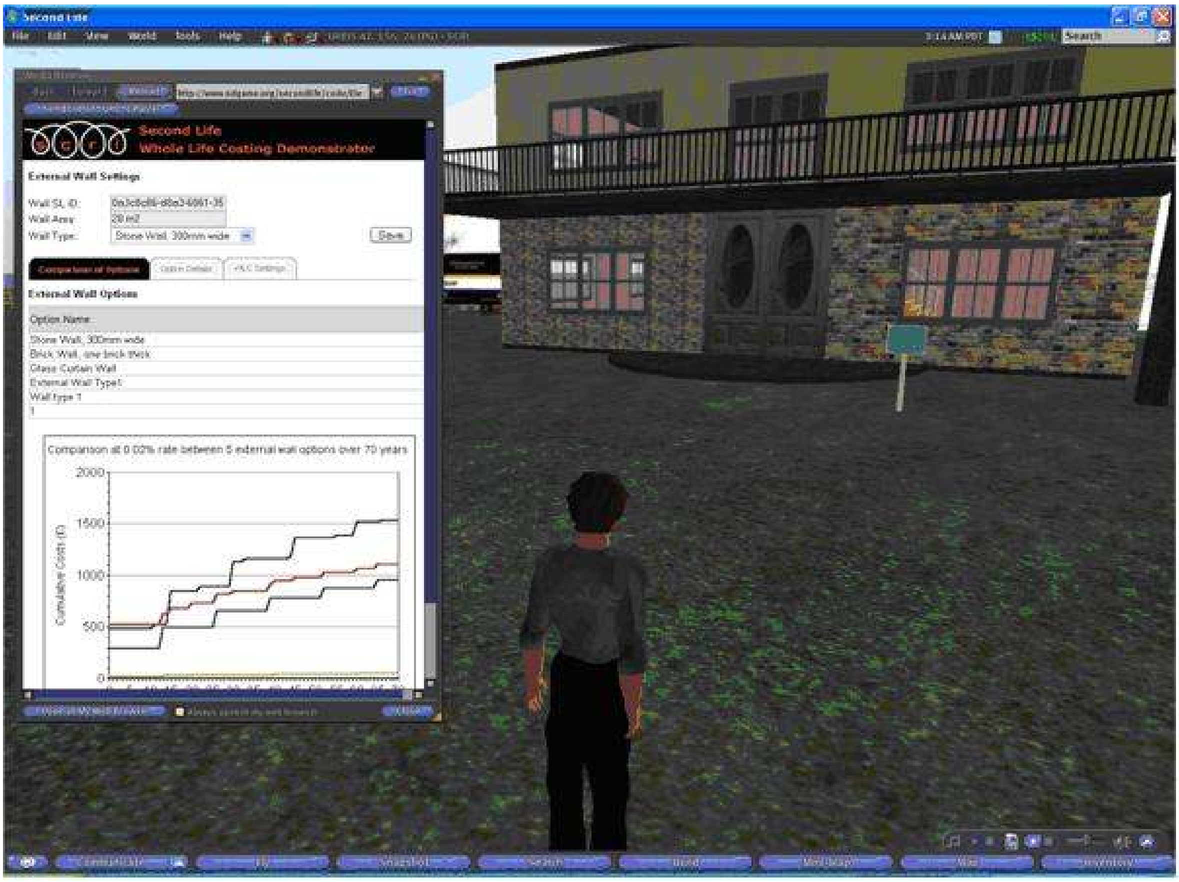


Figure 2: Integrating a Whole Life Costing application to Second Life

A number of mechanisms allow LSL scripts to communicate with users and other LSL scripts in Second Life as well as external applications running on computers outside Second Life, as Table 1 illustrates. The main mechanisms that can be used for communicating with external applications are Email, HTTP and XML-RPC. HTTP has been used for sending messages (requests) to the Whole Life Costing application (via a .NET interface). XML-RPC has been used for receiving data from the application. The XML-RPC.NET library has been used in creating the XML-RPC messages (XML-RPC, 2008).

Table 1: Communication mechanisms in Second Life

	Script Delay	**Object owner**	**Other users**	**Other objects**	**Scripts in the same object**	**Send to compu-ters outside SL**	**Receive from outside SL**	**Comment**
Chat: Whisper, Say, Shout	No	Yes	Yes	Yes	No	No	No	Must be within chat distance to be able to receive.
llOwnerSay	No	Yes	No	No	No	No	No	Owner must be in the same sim
llDialog Create	Yes	Yes	Yes	No	No	No	No	Only the directed user can receive and

								they must be in the sim
llDialog Response	No	Yes	Yes	Yes	No	No	No	Receiver must be within chat distance of where the dialog box was created
Instant Messages	Yes	Yes	Yes	No	No	No	No	
Link Messages	No	No	No	No	Yes	No	No	Only scripts contained within a given linked object may receive
Email	Yes	No	No	Yes	Yes	Yes	Yes	Link messages are better for intra-object communication
XML-RPC	No	No	No	No	No	No	Yes	Only connections from an external computer to SL can be initiated
HTTP	No	No	No	No	No	Yes	No	Only connections from SL to a non-Linden Lab server can be initiated

Most of the processing and user interaction is handled by the web server side (where the .NET interface to the Whole Life Costing application resides). An LSL based interface on the Second Life side handles only the communication requests and retrieves information from the Second Life environment. In a simple scenario, for example, the user (avatar) touches a building component. The LSL interface sends an HTTP request to the .NET interface on the web server indicating that the component has been touched. The dimensions of the component are passed to the server as HTTP query string arguments.

On receiving the request, the .NET interface retrieves the available component types from the Resource Database (e.g. brick wall, stone wall, etc), calculates the whole life costs for each type and creates and returns an HTML page that lists the types and allows the user to make a selection (through a drop down list). On receiving the HTTP response from the .NET interface, the Second Life client automatically launches the internal or an external web browser (depending on user preferences) that displays the HTML page (figure 2). The user can select the type of the component from there. On clicking on the ‘Save’ button on the web page, a message is send to the LSL interface, using XML-RPC this time, of the type of component selected. The type of component is stored in the Second Life environment for future reference.

This thin client architecture, where most of processing and user interaction is implemented on the server side, has been followed due to Second Life’s limitations as a software development platform. The Second Life LSL scripting language and editor are rather basic in comparison to standard programming languages and their integrated development environments. Scripts have to be attached to and replicated with each object (no global modules/routines can be defined) making the maintenance of complex projects difficult. Furthermore, the user interface controls provided by Second Life for handling user interaction are rather primitive. For example, there is no drop down lists or combo boxes for selecting among multiple choices. The Second Life standard dialog box may be used for displaying different options (each option represented by a button) but the number of buttons or caption size for each button is limited. User input can be only provided through the Second Life client chat line. On the other hand, the rich HTML controls available provide the opportunity for developing sophisticated user interfaces.

Regarding the HTTP based outgoing communication, the maximum body length of the HTTP messages is restricted to 2048 bytes (LSL-Portal, 2008). While there is no such restriction with the incoming XML-RPC messages, the implementation of the XML-RPC communication presents some challenges. An XML-RPC communication channel needs first to be established by an LSL script. The channel remains persistent for the life of the script and its number needs to be known by the external application sending the XML-RPC messages. However, as the communication channels are script specific and scripts are identified by the objects they are attached to, a new XML-RPC channel number needs to be added to the sending application each time the application needs to directly communicate with a Second Life object (on copying and attaching a script to another object, the script becomes a new one and a new channel is established). This is impractical as the number of objects may be large and not known in advance.

In order to overcome this problem, we have created a hidden ‘listener’ Second Life object that receives the XML-RPC messages and re-directs them to the appropriate objects using the communication mechanisms provided by Second Life for sending in-world messages between Second Life objects. The problem however is that these in-world messages have a limited range, i.e. they can only ‘heard’ by objects within ‘chatting’ distance (Table 1). Multiple listener objects need to be installed if a large area has to be covered.

As noted by IBM, the adoption and mainstreaming of Second Life technology depend on improving user experience, easy to use interfaces, improved graphics, better tools, open standards and more business and societal applications (IBM, 2007).

CONCLUSIONS

Second Life is not a mere 3-D multi-player online game. The immersive, rich experience that such environments offer combines many of the features of Web 2.0, such as group instant messaging, voice chat, profiles and real-time social networking, and a unique form of online social interaction that involves sharing various objects and creative collaboration on building and running places and services in the virtual world (user generated content). Second life offers great potential for creative architecture and building design, but more work is needed for a wider adoption in AEC industry.

This paper has outlined the potential of Second Life in the built environment, particularly in architecture and building design and demonstrated the integration of building whole life cycle application in Second Life. Future work includes development of application to monitor user behaviours in the built environment and also to develop tools to bring CAD models to Second Life.

REFERENCES

Bainbridge, W. (2007). The Scientific Research Potential of Virtual Worlds. *Science*, *317*(5837), 472-476.

Bakis, N., Kagiouglou, M., Aouad, G., Amaratunga, D., Kishk, M., and Al-Hajj A (2003), An Integrated Environment for Life Cycle Costing in Construction, in Proc. Of the 20th CIB W78 Conference on Information Technology in Construction, Waiheke Island, Auckland, New Zealand, 23-25

de Freitas, S. (2008), Emerging trends in serious games and virtual worlds, Emerging technologies for learning, vol 3, Becta

Diller, D. Ferguson, W, Leung, A., Benyo, B. & Foley, D (2004) Behaviour Modelling in Commercial Games, conference on Behaviour Representation in Modelling and Simulation (BRIMS) 2004.

IBM (2007), available at: <http://domino.research.ibm.com/comm/pr.nsf/pages/news.20070416_virtualworlds.html>

Juul, J. (2003) The Game, the Player, and the World: Looking for a Heart of Gameness, Keynote address presented at the Level Up Conference in Utrecht, The Netherlands, November 4–6, 2003. http://www.jesperjuul.net/text/gameplayerworld/.

Khemlani, L. (2007) Exploring Second Life and its Potential in Real Life AEC, available at:http://www.aecbytes.com/buildingthefuture/2007/SecondLife.html (Accessed on 22, August, 2007)

Kieran,C.(2007) Second Life and Google Earth are transforming the idea of architectural collaboration, available at:http://archrecord.construction.com/features/digital/archives/0701dignews-2.asp, (Accessed on 22, August, 2007)

Kirriemuir, J. (2007) "The Second Life of UK Academics", Ariadne Issue 53, http://www.ariadne.ac.uk/issue53/kirriemuir/

Leman Figen Gul; Maher, M.L. (2006) Studying Design Collaboration in DesignWorld: An Augmented 3D Virtual World Computer Graphics, Imaging and Visualisation, 2006 International Conference on
Volume , Issue , 26-28 July 2006 Page(s): 471 – 477

Livingstone, D., Kemp, J., (2006), Proceedings of the Second Life Education Workshop at the Second Life Community Convention, http://www.simteach.com/SLCC06/slcc2006-proceedings.pdf.

LSL-Portal (2008), available at: <http://wiki.secondlife.com/wiki/LSL_Portal>

Nareyek, A (2004) Artificial Intelligence in Computer Games – State of the Art and Future Directions ACM Queue 1(10), 58-65

Ondrejka, C. (2008) "Education Unleashed: Participatory Culture, Education, and Innovation in Second Life." The Ecology of Games: Connecting Youth, Games, and Learning. Edited by Katie

Salen. The John D. and Catherine T. MacArthur Foundation Series on Digital Media and Learning. Cambridge, MA: The MIT Press, 2008. 229–252. Doi: 10.1162/dmal.9780262693646.229

Salen, K., Zimmerman, E. (2004): Rules of Play. Game Design Fundamentals. Cambridge, Massachusetts and London, England: The MIT Press.

Saunders, R. L. (2007), 'The genesis of a virtual world revisited'. *International Journal of Web-Based Communities*, 3(3): 271-282.

Schome (2008), available at: http://schome.open.ac.uk/wikiworks/index.php/The_schome-NAGTY_Teen_Second_Life_Pilot

Second health (2008), available at: http://secondhealth.wordpress.com

Second Life (2008), available at: <http://secondlife.com>

Svarga (2006), available at: <http://nwn.blogs.com/nwn/2006/05/god_game.html>

Wikipedia (2008), Massively multiplayer online game, available at: http://en.wikipedia.org/wiki/Massively_multiplayer_online_game,

Wikitecture (2008), available at: http://studiowikitecture.wordpress.com/

Wired Travel Guide: Second Life, Wired, 14, no. 10 (2006) www.wired.com/archive/14.10/sloverview.html

Wong, K., (2007) City Turns New Leaf in Second Life, available at: http://aec.cadalyst.com/aec/article/articleDetail.jsp?id=451110, (Accessed on 22, August, 2007)

XML-RPC (2008), available at: http://www.xml-rpc.net

MULTICULTURALISM IN CONSTRUCTION: A MULTI-ATTRIBUTE APPROACH TO TENDER EVALUATION

Henry Odeyinka
School of the Built Environment, University of Ulster, UK
H.Odeyinka@ulster.ac.uk

A review of tender evaluation practices from around the world revealed the inadequacy of the 'lowest bidder' criterion. Whilst this inadequacy is recognised, many countries have introduced qualifications to this criterion and established procedures for the evaluation process. The objective of the qualifications is to select a qualified contractor whilst fostering competitiveness. However, this has led to variations in tender evaluation and contractor selection from country to country. Now with globalization in the construction market, the question arises as to which country's variation to adopt. This underscores the need for a multi-attribute approach to tender evaluation, which is the object of this study. Using a non-conventional approach, the study identified a list of contractors' attributes from literature, which are thought to be indicators of contractors' capability to execute contract. Employing cases from past projects, the attributes were scored on a 10-point scale for each contractor that participated in the tendering process. The sums of the multi attribute scores were determined using an additive multi-attribute model. Results showed an objective approach to contractor selection, which did not only remove the problem of the 'lowest bidder' criterion; it also eliminated the problem of which contractor selection method to adopt in a globalising construction market.

KEYWORDS: contractor selection, multi-attribute analysis, prequalification, tender evaluation

INTRODUCTION

Tendering process according to Moselhi and Martinelli (1990) is composed of two different and distinct activities. The first according to them deals with preparing tender estimates and is normally carried out by contractors, and leads to the submission of tender after the adjudication process. The second activity according to Moselhi and Martinelli (1990) deals with tender evaluation and is normally carried out by owners and/or their representatives (e.g. Quantity Surveyors and Project managers), and leads to the selection of one or more contractor(s) to construct the project. The first activity is of utmost importance to the contractor and has generated a lot of research activities (Jennings and Holt, 1998). However, the focus of this study is the second activity, addressing the issue of contractor selection, largely due to the problem of poor contractor performance and also due to the problem of devising an optimum method of selecting the best contractor in the context of global construction. Poor contractor performance is something that has plagued the construction industry for decades. Burrows (1981) highlighted the difficulties arising from poor communication between architects and builders that existed as long as 1750. Burrows (1981) submitted that judicious selection of procurement route and contractor, were prerequisites to project success. Whilst various reports into the problems of the industry have been undertaken in the UK (Simon, 1944; Banwell, 1964; Latham, 1993, 1994), a common contention has been that problems can be brought to a project as soon as the 'wrong' contractor is chosen.

In the UK, the Latham report (1994) and Egan report (1998) questioned the frequent practice of selecting the lowest tenderer. Instead, the report called for proper consideration and weighting of a range of selection criteria to be taken into account during contractor selection. Recognising the inadequacy of the 'lowest bidder' criterion, many countries have introduced qualifications to this criterion and established procedures for the evaluation process (Martinelli-Bello, 2006). Despite the variations in these procedures, they serve the common objective of selecting a qualified contractor while fostering competitiveness. Disqualification of a competitor, according to practices in some countries is generally based on the deviation of his tender sum from either a client's estimated cost or some calculated average of the bids received (Moselhi and Martinelli, 1990). In their review of the variations applicable in different countries around the world, Moselhi and Martinelli (1990) came out with the following findings:

> In Denmark, for example, the two highest and the two lowest bidders are disqualified and the closest to the average of the remaining bids is selected. A similar procedure is used in South Korea, but only the highest and lowest are disqualified. In other countries, the lowest bidder is selected provided that his tender sum is not less than (1) a specified percentage of the client's cost estimate (e.g. 80%, 70% in Pakistan and Saudi Arabia, respectively) or (2) a specified percentage of the average of all the tenders received (e.g. 90% in U.K.). In large projects with repetitive tasks, and/or units, the project is divided into three phases and contractors are asked to bid on the entire job. Only the work on two phases is awarded to the qualified contractors. The third phase is awarded later to the contractor who out performs the other. This procedure has been applied in Japan. In Canada and the USA, the 'lowest bidder' criterion is used, but contractors are generally required to accompany their proposal with a certified cheque or a bid bond in an amount equal to 10% of their total tender sum.

In a rapidly globalising and multicultural construction market, the question then arises as to which contractor selection method to adopt when the construction work involved cuts across the national boundary of both the contractor and the client and the project is not financed by international organisations. It is in an attempt to address this problem of contractor selection in a multicultural construction market that this study proposes the use of multi-attribute approach to tender evaluation for the purpose of contractor selection.

AN OVERVIW OF CONTRACTORS' ATTRIBUTES AND CONTRACTOR SELECTION METHODOLOGY

It is of paramount importance that contractors to be invited to participate in tendering be pre-qualified prior to the bidding process (Holt *et. al.*, 1994). According to them, a thoroughly and objectively pre-qualified contractor should be competent and able to execute the assigned project in accordance with all stipulated requirements. According to Seeley (1997), criteria for pre-qualification assessment include: contractor's reputation, financial stability, adequacy of resources, scope of work normally undertaken by contractors, availability to do the job, cooperation and price level.

In addition to contractor's pre-qualification assessment at the pre-tender stage, previous researches emphasised the need to consider contractors' other attributes during the prequalification leading to contractor selection apart from the 'lowest bidder' criterion alone.

According to Moselhi and Martinelli (1990), a list of contractors' attributes to consider in contractor selection includes: capital cost (bid amount), life cycle cost, number of years in business, volume of business, financial capacity, previous performance, project management organization, technical expertise, time of execution, and relation with subcontractors. In their survey of contractors' opinion to the use of multi-criteria in contractor's selection, Jennings and Holt (1998) employed the following criteria: low price, company experience of similar construction, company reputation, company financial standing, prior business relationship, early completion dates, experience of contractors' key persons, company image, qualifications of contractors' key persons, company negotiating skill, current workload of company, company informal contacts, company proximity to project, company nationality and company trade union record. In their survey of tendering practices in the Nigerian construction industry, Yusif and Odeyinka (2000) identified other factors to be considered in contractor selection other than price to include: technical ability, financial base, relationship with client/consultants and past performance among others.

While most authors agree on the use of multitudes of attributes and criteria, rather than the use of cost alone in prequalification for contractor selection, the major point of departure is which methodology for contractor evaluation/selection to adopt. In this context, evaluation is the process of investigating or measuring contractor attributes. Selection is the process of aggregating the results of evaluation to identify optimum choice. Whilst agreeing that absolute classification of some selection methodologies is not possible, Holt (1998) and Elmisalami *et. al.* (2006) attempted to classify some methodologies available for contractor selection, which include: bespoke approaches (BA), multi-attribute analysis (MAA), multi-attribute utility theory (MAUT), multiple regression (MR), cluster analysis (CA), fuzzy set theory (FST), and multivariate discriminant analysis (MDA). Whilst a detailed description of these methodologies is contained in Holt (1998), an attempt is made here to briefly describe MAA and MAUT, which are more relevant to this study.

Multi-Attribute Analysis (MAA)

MAA considers a decision alternative with respect to several of that alternative's attributes. In this respect, an attribute is a characteristic that can be measured. An objective is a characteristic against which an attribute is measured and should be pursued to its fullest. Hence, a contractor attribute represents one aspect of a decision option with respect to a client's objective (Holt, *et. al.,* 1995). Attributes may be measured quantitatively or otherwise. Indeed, a feature of MAA is that some or all of the attributes may not be quantifiable (Martinelli-Bello, 2006). The simplest MAA equation may be expressed as:

$$ACr_j = \sum_{i=1}^{n} V_{ij} \qquad \text{(Equation 1)}$$

where: ACr_j = aggregate score for contractor j; V_{ij} = variable (attribute) i score in respect of contractor j; and n = the number of attributes considered in the analysis. These are termed 'simple scoring' MAA models and because of their simplicity are frequently employed by Decision Makers (DM's) in industry. Their biggest failing is that V_i (albeit numeric) is often a very subjective measure. That is;

$$V_i = \sum_{i=1}^{n} f(x_i) \qquad \text{(Equation 2)}$$

where: $f(x_i)$ are the n functions of V_i normally subjectively (often implicitly) considered by the practitioner during evaluation. An improvement of *Equation (1)* is to attach weighting indices (W_i) to V_i thereby accentuating contractors' aggregated scores who performed better in higher weighted criteria and vice versa.

Hence; $ACr_j = \sum_{i=1}^{n} V_{ij} W_i$ (Equation3)

W_i may be a function of: (1) sole practitioner experience/predilection, (2) group consensus opinion and (3) survey and analysis of data, from a sample pertinent to the selection setting in which the model will be applied (Holt, *et. al.,* 1994).
Where the components (V_i and W_i in this instance) are represented by an infinite range of integers, then a unified aggregate contractor score (designated $\mathbf{U}ACr_j$, i.e. $0 \leq \mathbf{U}ACr_j \leq 1.0$) may be achieved via:

$$\mathbf{U}ACr_j = \frac{ACr_j}{ACr_{j\max}} \quad \text{(Equation 4)}$$

where the components are as previously described; and ACr_{jmax} is the maximum attainable aggregate score utilising W_i. Holt (1998) however suggested that the derivation of essential V_i and the strength of W_i should be further investigated in the light of previous researches (e.g. with respect to geographical location of project, nature of work, form of procurement option employed, etc.).

Multi-Attribute Utility Theory (MAUT)

According to Elmisalami *et. al.* (2006), MAUT is a multiple criteria decision analysis method used by decision makers when they must choose among alternatives based on two or more criteria. MAUT according to Holt (1998) utilises 'utility' to quantify the subjective components of MAA. According to Moselhi and Martinnelli (1990), in order to facilitate the understanding of MAUT, it is important to define the main terms used, which are stated below:
'Objectives': An objective generally indicates the direction where efforts should be concentrated to do better. In contradistinction from goals, goals are defined as the level of achievement of objectives.
'Attributes': Attributes are the scales against which the levels of achievement of objectives are measured. The attributes may be tangible such as dollar or Naira or intangible such as safety, quality, prestige and public image, etc.
'Utility' (normally expressed as U_i) is a measure of desirability or satisfaction of a characteristic (attribute), of an alternative (contractor). The utility concept was introduced to provide a uniform scale to compare and/or combine tangible and intangible attributes.

According to Holt (1998), the overall concept of MAUT can be very complex with respect to both models and utility weight derivation. According to him, MAUT may be applied to the contractor selection problem in one of two fundamental ways. Consider:

$$ACr_j = \sum_{i=1}^{n} U_i \quad \text{(Equation 5)}$$

where: U_i represents the n attributes considered by the Decision Maker (DM). These are a function of several dimensions i.e. $U_i = \sum f(ux_i)$. (ref. *Equation 2*). Hence the sum of integers U_i yield an aggregate score as described in *Equation 4.* Alternatively, U_i may be used in conjunction with scaling constants or weighting coefficients as follows:

$$ACr_j = \sum_{i=1}^{n} U_i W_i \quad \text{(Equation 6)}$$

where components are as described previously and n are the number of attributes.

According to Moselhi and Martinnelli (1990), *Equation 6* can be applied by the DM (e.g. an owner or his representative such as the Quantity Surveyor) following the 3-step procedure described below:

Step 1: Establish the selection criteria as a value hierarchy, which represent the owner's objectives and the measurable attributes of the contractor. It is important to avoid overlapping and double counting in selecting the attributes, to maintain the applicability of the additive model of *Equation 6.*
Step 2: Determine the relative weights associated with each attribute. These weights represent the relative importance that the decision maker(s) assigns to each; indicating his willingness to give up in one attribute in order to gain in another. To determine the relative weights, a two-step ranking procedure is used. An 'ordinal ranking' is used in the first step to determine the order of priorities among the attributes. This can be done using the approach of subjective assessment suggested by Dalkey (1972) and known as the Delphi method. Experts in the field are asked to establish an order of preference among the different attributes, which may also include preference of an attribute over a combination of others. A 'cardinal ranking' is then used in the second step to assign weights to each one of the attributes and justify their judgements.
Step 3: Construct the utility functions associated with the attributes being considered. These functions represent the satisfaction of the decision maker over the range of achievement levels that could be attained on each attribute. They are the most important input to a multi-attribute decision analysis. In order to construct a utility function, the most and least desirable outcomes for each attribute are first identified, and then assigned arbitrary values of 1.0 and 0.0, respectively. More information on how the utility functions are constructed and their characteristics can be found in (Moselhi and Martinnelli, 1990 and Martinelli-Bello, 2006).
According to Holt (1998), MAUT is similar to MAA in modelling terms but utilises a quantitative method of determining values for inclusion therein. Hence, MAUT can quantitatively consider both tangible (e.g. safety record) and intangible (e.g. contractor image) attributes, during evaluation. In this study however, it is the MAA methodology that is employed.

DATA AND METHODOLOGY

Data were collected using a case study approach. Tender data were collected on 10 completed residential building projects in Lagos State of Nigeria. However, due to space restriction, three of the cases are presented in this paper (Table 1). For case 1, 5 contractors tendered for the project under consideration, for cases 2 and 3, 8 contractors tendered for each of the projects. The details of the tender sum, completion duration and other details pertaining to each contractor that tendered are listed in Table 1. Apart from these details, 9 attributes derived from literature and from discussions with industry practitioners as essential criteria for contractor's prequalification were identified. These are: low tender sum (LTS), financial capability (FC), managerial capability (MC), technical expertise (TE), completion duration (CD), prior business relationship (PBR), current workload of company (CW), number of years in business (NYB) and past performance (PP). Each of these attributes was scored on a scale of 1 to 10 for each contractor by the DM, i.e. the client's Quantity Surveyor. As previously explained, the multi attribute analysis (MAA) methodology was employed in this study.

Table 1: Tender particulars of projects used for case study

Project No.	No. of contractors who tendered	Contractor No.	Tender sum[1] submitted (₦)	Completion duration (Wks)	No. of years in business	Client's QS estimate (₦)
		1	48,011,319.00	48	10	
		2	54,550,717.00	40	15	
1	5	3	46,865,450.00	48	15	44,967,500.00
		4	60,903,324.00	52	20	
		5	52,083,818.00	45	10	
		1	60,914,749.00	42	12	
		2	59,446,337.43	32	10	
		3	60,914,749.00	60	14	
2	8	4	69,282,163.50	32	13	60,485,010.00
		5	59,455,779.00	65	10	
		6	65,868,234.00	48	15	
		7	65,719,778.00	30	12	
		8	73,793,865.00	32	12	
		1	62,988,555.25	40	8	
		2	65,800,510.00	48	8	
		3	64,713,640.00	40	9	
3	8	4	67,080,000.00	44	5	63,331,648.67
		5	62,900,420.00	40	6	
		6	62,853,000.00	40.5	7	
		7	65,634,421.00	52	8	
		8	66,577,600.00	48	7	

Applying the Multi-Attribute Model to Tender Evaluation

The data obtained from the Quantity Surveyor's scoring of each of the 9 identified attributes for each contractor that tendered in each project is presented in Table 2. Using this data set, the multi-attribute analysis (MAA) was employed using the additive model in *Equation 3*, which is re-stated as flows:

$$ACr_j = \sum_{i=1}^{n} V_{ij} W_i \qquad \text{(Equation 3)}$$

From this equation, the V_{ij} component, whereby V_{ij} = variable (attribute) i score in respect of contractor j is represented by the data set in Table 2. The W_i component, which represents the weighting factor, is to be determined for the model to be useful for tender evaluation.

In order to determine the weighting factor, the two-step approach suggested by Moselhi and Martinnelli (1990) was employed. The Delphi method of ordinal ranking was employed in rank-ordering the 9 identified attributes. After 3 iterations of using the Delphi method on construction professionals, an ordered list of the 9 identified attributes was developed (Table 3). Following that, the technique of cardinal ranking was then employed in order to determine

[1] £1.00 = (₦ 240 (Nigerian Naira)

the appropriate weighting factor for each attribute. The result of this exercise is shown in Table 3.

Table 2: Multi-Attribute Score for each Contractor on Different Projects

Project No.	No. of contractors who tendered	Contractor No.	LTS (V1)	PP (V2)	TE (V3)	MC (V4)	FC (V5)	PBR (V6)	CD (V7)	NYB (V8)	CW (V9)
		1	9	7	6	6	8	9	8	7	6
		2	7	6	6	4	6	3	10	9	5
1	5	3	10	6	6	8	6	8	8	9	5
		4	6	7	7	5	8	4	6	10	7
		5	8	7	6	6	4	3	9	7	4
		1	8	7	6	6	6	8	6	6	7
		2	10	6	6	4	4	6	9	3	6
		3	8	9	8	8	8	8	4	9	9
2	8	4	4	7	6	6	6	6	9	8	7
		5	9	5	4	4	4	6	3	7	7
		6	5	8	8	6	6	6	5	10	6
		7	6	8	6	8	8	7	10	6	6
		8	3	7	4	8	8	5	9	6	8
		1	8	9	8	8	8	8	10	8	7
		2	5	8	6	8	8	6	6	8	7
		3	7	7	6	6	6	6	10	9	6
3	8	4	3	5	4	4	4	7	7	5	7
		5	9	8	6	8	8	6	10	6	7
		6	10	7	6	6	6	6	8	7	6
		7	6	8	8	6	6	8	4	8	7
		8	4	8	6	8	8	8	6	7	7

Table 3: Weighting factors for the Attributes

Attribute	Ordinal ranking	Cardinal ranking (Weight *W*)
Low tender sum (LTS)	1	10
Past performance on similar construction (PP)	2	9
Technical expertise (TE)	3	8
Managerial capability (MC)	4	7
Financial capability (FC)	5	6
Prior business relationship (PBR)	6	5
Completion duration (CD)	7	4
No. of years in business (NYB)	8	3
Current workload of company (CW)	9	2

Using the simple MAA additive model of *Equation 3* and the unified aggregate score (*Equation 4*), the attribute scores in Table 2 were used to multiply the weighting factors in

Table 3. This exercise was carried out for each contractor on all the projects studied. The result produced by the additive model is presented in Table 4. It is evident from Table 4 that for Project No. 1, the result of the multi-attribute evaluation of tenders submitted indicates that the most suitable contractor among those that tendered is Contractor No. 1. However, if the ‘lowest bidder’ criterion alone had been used, the project would have gone to Contractor No. 3. In the same way, for Project No. 2, the result of the multi-attribute evaluation of tenders submitted indicates that the most suitable contractor among those that tendered is Contractor No. 3. However, if the ‘lowest bidder’ criterion alone had been used, the project would have gone to Contractor No. 2 who eventually ranked 5th. In the same vein, it is evident from Table 4 that the multi-attribute evaluation of tenders for Project No. 3 indicates that Contractor No. 1 is most suited for the job among the 8 contractors that tendered. However, if the ‘lowest bidder’ criterion alone had been used, the project would have been awarded to Contractor No. 6 who finally ranked 3rd.

CONCLUSION

This study has attempted to apply the multi-attribute approach to tender evaluation using the case study approach. Results from 3 projects evaluated showed that the multi attribute analysis suggested the selection of contractors other than what the ‘lowest bidder’ criterion suggested. In view of the wide criticism against the use of the ‘lowest bidder’ criterion, it is suggested in the light of this finding that Quantity Surveyors should endeavour to embrace the use of the multi-attribute approach in tender selection so as to ensure contract performance, rather than cheaper price and poor or no performance.

Whilst there have been suggestions across the world on how to make amendments so that the lowest bid alone is not considered in tender selection, confusion runs riot when construction cuts across national boundaries of the contractors and clients. As such, the use of the multi-attribute approach brings a lot of objectivity to tender evaluation in our rapidly globalising and multicultural construction sector.

Table 4: Tender Evaluation using the Attributes, weighting Factors and the MAA Model

Project No.	Contractor No.	V_1	**W1**	V_2	**W2**	V_3	**W3**	V_4	**W4**	V_5	**W5**	V_6	**W6**	V_7	**W7**	V_8	**W8**	V_9	**W9**	**ACr_j**	**$ACR_{j\,max}$**	**$UACr_j$**	**Rank**
	1	9	**10**	7	**9**	6	**8**	6	**7**	8	**6**	9	**5**	8	**4**	9	**3**	6	**2**	407	540	0.754	**1**
	2	7	**10**	6	**9**	6	**8**	4	**7**	6	**6**	3	**5**	10	**4**	9	**3**	5	**2**	328	540	0.607	5
1	3	10	**10**	6	**9**	6	**8**	8	**7**	6	**6**	8	**5**	8	**4**	9	**3**	5	**2**	403	540	0.746	2
	4	6	**10**	7	**9**	7	**8**	5	**7**	8	**6**	4	**5**	6	**4**	10	**3**	7	**2**	350	540	0.648	3
	5	8	**10**	7	**9**	6	**8**	6	**7**	4	**6**	3	**5**	9	**4**	7	**3**	4	**2**	337	540	0.624	4
	1	8	**10**	7	**9**	6	**8**	6	**7**	6	**6**	8	**5**	6	**4**	6	**3**	7	**2**	365	540	0.676	3
	2	10	**10**	6	**9**	6	**8**	4	**7**	4	**6**	6	**5**	9	**4**	3	**3**	6	**2**	341	540	0.631	5
	3	8	**10**	9	**9**	8	**8**	8	**7**	8	**6**	8	**5**	4	**4**	9	**3**	9	**2**	430	540	0.796	**1**
2	4	4	**10**	7	**9**	6	**8**	6	**7**	6	**6**	6	**5**	9	**4**	8	**3**	7	**2**	333	540	0.617	6
	5	9	**10**	5	**9**	4	**8**	4	**7**	4	**6**	6	**5**	3	**4**	7	**3**	7	**2**	296	540	0.548	8
	6	5	**10**	8	**9**	8	**8**	6	**7**	6	**6**	6	**5**	5	**4**	10	**3**	6	**2**	356	540	0.659	4
	7	6	**10**	8	**9**	6	**8**	8	**7**	8	**6**	7	**5**	10	**4**	6	**3**	6	**2**	389	540	0.720	2
	8	3	**10**	7	**9**	4	**8**	8	**7**	8	**6**	5	**5**	9	**4**	6	**3**	8	**2**	324	540	0.600	7
	1	8	**10**	9	**9**	8	**8**	8	**7**	8	**6**	8	**5**	10	**4**	8	**3**	7	**2**	447	540	0.828	**1**
	2	5	**10**	8	**9**	6	**8**	8	**7**	8	**6**	6	**5**	6	**4**	8	**3**	7	**2**	366	540	0.678	6
	3	7	**10**	7	**9**	6	**8**	6	**7**	6	**6**	6	**5**	10	**4**	9	**3**	6	**2**	368	540	0.681	4.5
3	4	3	**10**	5	**9**	4	**8**	4	**7**	4	**6**	7	**5**	7	**4**	5	**3**	7	**2**	251	540	0.465	8
	5	9	**10**	8	**9**	6	**8**	8	**7**	8	**6**	6	**5**	10	**4**	6	**3**	7	**2**	416	540	0.770	2
	6	10	**10**	7	**9**	6	**8**	6	**7**	6	**6**	6	**5**	8	**4**	7	**3**	6	**2**	384	540	0.711	3
	7	6	**10**	8	**9**	8	**8**	6	**7**	6	**6**	8	**5**	4	**4**	8	**3**	7	**2**	368	540	0.681	4.5
	8	4	**10**	8	**9**	6	**8**	8	**7**	8	**6**	8	**5**	6	**4**	7	**3**	7	**2**	363	540	0.672	7

REFERENCES

Banwell, H. (1964) *The Placing and Management of Contracts for Building and Civil Engineering Work,* Report of the Committee of Sir Harold Banwell, HMSO, London.

Burrows M. (1981) *Tendering in the Building Industry 1750-1850,* M.Phil thesis, Nottingham University.

Dalkey, N.C. (1972) *Studies in the Quality of Life: Delphi and Decision Making,* Lexington Books (Heath), Lexington, Massachusetts.

Egan, J. (1998) *Rethinking Construction*. London, Department of the Environment Transport and Regions.

Elmisalami, T, Walters, R and Jeselskis, E. J. (2006) Construction IT decision making using multiattribute utility theory for use in a laboratory information management system. *J. Construction Engineering and Management,* **132** (12), 1275-1283.

Holt, G.D., Olomolaiye, P.O. and Harris F.C. (1994) Evaluation prequalification criteria in contractor selection, *Building and Environment,* **29**(4), 437-48.

Holt, G.D., Olomolaiye, P.O. and Harris, F.C. (1995) A review of contractor selection practices in the UK construction industry, *Building and Environment,* **30**(4), 553-61.

Holt, D.G. (1998) Which contractor selection methodology? *Int, J. Project Management,* **16**(3), 153-164.

Jennings, P. and Holt, D.G. (1998) Prequalification and multi-criteria selection: a measure of contractors' opinions, *Construction Management and Economics,* **16**, 651-660.

Latham, M. (1993) *Trust and Money,* Interim Report of the joint Government/Industry Review of Procurement and Contractual Arrangements in the United Kingdom Construction Industry, HMSO, London.

Latham, M. (1994) *Constructing the Team,* Final Report of the joint Government/Industry Review of Procurement and Contractual Arrangements in the United Kingdom Construction Industry, HMSO, London.

Martinelli-Bello, A. (2006) *Bids Evaluation: A Multi-attribute Utility Approach,* M.Eng. Major Technical Report, Centre for Building Studies, Concordia University, Montreal.

Moselhi, O. and Martinelli, M. (1990) Analysis of bids using multi-attribute utility theory. *In Proceedings of the International Symposium on Building Economics and Construction Management*, Sydney, Australia, 1990. Pp. 335-345.

Seeley, I.H. (1997) Quantity Surveying Practice, Macmillan Education Limited, London.

Simon Committee (1944) *The Placing and Management of Building Contracts*, Report of the Simon Committee, HMSO, London.

Yusif, A. and Odeyinka, H.A. (2000) An evaluation of tendering practice in the Nigerian construction industry. *Construction in Nigeria*, **15**(2), 3-7.

MEASURING THE PERFORMANCE OF CONSTRUCTION DEVELOPMENT PROJECTS: A PROPOSAL TO EXPAND THE SPECTRUM OF CRITERIA USED

Sidney Newton
The University of New South Wales, Sydney, NSW, Australia
s.newton@unsw.edu.au

Dennis Lenard
The University of New South Wales, Sydney, NSW, Australia
d.lenard@unsw.edu.au

Denny McGeorge
The University of New South Wales, Sydney, NSW, Australia
DennyM@fbe.unsw.edu.au

The economic impact of construction and property development can be measured in a variety of ways, but inevitably those measures are expressed in financial terms: return on investment, expenditure cost, value-for-money, etc. Hardly surprising, perhaps, given the tradition of financial focus in both economics generally and in the construction and property industries more specifically. However, we are now witnessing a growing concern internationally, and across industries, with broader corporate responsibilities than just shareholder financial return. Broader corporate social considerations and emerging environmental issues have prompted an accelerating move to account for the impact of our economic decisions in broader terms: the so-called 'triple bottom line' of people, planet, and profit.

The triple bottom line movement is already driving fundamental change in accounting and company reporting practices. This paper will present a related proposal to expand the spectrum of economic criteria used in the measurement of construction and property development impact. Construction and property development contribute to individual, community and national prosperity (wealth) in the provision of products and services to and for the community. The paper proposes a more comprehensive index than is currently used in performance benchmarking analyses. The index we propose provides a measure of both the organisation delivering the development project and the project itself. In this sense, it seeks to determine the necessary (sustainable) level of national prosperity and wellbeing to be earned from any given development process.

The paper presents a case for such an index, a framework of potential performance and quality indicators, and how such a benchmarking process might improve how we measure the economic impact of construction and property development.

KEYWORDS: triple-bottom-line, competitiveness, key-performance-indicators.

INTRODUCTION

The measurement of performance is now a fundamental tool for business decision-making by management. Indeed best practice guides, such as The Quality Management Standard ISO 9001:2000 increasingly make it a requirement. Performance measurement provides a quantitative evaluation of current performance, allows for performance to be tracked and analysed over time, and improves planning and forecasting capabilities (Wade and Recardo, 2001). It is popular precisely because it moves the focus of decision-makers away from a tradition largely limited to the monitoring of productivity and financial results. Monitoring such aggregated outcomes alone provides insufficient detail for effective business analysis, and offers no link back to the drivers of future change that is so critical to strategic management. Monitoring a broader raft of performance criteria, that more explicitly includes multiple input and output factors, is required (Dresner, 2008).

So-called 'Key Performance Indicators' (KPI's) reference a particular collection of input and output factors specific to an organisation, industry or country. KPI's are selected to provide a clear business focus to the data collection, analysis and planning activities. Over time and across organisations/industries/countries, the suite of KPI's allow performance to be benchmarked against best practice and particular business goals. Selecting and monitoring appropriate KPI's can also highlight the critical factors to change, and how to change them, in order to drive business improvement. In the UK, Constructing Excellence has made significant and effective progress in developing KPI's that are specific to the construction industry. Their mantra has been to start simple, measure what's important, and to work together with other organisations (Young and Print, 2006). An open mix of organisation-specific with industry-aligned KPI's are recommended, but no particular set are identified.

This paper takes a more prescriptive look at KPI's in the particular context of construction development. Construction development is that aspect of property development that explicitly involves significant new construction work. The perspective we propose will seek to address two key imperatives:

(i) the need to promote a richer interpretation of value: one that references the different forms of capital that now impact on business activity. This will draw from developments in accounting practices, where financial performance is now being complemented with social and environmental performance indicators.

(ii) the need to evaluate performance in meaningful terms: meaningful in terms of productivity capacity. This will draw from the broad economic discourse on competitiveness, and the recognition that wealth creation comes exclusively from microeconomic productivity gains. Macroeconomic elements do have impact, but only indirectly, and only in so far as they impact on microeconomic productivity.

TRIPLE BOTTOM LINE

There is a growing expectation on the part of shareholders and the community at large, that businesses should be judged on more than just the traditional financial bottom line. The ultimate success of a business has always included a degree of consideration for the social /ethical performance of the organisation. More recently, broad community interest in sustainability and environmental impact has elevated concerns in those regards as well.

Sustainability requires that financial, environmental and social considerations are integrated into the fundamental, core business activities (Sikdar et al., 2004).

The belief in ethical business practices and social responsibility has prompted the development of a concept known as 'Triple Bottom Line'. As the name suggests, this is where financial considerations are set alongside social and environmental performance measures. Many corporations now produce financial (profit), social (people) and environmental (planet) annual reports, detailing activities and creating a balance-sheet of negative and positive performance in sustainability terms. Such has been the interest in the concept that a Global Reporting Initiative (GRI, 2000) has been developed to provide a shared framework of concepts, consistent language, and metrics for Triple Bottom Line reporting. The Global Reporting Initiative (GRI) is a community development, agreed and improved by community consensus, and in fact goes well beyond just Triple Bottom Line reporting. However, the framework contains general and sector-specific content that ensures transparency in the reporting approach, supported by reporting guidelines that provide principles and definitions to ensure consistency, including KPI's. Whilst it is only one of several such initiatives, the GRI provides a robust basis for auditing and measuring performance in Triple Bottom Line terms.

There are limitations to the GRI and Triple Bottom Line reporting more generally. Most significantly, perhaps, is the allegation that these reports provide a smoke-screen for inaction. In other words, the purpose of Triple Bottom Line reporting might just as easily be taken by an organisation to be a marketing tool, as to be a core business activity. Sceptics maintain that in any case, whatever might be presented in terms of social and/or environmental achievements, the financial achievement remains the overwhelmingly dominant business consideration (Norman and MacDonald, 2004). It is also the case that, despite the GRI and other initiatives (such as AccountAbility's AA1000 Assurance Standard – AccountAbility, 2003), there is as yet no single framework of generally accepted standards for managing Triple Bottom Line reporting. This mixed bag of options creates key dilemmas for organisations: between national and global frameworks; specific and general standards; how to assure compliance; integration of standards across national boundaries and the entire supply chain; etc. (Ligteringen and Zadek, 2005).

Notwithstanding there are limitations with it, the GRI framework demonstrates that with further integration the increased regulatory requirement for transparency and consistency is achievable for Triple Bottom Line reporting. Some of the benefits derived from increased alignment of standards are already beginning to emerge, with GRI providing a satisfactory basis for various other concerns to be analysed within the Triple Bottom Line reporting context, such as community impact (Welford and Gilbert, 2008) and supply chain transparency (Plugge and Wiemer, 2008).

COMPETITIVENESS

Measuring the performance of construction development projects is primarily about measuring competitiveness. Competitiveness in this sense can often be confusing, since it tends to focus on the overall performance of the organisation and the particular political, legal and social circumstances of the organisation (Blunck, 2006). This would include various forces, such as technological innovation, public policy, infrastructure support, and the organisational structure of the industry. Contextual factors can certainly influence competitiveness. It is confusing, however, because the circumstance and overall performance of the organisation are necessary to improve competitiveness, but they are not sufficient (McGahan and Porter, 1997). The context is a facilitator, not a driver of competitiveness. The overall performance is an aggregate and equally fails to link directly with the drivers of competitiveness.

What drives competitiveness, unequivocally, is productivity (Porter et al., 2007). Productivity can be described and measured in various ways (Saari, 2006), but inevitably it comes down to some form of ratio between some set of inputs to the process, and some set of outputs. One critical distinction, however, is that between the productivity of the organisation in general, and the productivity of the organisation specific to a particular project. The factors and measures for each of these aspects are potentially quite different. Given the project-based nature of construction developments, this is an important distinction worthy of further consideration.

According to Porter et al. (2007), "The microeconomic foundations of productivity rest on three interrelated areas: (1) the sophistication and capabilities with which domestic companies or foreign subsidiaries compete, (2) the quality of the microeconomic business environment in which they operate, and (3) the state of the development of clusters that provide benefits through the proximity of related companies and institutions." These three factors are presented as the microeconomic foundation of national productivity, but we propose that an equivalent set of components might equally be employed to describe the foundations of productivity for an organisation. A set of measures that represented the sophistication, environment and clustering capabilities of an organisation, would in that circumstance provide a fundamental measure of productivity capacity for the organisation. What it does not provide is any sense of the extent to which that productivity capacity is being exercised in any particular situation. For that, consideration has to be given to the particular situation, which in the case of construction development is the project.

Construction development at a project level can be considered across a broad range of factors and an inordinate number of frameworks have been developed to evaluate construction projects in their full compass. It was Vitruvius, a Roman architect, who first defined the three conditions for good architecture as: commodity (functionality), firmness (structural stability), and delight (aesthetics). CABE (2006) has adopted the same foundation for their evaluation process, as has the Design Quality Indicator Online (http://www.dqi.org.uk/). But construction development is more than just about architecture. It is also about individual, community and national prosperity – wealth in the fundamental sense. Taken together, what this suggests is that it should be entirely feasible to determine a set of components specific to the construction development project that evaluate the productivity capacity of a particular project in a particular situation.

KEY PERFORMANCE INDICATORS

The development of the Triple Bottom Line reporting initiative demonstrates that a richer interpretation of value can be developed as the basis of a global standard. The GRI then illustrates how a consensus can be reached on the scope and application of such a standard. That process needs to be adopted and applied in the context of construction development projects, but as a prerequisite the expectation should be to produce a prescriptive framework of components that constitute the standard.

It is also argued that construction development needs to be evaluated in terms of competitiveness if it is to be considered at all in terms of genuine wealth creation. Productivity is identified as the key driver for wealth creation, and whatever prescriptive framework is proposed needs to attend to productivity capacity. It is proposed that productivity capacity needs to distinguish between the organisation generally, and the project itself. This means that the components proposed to constitute the evaluation framework have to address the two aspects of productivity independently.

Working with these two key imperatives, the following components are proposed as an initial set of evaluation criteria. It is to be expected that the candidate set we propose will require refinement and further modification. The purpose of this paper is to present the expanded framework of criteria as the basis for future development.

The following articulation of the KPI's we propose is based broadly around the so-called '12 pillars of competitiveness', identified by the World Economic Forum in their Global Competitiveness Report (World Economic Forum, 2007). Aspects also draw directly on the explication of the microeconomic foundations of productivity provided in that same report by Porter et al. (2007). Whilst the Global Competitiveness Report is articulated in the context of global competitiveness and directed at the productivity of entire economies, the same factors appear to have compelling parallels in the context of competition between alternative development projects and the productivity capacity building of particular development organisations.

The Key Performance Indicators we propose are in two sets. The first set is concerned with the organisational level, which in our context would be a measure of the Developer Performance. The second set is concerned with the project level, which in our context would be a measure of the Development Excellence.

Developer Performance

Component 1: Quality of the Supply Chain

Developments provide an important link in the process of community wealth creation, which makes their place in the broader supply chain all the more important. Thus, not only is an effective material and labour supply critical to the development itself, but strong external alliances can gear the overall community benefit significantly.

Component 2: Investor and Consumer Confidence

Investor and consumer confidence speaks to the stability and strength of a developer. Various indicators are possible to evaluate the levels of confidence in a developer. It is anticipated that preference should be given to the drivers of investor confidence (such as operational transparency), rather than the impact of investor confidence (say, on share-prices).

Component 3: Strategic Advantage and Innovation

The major wealth creator is innovation. The design and development of cutting-edge products and processes to underpin economic growth is fundamental. This requires an environment that is conducive to innovative activity, at both the corporate and project level. Great projects are created by great companies that strive to be at the cutting edge through research and development.

Component 4: Business Sophistication

Business sophistication is conducive to higher efficiency in the production of goods and services. When companies and suppliers are interconnected in groups ("clusters"), efficiency is greater, leading to greater opportunities for innovation and superior development outcomes.

Development Excellence

Component 5: Infrastructure

The existence of high-quality infrastructure is critical. Developments that have a well-developed transport and communications infrastructure network nearby enhance the communities' ability to connect to core economic activities schools and facilities.

Component 6: Design Quality

"Well-designed residential developments can increase opportunities for positive social interaction, reinforce social identity and pride in an area, and encourage social inclusion. These in turn contribute towards improved health, wealth, morale, goodwill and self-esteem. Other benefits include giving a sense of belonging, promoting neighbourly behaviour, involving communities, and feeling safer and more secure." (CABE, 2006). Design quality also impacts on developer and consumer investment returns.

Component 7: Product Quality

Product quality includes the materials and systems making up the development in the context of maintainability and sustainability over the project life. It also includes artisan skill levels and standards of workmanship.

Component 8: Community Impact

A quality development project has a direct impact on the attractiveness of the surrounding community by raising expectations, investment potential. It may contribute substantially to community wellbeing.

Component 9: Environmental Impact

Quality projects deliver resource conservation, waste minimisation and sustainable futures of the developments functional life.

Component 10: Consumer Equity and Investment

Quality developments generate investment returns for the developer and the consumer through effective development design and delivery. A sound development generates equity growth for the consumer significantly beyond inflation.

CONCLUSIONS

Measuring the performance of construction development projects needs to fall in line with standard performance measurement practice, and more explicitly include multiple input and output factors. This paper has taken a prescriptive look at KPI's in the particular context of construction development, with two key imperatives: (1) to provide a richer interpretation of value that recognises social and environmental as well as financial indicators, and (2) to evaluate performance of both the organisation and the situation in terms of productivity capacity.

The richer interpretation of value stemmed from current initiatives in Triple Bottom Line reporting. These initiatives demonstrate that it is not only feasible to accommodate non-financial factors within an accounting context, but that international consensus can drive the entire process around a prescribed framework of components.

An overview of competitiveness revealed the significance of productivity capacity, and the need to distinguish clearly between the organisation and the project in that regard. Such a distinction is possible, and generates two complementary sets of components for the measurement framework we propose.

The measurement framework we propose comprises ten components: four relate directly to the developer performance, and six relate directly to the development excellence. Each proposed component is briefly described. Collectively, the components represent an expanded framework of criteria for measuring the performance of construction development projects. This framework is a proposal to expand the spectrum of criteria used as the basis for future development and discussion.

REFERENCES

AccountAbility (2003) Assurance Standard AA1000. London: AccountAbility

Blunck, F. (2006) What is Competitiveness? The Competitiveness Institute, available at: http://www.competitiveness.org

CABE. (2006) Design Review: How CABE evaluates quality in architecture and urban design, London: CABE.

Dresner, H. (2008) The Performance Management Revolution: Business Results Through Insight and Action. New Jersey: John Wiley and Sons.

GRI. (2000) Sustainability Reporting Guidelines. Amsterdam: Global Reporting Initiative.

Ligteringen, E. and Zadek, S. (2005) The Future of Corporate Responsibility Codes, Standards and Frameworks. An Executive Briefing by The Global Reporting Initiative and AccountAbility, available at: http://www.globalreporting.org/

McGahan, A.M. and Porter, M.E. (1997) How much does industry matter, really? Strategic Management Journal. 18(Summer Special Issue), 15–30.

Norman, W. and MacDonald, C. (2004) Getting to the Bottom of "Triple Bottom Line". Business Ethics Quarterly, 14(2)

Plugge, L. and Wiemer, J. (2008) Small, Smart and Sustainable: Experiences of SME Reporting in Global Supply Chains. Amsterdam: Global Reporting Initiative.

Porter, M.E., Ketels, C. and Delgado, M. (2007) The Microeconomic Foundations of Prosperity: Findings from the Business Competitive Index, in The Global Competitiveness Report 2007-2008. World Economic Forum, 51-81, available at: http://www.weforum.org/

Saari, S. (2006) Productivity: Theory and Measurement in Business, available at: http://www.eanpc.org/pdfs/EPC/Wed_Res_1730_Saari.pdf

Sikdar, S.K., Jain, R. and Glavic, P. (eds) (2004) Technological Choices for Sustainability. New York: Springer-Verlag.

Wade, D. and Recardo, R. (2001) Corporate performance management : how to build a better organization through measurement-driven strategic alignment. Oxford: Butterworth-Heinemann.

Welford, R. and Gilbert, S. (eds) (2008) Reporting on Community Impacts: A survey conducted by the Global Reporting Initiative, the University of Hong Kong and CSR Asia. Amsterdam: Global Reporting Initiative.

World Economic Forum. (2007) The Global Competitiveness Report 2007-2008, Hampshire: Palgrave Macmillan.

Young, A. and Print, M. (2006) KPIs and Benchmarking: Best Practice Guide, Construction Excellence, available at: http://www.constructingexcellence.org.uk/

A STRATEGIC VIEW OF ICT SUPPORTED COST MANAGEMENT FOR GREEN BUILDINGS IN THE QUANTITY SURVEYING PRACTICE

Wilfred M. Matipa [BSc, MSc, PhD, MCIOB, MAACE]
Department of Built Environment, Faculty of Technology & Environment, Liverpool John Moores University, Liverpool, Merseyside, UK
W.M.Matipa@ljmu.ac.uk

Denis Kelliher [BE, PhD, CEng, MIEI]
Department of Civil & Environmental Engineering, Informatics Research Unit in Sustainable Engineering [IRUSE], National University of Ireland Cork, Cork City, Ireland

Marcus Keane [BE, PhD, MIEI]
Department of Mechanical and Biomedical Engineering, National University of Ireland Galway, Galway, Ireland

For the Republic of Ireland to meet the European Parliament directive 2002/91/EC – *which places a duty on building developers to design, build and operate structures that meet the sustainability criteria set in the directive* - the architecture, engineering, construction and facilities management (AEC/FM) industry must take up and practice green building systems that promote total integration of the construction process. By definition green building or sustainable building is the process of producing a constructed facility that encompasses ultimate energy efficiency, forward-thinking resources management, and general sustainable construction. Achieving green building, however, requires an integrated team; combining a wide range of different specialists through in-depth collaboration so that the complexity of trade-offs between architectural features, building services and other factors can be reached. The aim of the research has been twofold: firstly to highlight the availability and use of software systems in the Irish construction cost consultancy; and secondly to gather views from practicing professionals on how the available systems could ease the implementation of total cost management of green buildings. Using primary data the research concludes that the industry is well poised to move into the next generation of surveyors that would fully participate in the envisaged green construction industry.

KEYWORDS: Information Technology, cost management, Sustainable Construction, Quantity Surveying

INTRODUCTION

The Irish construction industry operates in a similar pattern to most international industries in the developed world. From design to construction, various professionals use complex tools and techniques to optimise client requirements. The most recent key requirement for most clients has been to meet the European Parliament directive 2002/91/EC – [*which places a duty on building developers to design, build and operate structures that meet the sustainability criteria set in the directive (Morrissey, O'Donnell, Keane, and Bazjanac, 2004)]*. Meaning, construction professionals must take up and practice green building systems that promote total integration of the construction process. By definition, green building or sustainable building is the process of producing a constructed facility that encompass ultimate energy efficiency, forward-thinking resources management, and general sustainable construction (Rajgor, 2004). Achieving green building, however, requires an integrated team; combining a wide range of different specialists through in-depth collaboration so that the complexity of trade-offs between architectural features, value and cost, building services and other factors can be reached (Sorrell, 2003). This research is part of a strategic approach to implementing green building practices, by promoting an early convergence of professional work in the building product delivery process.

CHALLENGES OF OPTIMISING VALUE FOR CONSTRUCTED FACILITIES

Naturally, an optimal value of a constructed facility can only be achieved if the right balance between performance, cost, delivery time (Ashworth, 2004; Dundas, 2005) and the market value is achieved. In the case of green buildings, getting such a balance requires a great deal of simulations from the project team so that all decisions prove not only environmental friendly, but also valuable, workable, and cost effective. As a result, the ability to collaborate in early phases within the project team, with a view to providing expertise on life-cycle analysis of all decisions cannot be over-emphasised (Hipkiss, 2005). Integration, however, cannot easily be achieved because of the diverse professional disciplines on each project (Sorrell, 2003). Divergence in professional specialisation and interests, and the sequential nature of construction stages have naturally caused industry-wide operational islands; leading to fragmented building performance assessments (Morrissey, O'Donnell, Keane, and Bazjanac, 2004), as shown in Figure 1.

Because of industrial fragmentation, cultural issues as well as business issues tend to have stronger sentiments each time the issue of operational integration is considered for the construction industry. A building's "life" spans its planning; its design, construction and operation; and its ultimate reuse or demolition (Osso *et al*, 1996). Often, the entity responsible for design, construction, and initial financing of the building is different from those operating the building, meeting its operational expenses, and paying employees' salaries and benefits (Osso, *et al*, 1996). However, the decisions made at the first phase of building design and construction can significantly affect the costs and efficiencies of later phases; that is why it's crucial to include a Quantity Surveyor at design stage (Ibid). Life-cycle cost analysis – *an increasingly accepted analytical method that calculates costs over the "useful" or anticipated life of an asset* – reveals that low up-front expenditures, though easier to finance at building inception, can result in much higher costs over the life of a building or system (Ashworth and Hogg, 2002). There are generally two complementary ways to achieving integration in the project team, so as to implement green building practices: (i) by business relationships between firms; and (ii) by identifying, and using the right technological tools and techniques that can facilitate the smooth running of the integrated team. The latter is the focus of this research.

The Importance of Traditional Cost Modelling Systems

Despite the increase in the demand for more sustainable practices, traditional systems continue to play a crucial role in the modeling of construction cost data (Ferry et al, 2003).

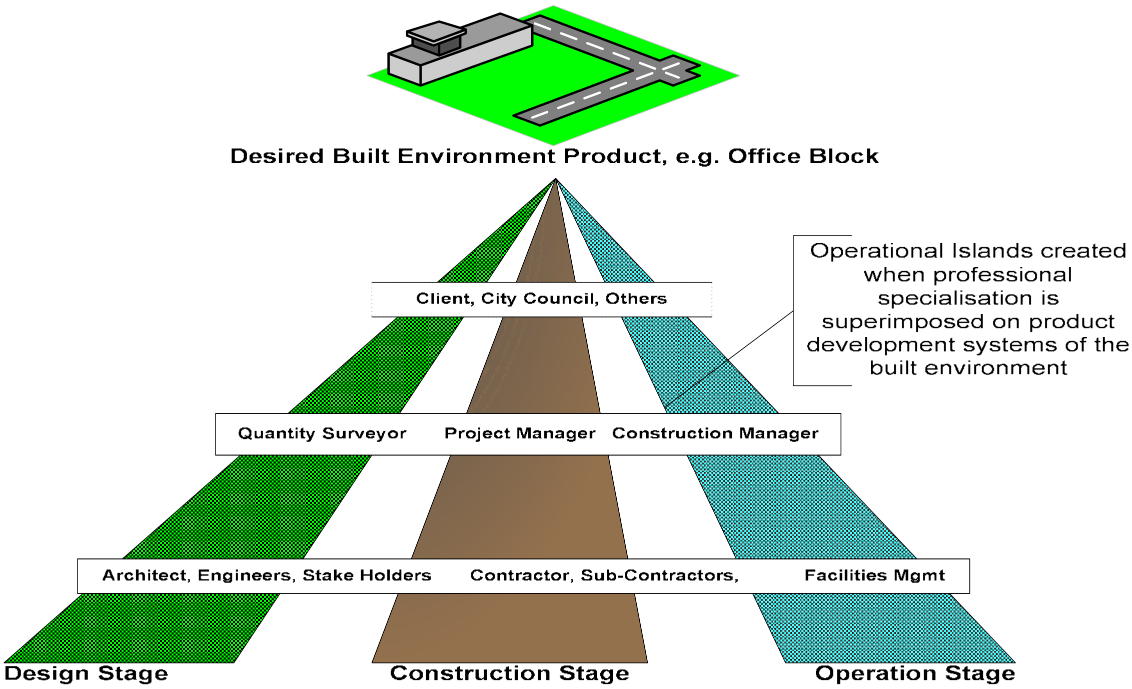


Figure 1: Operational Islands Created by Superimposing Operational Specialisation on Industrial Segmentation [Adapted: Kerzner, 2003]

Figure 2.0 abstracts the type of traditional cost models mapped against the generic design stages, and examples of how cost models are used at various stages. Using Figure 2.0 it can be observed that the cost modeller requires not only design data but also historical cost information about the product. However, practical implementation of the examination of the economic benefits and environmental ramifications of green buildings, with life-cycle assessments is extremely harder when using traditional project appraisal systems that are endemic in most construction industries (Erlandsson and Borg, 2003; Osso *et al*, 1996). Quantity surveyors realise that actual calculations of the building's total economic and environmental impact and performance – *from material extraction and product manufacture to product transportation building design and construction, and operations and maintenance, and building reuse or disposal (Sorrell 2003)* – can be taxing. For instance, the general cost management of projects that are highly mechanical and electrical [M & E] in nature is assigned to M & E firms; mainly by way of provisional and or prime cost sums because of the specialised nature of the mechanical and electrical profession, making it extremely difficult and risky for the Quantity Surveyors to manage such costs. The more complex project become, the higher the demand for better cost modelling tools for the quantity surveyor (Sorrell, 2003). This development, among other factors, has led to the changing role of the cost consultant the world over. There are complex LCA systems used as powerful decision making support tools (Erlandsson and Borg, 2003), such as the BRE's "Envest"; which is a system based on the top down approach, because it has been developed for use in the design phase of a building project. Most programs, however, are still user unfriendly due to the shear amount of data required to appraise a design. However, it is envisaged that emerging software would boost project appraisal and analysis, from the aspects of time, cost, performance and market value; and enhance the work of a quantity surveyor.

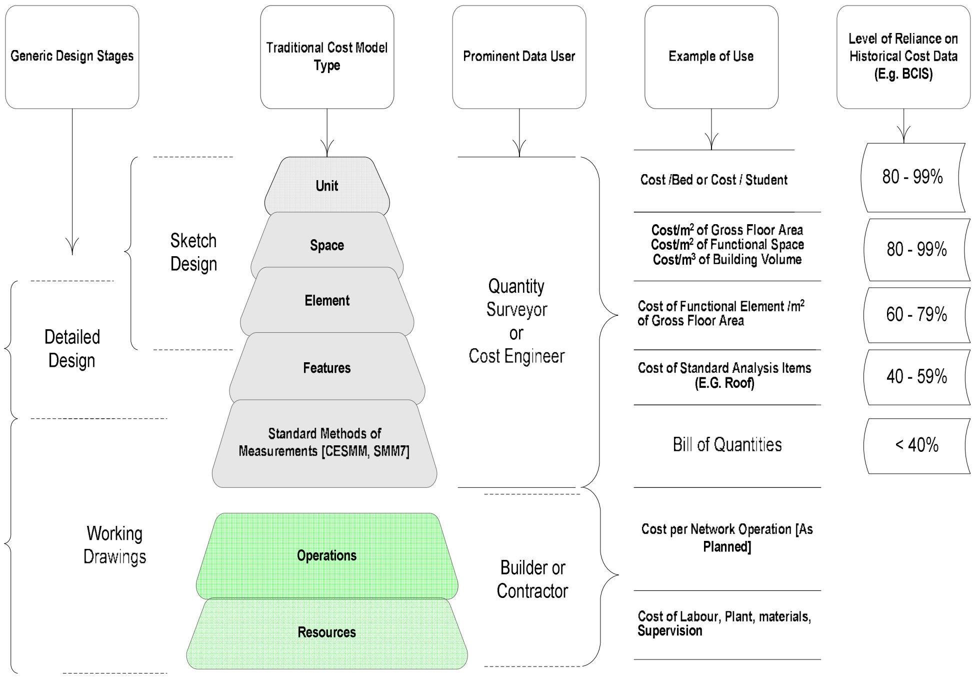


Figure 2: Type of Cost Models Mapped against Generic Design Stages [Adapted: Ferry et al, 2003]

If integrated, cost modelling systems can be important to the business of Quantity Surveying because they help professionals achieve 'total cost management' of a constructed facility – a concept which supports green building. As a result computing power [information and communication technology (ICT)] is inevitable in the cost consultancy sector of any construction industry because it increases the speed to capture, analyse and share data to facilitate decision making.

RESEARCH DESIGN AND DATA COLLECTION

In order to extract a sound understanding of the established body of knowledge on integrated cost management of sustainable construction, the following research questions were formulated:

I. What kind of software is the industry using for the design, construction and running of constructed facilities?
II. Could the available software promote information sharing; hence facilitate integrated and collaborative approach to business?

A questionnaire was the main instrument for data collection because: (1) The type of population – literate; (2) Most of the population could not find time for an interview; (3) The increasingly expensive nature of alternative means of data collection.

Sampling Design

By definition, simple random sampling is a form of sampling design in which ***n*** distinct units selected from ***N*** units in the population in such a way that every possible combination of ***n*** units is equally likely to be the sample selected (Everitt, 1998). Stratified random sampling therefore is the random sampling from each strata of a population after stratification (Ibid). The population for this research was naturally stratified, by the Society for the Chartered Surveyors of Ireland (2004) according to the county where a firm operated from. (i) Cork; (ii) Dublin; (iii) Waterford; (iv) Limerick; and (v) Galway. However, companies that had outlets in more than a single country were only represented by their headquarters. Stratified sampling was used because it ensures that different groups of a population are adequately represented in the sample so that the level of accuracy in estimating parameters is increased (Nachimias and Nachimias, 1992). The aim was to achieve a total population (N) of fifty (50) respondents so as to increase the chances of a high response rate. Twenty three (23) responded, or a 46% response rate. Even though a higher response rate could have been desired, data collection proved extremely sluggish despite all four methods of questionnaire distribution namely: (i) Postal mail; (ii) Electronic mail; (iii) Web-link hosted by a private consultant; and (iv) personal delivery. The presentation and eventual analysis of the results from the survey follow the sequence of questions set in the questionnaire so that the clarity of the research is enhanced.

Key Details of Respondents to the Research Questionnaire

The breakdown of respondents, according to their respective positions within firms would bolster the validity and reliability of primary research data. Fifty seven percent (57%) of respondents had managing director portfolios at the time of the survey; seconded by seventeen percent (17%) senior Quantity Surveying portfolios. Though unexpected at the time of questionnaire distribution, this development adds a strategic dimension to the research mainly because respondents would have a proportionally high number of years of Quantity Surveying experience coupled with visionary duties of steering the firm to a prospective future. Experience in the Quantity Surveying business, as earlier alluded to, can impact the quality and reliability of research information. Sixty seven percent (67%) of respondents had more than fifteen (15) years of experience while twenty two percent has experience ranging from six (6) to ten (10) years. There was virtually no responded with less than 5 years of experience in Quantity Surveying. This dimension is crucial for this research because information is obtained from people that have experienced cyclical movements of the construction market; and the eventual changing role of the quantity surveyor. Naturally, consultancies tend to have a relatively small number of personnel. The research results showed that 52% of firms had Quantity Surveying personnel ranging from 5 – 10. However, this was to be expected, because most consultants can manage many projects with a small number of professionals. The firms that tended to have more personnel were big players on the market, with many offices across the country.

Project Specialisation

Within the industry, certain firms specialise in building related works, while others specialise in refurbishments and/or repair works. Because of the complexity, and in most cases, the specialised nature of Mechanical and Electrical [M&E] projects, some Quantity Surveying companies tend to apportion the overall cost management of such projects to the M&E specialists; using lump-sums or prime cost sums. Other Quantity Surveying firms have dedicated professionals specialised in M&E works. A fair amount companies that offer M&E cost management. Some of the M&E installations include HVAC systems for buildings. Because such installations have a huge impact on the initial as well as overall financial investment, it becomes essential that prudent economic simulations are carried out so as to assess the likely return on investment prior to committing finances. It is therefore important for any Quantity Surveying firm, with or without M&E specialists, to carefully analyse and appraise the financial and economic prudence of design decisions on M&E systems. Most Quantity Surveying firms can handle assorted projects type ranging from civil to refurbishment. This could be attributed to the generic nature of the profession, which most cases, allows consultants to manage the costs of projects irrespective of their size, type and complexity, using the same principles of total cost management. It is could therefore be argued that the industry is well poised to manage any sort of project, as is evidenced from the respondents' view.

Project Teams and Documentation

The perception of importance of Quantity Surveying at generic phases of the project provides the starting point of the overall assessment of role of cost management within a project team. For instance, if respondents felt quantity surveyors were not important at the preliminary stage, it could have been concluded that they were still operating with relatively conservative approach which promotes the production of bills of quantities from drawings: also referred to as '*costing a design'*. However, respondents were of the view that Quantity Surveying is 'highly' essential at all stages of the project life cycle. The preliminary stage as well as the design and construction stage had the highest scores. Kinney and Soubiran (2004) argued that 80% of the cost of the project is committed at about 20% stage of the project life cycle. This phenomenon shows that it is crucial to analyse design options, not only from the aesthetic point of view, but also from the financial, economic, and build-ability points of view; and the overall anticipated impact [positive or otherwise] of the proposed development, at an early stage.

Information Technology Packages in Use and Level of Information Sharing

The available software systems for cost consultancy business typify any world-class construction industry. Build-soft and Microsoft Excel are the most widely used systems for the preparation of quantities, estimating and cost planning, cost monitoring, and final accounts management. Similarly, project planning systems such as Microsoft Project Planner, Power Project, and Primavera Project planner are predominantly used for project planning purposes; while AutoCAD and Voloview are used for accessing visual design data. Research question 1: asked for the '*kind of software is the industry for the design, construction and running of constructed facilities?*' Results paint a good picture of useful software systems available to cost consultants; and that they could utilise the systems to uphold green building.

Optimum application of available software systems for appraisal and analysis of projects does not however rely on the software alone, but the user. For one to model the financial, economic, and sustainable performance of a constructed product from design to completion, more systems would be desirable; especially systems that offer integrated data so as to allow effective cost modelling. Despite the availability of software systems, information sharing amongst professionals is predominantly a hybrid [a combination of paper and electronic systems] at 61% while paper systems are used by 39% of respondents. There are legal risks associated with the electronic data transfer systems. Construction cost management goes hand in hand with contract administration, settlement of claims, and valuation for accounts, to mention but a few. Therefore, respondents argued that even though electronic systems supersede paper ones, it still remains essential that a paper back-up system is set up in preparation for dispute resolutions. Respondents were confident with the efficiency of the current data sharing systems in place because 30% rated the system as very efficient, 48% said the system was efficient, and 22% indicated the system was quiet efficient.

Stage in the Project Life cycle when Available Software is crucially-Important

Even though respondents were of the view that available software systems were crucial at all stages of the product life-cycle, it is important to note that design and documentation scored very high, as shown in Figure 3.

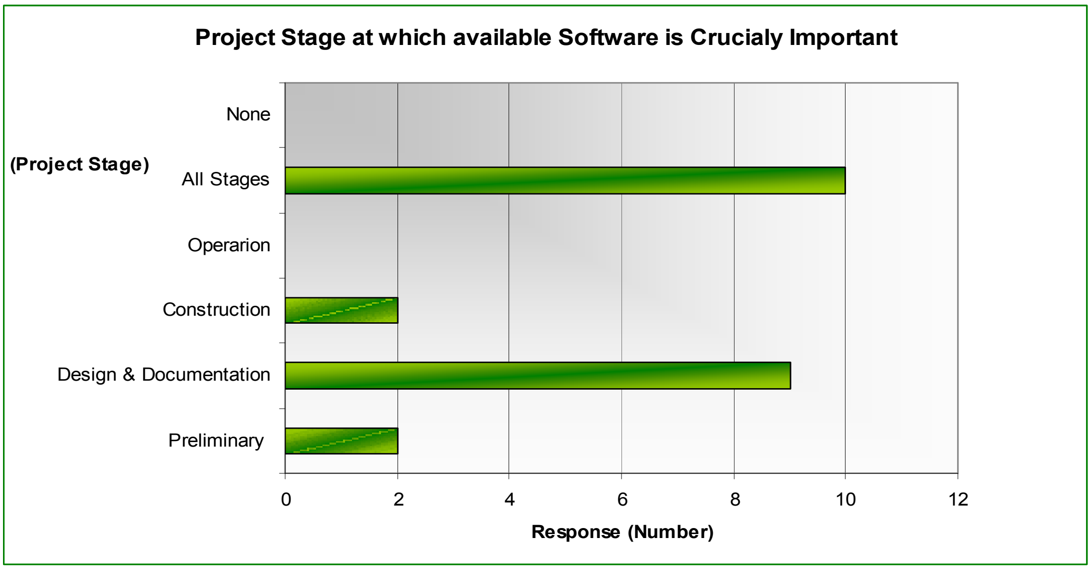


Figure 3: Rating the Project Stage at which Available Software is Crucially Important

Thirty nine (39%) percent felt the systems totally encouraged information sharing, while twenty two (22%) felt the systems encouraged information sharing to a large extent. However, 26% felt that information sharing, though encouraged, was to a less extent; and 13% felt the software did not encourage information sharing. In terms of the extent they used the software for information sharing in the project team: 39% used the software at a high rate; 39% on an average rate; 17% on a low rate, and 4% never used the software. To test respondents' consistency, they were asked to rate the extent to which available software discouraged information sharing. Fifty seven percent (57%) were of the view that the software did not discourage information sharing, while 43% felt the software discouraged information sharing; to a less extent. Because information sharing is pertinent to this research, it was important to establish correlations between selected sets of observations.

According to Witte and Witte (1997) a positive relationship among pairs of observations tend to occupy similar relative positions in their respective distributions, while negative relationships tend to occupy dissimilar and opposite positions in their respective distributions. If however there is no regularity among the pairs of observations, it could be interpreted that there could be no significant relationships (Ibid). Even though a correlation coefficient, regardless of size, never provides information about whether an observed relationship reflects simple cause-effect relationship or some complex state of affairs, it is a prudent way to engage predictive measures of the trends using current body of knowledge. To describe correlation between quantitative data and qualitative data with two categories, assign arbitrary numerical codes, such as 0, 1, 2, 3, to the two qualitative categories then use the Pearson ***r*** formula, also known as a point bi-serial correlation coefficient. Alternatively, to describe the relationship between two qualitative variables, again assign arbitrary numerical codes to the categories of both qualitative variables and solve the formula in Equation 1, also designated as Crammer's ***phi*** coefficient (Witte and Witte, 1997).

$$r = \frac{\sum \left(x - \bar{x} \right)\left(y - \bar{y} \right)}{\sqrt{\sum \left(x - \bar{x} \right)^2 \sum \left(y - \bar{y} \right)^2}}$$

Equation 1: Pearson's Correlation Coefficient Computation Formulae [Source: Witte and Witte, 1997; Microsoft Excel Functions, 2003]

The Pearson correlation coefficient was used to determine the consistency of respondents on information sharing resulted in:

(a) Compare rating for '*the extent to which the software systems encourage information sharing'* with *'the usage of the software for actual information sharing'* at **0.70;**

Though positive, the correlation coefficient shows that even though respondents felt the software encouraged information sharing, they did not fully implement information sharing using the software. Because the observation data sets are relatively small, a higher positive correlation would have dispelled the inconsistency.

(b) Compare the rating for *'the extent to which the software systems discourage information sharing'* with '*the usage of the software for actual information sharing*' at **-0.99;**

The negative correlation coefficient reflects a more realistic picture of the perceptions because respondents felt the software did not discourage the use, hence perceptions and actual implementation of information sharing create a negative correlation, as is the case.

The second research question assessed available software promotes information sharing; hence facilitate integrated and collaborative approach to business. There was a slight positive correlation between the usage of MS Excel and Buildsoft, calculated at **0.51** using the Pearson's coefficient. From the results, it could be deduced that the integration of software packages – *a key to cost management* – has not taken off on a big scale within the cost consultancy sector. As a result, encouraging software interoperability would even be more challenging. There were leading questions embedded in the survey where respondents were asked to comment: they include:

(i) The Extent to which Software Discourages Project Information Sharing

Respondents' perception of the extent to which software is a contributory factor to the poor implementation of information sharing is as follows: (1) When different software is used, or data is imported into a different file format;(2) Poor communication amongst professionals, especially on the location of information;(3) Poor linkage between pre-contract and post contract activities, mainly because data standards are not compatible;(4) Computers do not improve the work (i.e. the way professionals design), but has huge effect on communication, though accessibility to drawings can be universal; (5) Because old systems still work and have proven reliable, especially when systems fail, professionals do not tend to experiment on newer technologies;(6) The generic procurement system is still Design-Bid-Construct, therefore team participation follows that pattern;(7)Some traditional aspects of Quantity Surveying must remain un-automated e.g. taking off quantities;(8) Incompatible software between different disciplines of the design team.

(ii) Aspects of Cost Consultancy Business worth Automating

Respondents argued that: (1) No part of the business should be automated because allowing software to dictate the modus-operendi could be detrimental to the profession; (2) Collection, analysis and use of cost data and of historical cost information need to be automated;(3) Measurement and generation of quantities, and billing, interim and final accounts aught to be automated;(4) Even though it is difficult to automate most of the QS work (soft nature) but software for costs in use would be useful (cost Planning), economics or cost in use; (5) Proper business records in cases of disputes, litigation, etc. Modern software needs to improve in its recording of data, e.g., records of emails sent;

(iii) Anticipated Threats to Traditional Cost Consultancy Business

Assessing the threats to one's business is crucial for survival in a competitive environment. The following are some of the threats perceived by quantity surveyors: (1) Fees: too low which leads to poor service, unsatisfied client, lack of work; (2) Software: too reliant on software, hence weakening the technical strength of new surveyors;(3) Skills: Too many consultants go for the 'FAT' budget, its easy to come under-budget, and client looses out; (4) Non audit-ability of artificial information in terms of statistical data on future life cycle costing; (5) Demand for sustainable construction will put pressure on cost consultancy, because clients would not only demand historical data, but also futuristic data; (6) Engineers and architects are trying to carryout the job of the quantity surveyors, thereby increasing their fees; (7) An amalgam of various computer packages in lieu of a more streamlined approach. Because clients wish to get value for money, and they are not going to be paying for something that can easily be done automatically

CONCLUSION AND DISCUSSION

For quantity surveyors to fully implement total cost management during the product life cycle, it is important to integrate cost management systems. Software interoperability offers a good prospect for total cost management, though there has been a lack of market data from the industry which, if available, would be crucial for the marketing of the software solutions emanating from research institutions. The nature of Quantity Surveying is such that it uses a relatively high volume of assorted information from a myriad of sources; as a result a suitable package from the quantity surveyor's point of view, is one that can capture as many of the operational dimension they are involved in day today running of the business, without disrupting the body of knowledge built over the years; systems aught to complement existing cost algorithms such as standard methods of measurement. Additionally, collaborative working would result in the implementation of total cost management, hence contributing to sustainable construction. It becomes absolutely crucial that surveyors take up newer integrated systems if they are to compete adequately on the market.

REFERENCES

Ashworth, A., (2004) Cost Studies of Buildings 4th Edition, Pearson Prentice Hall, Harlow, London, Tokyo, Cape Town

Ashworth, A., and Hogg, K., (2002) Willis's Practice and Procedure for the Quantity Surveyor, 11th Edition, Blackwell Science, Oxford, London

Dundas, C., (2005) 'Rethinking Construction' Part 2, *Building and Construction,* May 2005, 12 – 13, Dundas Publications, Durham

Erlandsson, M., and Borg, M., (2003) Generic LCA – methodology applicable for buildings, constructions and operational services – today practice and development needs, Building and Environment, 38 (7), 919 – 938

Everitt, B., S., (1998) The Cambridge Dictionary of Statistics, Cambridge University Press, Cambridge

Ferry et al (2003) Cost Planning of Buildings Seventh Edition, Blackwell Science, Oxford

Hipkiss, R., (2005) Lowest Price Can Lead to Highest Cost, Building Engineer, March 2005, 80(3), 18 – 19

Kerzner, H., (2003) Project Management: A systems Approach to Planning, Scheduling, and Controlling, 8th Edition, John Wiley & Sons, Inc. New Jersey

Kinney, C., L., and Soubiran, N., (2004) Interactive Roadmap to Conceptual Cost Estimating, *Cost Engineering*, 46(9), 31 – 40

Morrissey, E., O'Donnell, J., Keane, M., and Bazjanac, V., (2004) Specification And Implementation Of IFC Based Performance Metrics To Support Building Life Cycle Assessment Of Hybrid Energy Systems, *Proceedings of the SimBuild 2004 Conference, IBPSA-USA*, National Conference Boulder, CO, August 4-6, 2004

Nachimias, C., F., and Nachimias, D., (1992) Research Methods in the Social Science 4th Edition. St Martins Press Inc. London

Osso *et al* (1996) Sustainable Building Technical Manual: Green Building Design, Construction, and Operations, Public Technology and the U.S Green Building Council, USA

Rajgor, G., (2004) Sustainable Building: Firing on target - US building designers aim for green, Refocus, 5(2), 62 – 63

Society for Chartered Surveyors in Ireland (2004) Search for Quantity Surveying Members of the Institute, http://www.scs.ie/ASP/searchMembpub.asp [Accessed February 2004]

Sorrell, S., (2003) Making the link: Climate policy and the reform of the UK construction industry, Energy Policy, 31 (9), 865 – 878

Witte, R., S., and Witte, J., S., (1997) Statistics 5th Edition, Harcourt Brace College Publishers, London, Tokyo, San Diego

KEY CHARACTERISTICS OF SMALL CONSTRUCTION FIRMS: A UNITED KINGDOM PERSPECTIVE

Shu-Ling Lu
School of the Built Environment, University of Salford, Salford, M5 4WT, UK
S.L.Lu@salford.ac.uk
Martin G. Sexton
School of the Built Environment, University of Salford, Salford, M5 4WT, UK
M.G.Sexton@salford.ac.uk
Carl Abbott
School of the Built Environment, University of Salford, Salford, M5 4WT, UK
C.Abbott@salford.ac.uk

The International Council for Research and Innovation in Building and Construction (CIB) Task Group (TG) 65 – Management of Small Construction Firms has the following objectives: define the concept and scale of 'small construction firm' activity in various country contexts; identify generic antecedents to the successful management of small construction firms, as well as discern country-specific drivers and constraints; and, focus on developing appropriate methodologies for the study of management of small construction firms. This paper reports the UK part of an ongoing international survey and series of workshops to investigate the principal characteristics and scale of small construction firms in different countries. First, the work of TG65 is briefly described. Second, the UK position is articulated – including the definition of small construction firms, their number and turnover. Finally, generic methodology lessons for CIB TG65 are proposed.

KEYWORDS: small construction firms; research methodology

1.0 INTRODUCTION

1.1 Background of the CIB TG 65

Small construction firms play an increasingly important part in improving the overall performance of construction industries across the world. The growing role of small construction firms is evidenced in the United Kingdom (UK), for example, with 99.8% of construction firms having less than 50 staff (BERR, 2006). This construction industry structure is reasonably uniform across all developed countries, with the proportion of small firm activity being even more pronounced in developing countries. In addition, construction projects typically draw together a significant number of diverse small and large construction firms with varying collaborations (Betts and Wood-Harper, 1994). It is acknowledged that large firms' performance is significantly impacted by their small supply chain partners' performance (e.g. Egan, 1998; Latham, 1994). The small construction firm activity of construction industries is, therefore, not only significant in its own right, but also plays an instrumental role in the performance of large construction firms and supply chains. The successful management of small firms, however, is often plagued by their inherent characteristics; in particular, limited staff capacity and capability, scarce time and resources for innovation; excessive influence of owner-managers, and difficulty in raising finances and maintaining adequate cash flows. The challenge to the industry is the development of business strategies, organisation of work, technologies and human resources which are appropriate to the characteristics and needs of small construction firms in different country contexts. Addressing this challenge is the focus of the International Council for Research and Innovation in Building and Construction (CIB) Task Group (TG) 65 - Management of small construction firms.

1.2 Aims and objectives of the CIB TG 65

The aim of this Task Group is to:

- bring together the experience and expertise of researchers and practitioners who would not have otherwise interacted with each other;
- develop, share and disseminate appropriate research methodologies, and organisation and management theory and practice with regard to the successful management of small construction firms within the CIB network membership and to the wider international academic and industry communities; and,
- encourage and enable new collaborative, multi-disciplinary research activity to take place through the establishment of a critical mass of interested and diverse researchers and practitioners.

The specific research objectives are to:

- define the concept and scale of 'small construction firm' activity in various country contexts;
- identify generic antecedents to the successful management of small construction firms, as well as discern country-specific drivers and constraints; and,
- focus on developing appropriate methodologies for the study of management of small construction firms.

1.3 Background of the project

The TG 65 has a three-year programme (as set out in the TG 65 programme and deliverables [1]). Since its launch in October 2005 in Rome, Italy, it has undertaken a number of meetings / workshops to address its specific aims and objectives (see Section 1.2 above). In response to TG65 aims and objectives, an ongoing international survey of the principal characteristics and scale of small construction firms in different countries is carried out. It is agreed that each TG 65 member to produce a paper from his/her countries perspective, which, collectively, will feed into the questionnaire design. Survey design will be developed, and discussed / signed off at the next TG65 meeting in the CIB Joint International Symposium 2008 in Dubai, 15th – 17th November 2008. Indicative issues to be covered were identified as follows:

- Definition of small construction firms (e.g. number of employees, turnover and legal identity)

- Structure of industry (e.g. what percentage of firms are 'small' in individual countries' construction sectors)
- Key contexts / pressures facing small construction firms (e.g. key public policies, staff / skill shortages and procurement practices)
- Relevant role of information and communication technologies (ICTs)
- Sampling strategy for survey

This paper reports the UK part of this international survey.

2.0 THE UK POSITION

2.1 Definition of micro, small and medium-sized enterprises (SMEs)

There is no single official definition of a small firm in the UK. Currently there are two principal classifications in the UK which are described below.

1. The Companies Act 1985

According to the Companies Act 1985 definitions [2] for a SME in relation to compulsory audit thresholds, a company (or group) qualifies as a small or medium-sized company (or group) if it meets two out of three criteria relating to turnover, balance sheet total and number of employees in its first financial year, or in the case of a subsequent year, in that year and the preceding year (see Table 1). For example, the audit exemption conditions are met if a company qualifies as small;

- it employs fewer than 50 staff and has a turnover of not more than £5.6 million;
- it employs fewer than 50 staff and has a balance sheet total of not more than £2.8 million; or,
- it has a turnover of not more than £5.6 million and a balance sheet total of not more than £2.8 million.

2. Department for Business, Enterprise and Regulatory Reform (BERR)

The UK Department for Business, Enterprise and Regulatory Reform (BERR), defines the size of a firm by using number of employees (see Table 1). The BERR defines:

- micro companies as having less than 10 staff;
- small companies as having less than 50 staff;
- medium companies as having between 50 and 249 staff; and,
- large companies as having 250 staff and over.

Table 1 shows a summary of UK SME definitions. In general, statistical definitions of an SME use one (BERR) or more of three defining measurements (the Companies Act 1985): number of employees; turnover; and, size of the balance sheet. There is significant consensus that 'a small firm' is defined as having less than 50 staff. In addition, it was found the use of turnover and/or balance sheet total were a key distinguishing factors.

Table 1: A summary of UK SME definitions

UK SME definition	Size definition	Number of employees	Turnover	Balance sheet total
The Companies Act 1985	**Small company**	not more than 50	not more than £5.6 million	not more than £2.8 million
	Small group	not more than 50	not more than £5.6 million net (or £6.72 million gross)	not more than £2.8 million net (or £3.36 million gross)
	Medium-sized company	not more than 250	not more than £22.8 million	not more than £11.4 million
	Medium-sized group	not more than 250	not more than £22.8 million net (or £27.36 million gross)	not more than £11.4 million net (or £13.68 million gross)
Department for Business, Enterprise and Regulatory Reform (BERR)	**Micro firm**	0-9 employees	N/A	N/A
	Small firm	0-49 employees (includes micro)	N/A	N/A
	Medium firm	50-249 employees	N/A	N/A
	Large firm	With 250 employees and over	N/A	N/A

2.2 Structure of industry

The UK construction industry constitutes about twenty-one per cent of the total enterprises and employs in excess of two million people in the UK (BERR, 2006). This position is summarised in Table 2. The dominant role of small construction firms within the UK is evidenced by 99.8% of UK construction companies having less than 50 staff, employed 74.2 % of total construction workforce (BERR, 2006).

Table 2: Number of enterprises, employment and turnover in the private sector (including public corporations and nationalised bodies) by number of employees

Categories		**Total**	**Size (number of employees) (%)**				
		(=100%)	**None** [*1]	**1-9**	**1 - 49**	**50 - 249**	**250 +**
Businesses	**All industries**	4,466,700	73.0	22.5	26.2	0.6	0.1
	Construction	920,780	86.3	11.9	13.5	0.2	0.0
Employment (/ 1,000)	**All industries**	22,402	15.9	16.6	31.2	11.7	41.1
	Construction	2,010	41.1	18.4	33.1	9.1	16.7
Turnover (/ £ million, excluding VAT)	**All industries**	2,613,907	7.9	14.7	29.2	14.8	48.1
	Construction	218,738	22.9	17.1	32.5	12.2	32.4

Source: BERR Enterprise Directorate Analytical Unit (2006, Table 3 UK Industry Summary and Table 5 UK Divisions)

[Note] [*1]: “None" comprises sole proprietorships and partnerships comprising only the self-employed owner-manager(s), and companies comprising only an employee director.

2.3 Key contexts / pressures facing small construction firms

There is agreement that small firms’ management is constrained by intrinsic problems which large firms do not have. Specific issues raised in the literature on small firms are as follows.

2.3.1 The role of the owner(s)/manager(s)

The manager(s)/owner(s) of small construction firms have been found to have a pivotal role in decision making processes (e.g. Lu and Sexton, 2006; Sexton and Barrett, 2003; Miozzo and Ivory, 1998; Hankinson *et al*., 1997). This is consistent with Storey (1994) and Chaganti *et al*. (1995), arguing that each small firm is unique and very much reflects the personal characteristics of the company owner.

2.3.2 Company structure

Many small firms lack clear formal structures and recording procedures compared to large firms (e.g. Gurran and Blackburn, 2001). Management of small firms tends to come about in very fluid, informal ways. For example, one of the main ways of communicating information is via informal face-to-face discussions between individuals which mean that there generally no printed copies. Thus the challenge for research within construction SMEs is that the source of data must rely almost exclusively on staff.

2.3.3 Resource limitations

The issue of resource limitations of small firms compared to large firms has been highlighted in the literature (e.g. Robinson and Pearce, 1984; Rothwell and Zegfeld, 1982). They depict that small firms lack the necessary resources (such as finance, staff and time) to engage in strategic planning, and instead focus on operational aspects geared primarily to survival on a day-to-day basis. This limitation is particularly hard felt with respect to workforce development opportunities and training. Small firms can have difficulty in raising finance and maintaining adequate cash flow which can result in limited scope for capital or ongoing investment in appropriate staff training and research and development. The Chartered Institute of Building (CIOB, 2005), for example, argue that the majority of building firms rely on a nominally self-employed labour force and these self-employed workers are not in a position to be able to invest in their own training. In addition, small firms have scarce time and resources to allocate to external interaction. This limits the flow and amount of information on which to have discussions. Various studies have illustrated the importance of networking in small construction firms (e.g. Sexton *et al*., 2006).

2.3.4 Family-owned small businesses

Family-owned small businesses constitute a large proportion of the overall small business population in Britain. The UK Small Business Service (SBS) (2006, p. 187), for example, indicate that "71% of businesses owners described their business as a family-owned one." The implication of this is that family businesses are important contributors to construction SMEs. Cromie and O'Sullivan (1999, p. 77), argue that "a person who is a member of the family which owns a family business will be in a privileged position compared to non-family personnel and this can facilitate career development." It is argued that the owner of the firms would be more keen to mentor and offer management opportunities to their own family.

2.4 Relevant role of ICT

There is agreement that information technologies (IT) or information and communication technologies (ICTs) play a significant role in the reduction of construction cost (e.g. Latham, 1994). However, there is a dearth of reliable statistics of ICTs investment or the value-add of ICT in UK construction SMEs. It has been argued that the level of IT or ICT employed by construction SMEs is very much limited to CAD, e-mail applications and word processing (e.g. Love et al., 2001). The research conducted by Hari *et al*. (2005), revealed that the limited use of IT in the construction industry is due to lack of investment; lack of time to learn; and, the lack of awareness of the benefits of transforming knowledge into explicit knowledge.

3.0 GENERIC METHODOLOGY FOR CIB TG 65 PROJECT

This section concentrates on the design and operation of the methodology used to guide the TG 65 international survey project. The structure of this section is as follows. First, the overall research process is introduced. Second, emerging issues for the generic CIB TG 65 questionnaire are proposed.

3.1 Overall research process

There are five main processes conducted in this research (see Figure 1 below). First, position papers for each country will be produced. Currently, fourteen countries are involved. Second, across country analysis for position papers will be carried out. The findings will be presented by the TG65 joint co-ordinators in the following task group meeting. The presentation will be designed to stimulate a discussion by the TG65 members and also provide content for TG members to debate the key issues identified in the position papers. The data from this phase will be qualitative in nature. The cognitive mapping technique therefore will be used to help us to see the relationships between different ideas and perspectives emerging from position papers. This is evidenced by Eden (1992), arguing that the cognitive mapping technique allows the key concepts and relationships articulated by the researcher to be externalised and synthesised in a clear layout that facilitates critical enquiry and reflection. Therefore, 'Decision Explorer' software package (cognitive mapping tool) will be used. In addition, the CIB TG 65 website [1] will be used as a main information-sharing platform where its members can share and exchange their ideas. The CIB TG65 website is currently maintained by its joint co-ordinators. Third, the generic questionnaire for the survey will be developed and signed off by TG65 members. It is agreed that the survey questionnaire will be written in English. Fourth, an international survey will be conducted. On-line survey method will be used in this research. This survey will be distributed through the CIB website. Through this channel, we hope, we will have better opportunities to get broad view across the world. Finally, across country analysis will be carried out. It is expected that a 'cross-country analysis and synthesis' report will be produced. This report will be co-authored by each country lead contact person. The data from on-line questionnaire survey will be quantitative in nature. The quantitative data captured from the questionnaires will be only analysed to establish statistical means and present the findings in graph form to enable the relative importance of factors to be identified and compared more easily. Methods used for analysis will include descriptive statistics and selected statistical testing.

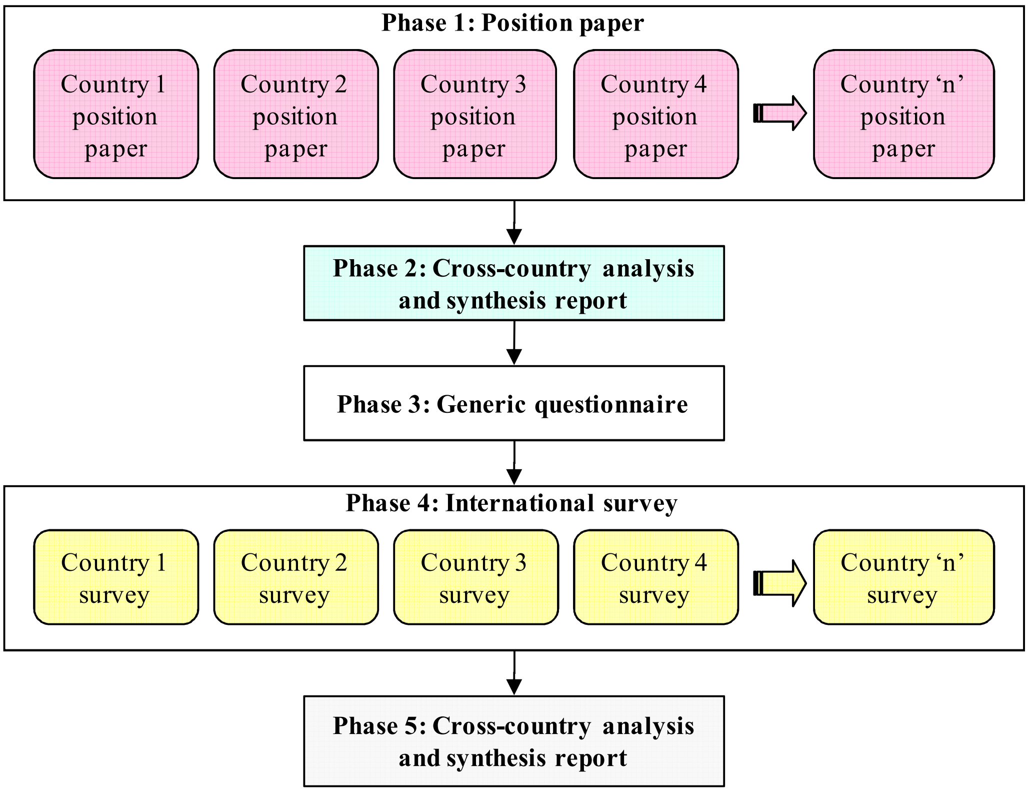


Figure 1: CIB TG 65 project overall research process

3.2 Emerging issues for the questionnaire

The UK perspective indentifies the following as fruitful issues for investigation through the questionnaire phase.

1. Company size (see Section 2.1)

No. of employees: ________; Annual turnover: _________; Balance sheet total: _______

2. Ownership of the company (see Section 2.3.1 and 2.3.4)

☐ Subsidiary (Controlled by a parent company) ☐ Family-owned business

☐ Proprietary (with owner managers) ☐ Other (Please specify) _____________

☐ Private (owners separate from management)

3. Company Structure (see Section 2.3.2)

☐ Investors in People (IiP) accreditation ☐ Total Quality Management (TQM)

☐ ISO 9001 accreditation ☐ Other (Please specify) _____________

4. Human resource management (see Section 2.3.3)

4.1 Networks

☐ Engagement with industry initiatives (e.g. Rethinking Construction agenda)

☐ Engagement with Government support programmes (e.g. Movement for Innovation (M4I) demonstration projects)

☐ Other (Please specify) ____

4.2 Current training provision

☐ No training ☐ Rarely ☐ Occasionally ☐ Quite often ☐ Frequently

5. ICT infrastructure (see Section 2.4)

☐ Internet infrastructure ☐ E-mail ☐ E-commerce ☐ Other (Please specify) _______

4.0 CONCLUSION

The paper has set out the rationale and objectives of CIB TG 65 - 'Management of Small Construction Firms.' A review of the principal characteristics and scale of small construction firms in the UK was presented. Emerging issues for the generic CIB TG 65 questionnaire were identified.

NOTES

[1] Fuller details of CIB Task Group 65 (e.g. programme and deliverables) can be accessed at http://www.buhu.salford.ac.uk/CIBTG65/.

[2] Thresholds for Small and Medium-sized Companies and Groups, URN No: 05/1973, (available at http://www.berr.gov.uk/bbf/financial-reporting/acc-audit-developments/page16361.html, assessed on 7th February 2008)

REFERENCES

Betts, M. and Wood-Harper, T. (1994), "Reengineering Construction: A New Management Research Agenda", Construction Management and Economics, 12, pp. 551-556.

Chaganti, R., DeCarolis, D. and Deeds, D. (1995), "Predictors of Capital structures in Small Ventures", Entrepreneurship Theory and Practice, 20 (2), pp.7-18.

Chartered Institute of Building (CIOB) (2005), CIOB Reveals Results from Skills Shortage Research (available at: http://www.prnewswire.co.uk/cgi/news/release?id=151701).

Cromie, S. and O'Sullivan, S. (1999), "Women as Managers in Family Firms", Women in Management Review, 14 (3), pp. 76-88.

Department for Business, Enterprise and Regulatory Reform (BERR) (2006), SME STATISTICS 2006, BERR: Enterprise Directorate Analytical Unit (available at http://stats.berr.gov.uk/ed/sme/).

Eden, C. (1992), On the nature of cognitive maps, Journal of Management Studies, 29, pp. 261–265.

Egan, J. (1998), Rethinking Construction: Report of the Construction Task Force on the Scope for Improving the Quality and Efficiency of UK Construction, DETR: London.

Gurran, J. and Blackburn, R. A. (2001), Researching the Small Enterprise, 1st ed, Sage Publications: London.

Hankinson, A., Bartlett, D. and Ducheneaut, B. (1997), "The Key Factors in the Small Profiles of Small-Medium Enterprise Owner-Managers that Influence Business Performance: The UK (Rennes) SME Survey 1995-1997 An international Research Project UK Survey", International Journal of Entrepreneurial Behaviour & Research, 3 (3), pp. 168 – 175.

Hari, S., Egbu, C. and Kumar, B. (2005), “A Knowledge Capture Awareness Tool: An Empirical Study on Small and Medium Enterprises in the Construction Industry”, Engineering, Construction and Architectural Management, 12 (6), pp. 533 – 567.

Latham, M. (1994), Constructing the Team, HMSO: London.

Love, P.E.D., Irani, Z., Li, H., Tse, R.Y.C. and Cheng, E.W.L. (2001), An Empirical Analysis of the Barriers to Implementing E-commerce in Small-Medium Sized Contractors in the State of Victoria, Australia, Construction Innovation, 1(1), pp. 43–54.

Lu, S. and Sexton, M. (2006), “Innovation in Small Construction Knowledge-Intensive Professional Service Firms: A Case Study of an Architectural Practice”, Construction Management and Economics, 24, pp. 1269-1282.

Miozzo, M. and Ivory, C. (1998), Innovation in Construction: A Case Study of Small and Medium-sized Construction Firms in the North West of England, Manchester School of Management, UMIST: Manchester, UK.

Sexton, M.G. and Barrett, P.S. (2003), “Appropriate Innovation in Small Construction Firms”, Construction Management and Economics: Special Issue on Innovation in Construction, 21, September, pp. 623-633.

Sexton, M., Barrett, P.S. and Aouad, G. (2006), “Motivating Small Construction Companies to Adopt New Technology”, Building Research and Information, 34 (1), pp. 11-22.

Small Business Service (SBS) (2006), Annual Survey of Small Businesses: UK 2004/05, March, Department of Trade and Industry, SBS (available at http://www.berr.gov.uk/files/file38251.pdf).

Storey, D.J. (1994), Understanding the Small Business Sector, Routledge: London.

Robinson, R. and Pearce, J. (1984), “Research Thrusts in Small Firm Strategic Planning”, Academy of Management Review, 9, pp. 128-137.

Rothwell, R. and Zegfeld, W. (1982), Innovation and the Small and Medium Sized Firm, Printer: London.

DEVELOPING A CONCEPTUAL FRAMEWORK OF A CROSS-CULTURAL STUDY OF BUSINESS RELATIONSHIPS: THE UAE CONSTRUCTION INDUSTRY

Habiba Al Hatmy (PhD Candidate)
Liverpool John Moores University, School of Built Environment, Liverpool, UK
halhatmy@royaljetgroup.com

Yassine Melaine (Programme Leader-MSc Construction Project Management and MSc Quantity Surveying / Commercial Management)
Liverpool John Moores University, School of Built Environment, Liverpool, UK
Y.Melaine@ljmu.ac.uk

Ahmed Beloucif (Course Leader MSc International Business)
Aberdeen Business School, The Robert Gordon University, Garthdee Road, Aberdeen AB10 7QE, UK.
a.beloucif@rgu.ac.uk

ABSTRACT

Recently, the UAE has witnessed an increase of foreign direct investments in the construction industry sector. Hence cross-cultural business communication, marketing, and management have gained important dimensions not only due to interaction with foreign cultures but also because the workforce within their national borders is becoming more and more culturally and ethnically diverse. In the present scenario, effective cross-cultural management has become essential for the success of business relationships. Academics have studied the impact of cross-cultures in business in general. However, there is hardly any study examining Arabic culture interacting with other cultures due to changes in the market place. Therefore, this paper attempts to review the existing literature in order to analyse its gaps, and propose a theoretical framework (figure 1) that would lead to a better understanding of effective marketing strategies to bridge the gap between different cultures and study their impact on business dimensions and relationships in the UAE.

KEYWORDS: Cross-Culture, Business-Relationship Marketing, Construction.

INTRODUCTION

Doing business and marketing in a global environment has its own challenges. When people from distinct national cultures interact with each other, they are confronted with unfamiliar interaction patterns and communication styles, different business goals and logics, all of which may be difficult to deal with or interpret. The concept of management and communication across cultures and its impact on global marketing has generated a lot of interest amongst scholars. Hofstede (1995) aptly says that *"the business of international business is culture"*. This paper aims to explore the different theories proposed by the scholars relating to culture, cross-cultural management, cross-cultural communication and in particular business relationship marketing in the construction industry in the UAE. In this country, *"relationships and mutual trust are paramount for any successful business interaction and can only be developed through face-to-face meetings. It is important to spend time with your Emirati business counterparts and ensure future meetings take place to continue cultivating the relationship"* as advised by Communicaid (2007).

The recent years have seen a phenomenal growth in the volume of international trade. Multinational corporations have more than half of their sales in foreign markets. Similarly, foreign investment has risen around the globe. Hence cross-cultural business communication, marketing, and management have gained important dimensions not only due to interaction with foreign cultures but also because the workforce within their national borders is becoming more and more culturally and ethnically diverse. Although a lot of scholars have produced a lot of valuable work on cross-cultural management, communication, and marketing, they seem to agree that most of the studies have been western-oriented or mostly produced and generally validated according to the western standards. As a result, significant gaps still exist and there are areas that have not been covered by the scholars.To the knowledge of researcher, there are no published research works in cross-cultural relationship marketing studies in the Arab world and few are directly related to the subject area and the U.A.E (Abbas et al., 1995; Darwish, 1977 and 2001). Therefore, this study will draw concepts from management and marketing. Thus, this paper attempts to review the literature review, analyse its gaps, and propose a theoretical framework (figure 1) that would lead to a better understanding and recognition of differences in communication style, business expectations, approaches, and the regularities of these culturally-determined differences, with particular reference to the U.A.E.

CONCEPTUAL FRAMEWORK DEVELOPMENT

The concept of culture has always generated a lot of interest amongst scholars. In the global age, understanding the domain of culture becomes even more important to have effective cross-cultural communication and management. Although, it still remains *"a fuzzy, difficult-to-define construct"* (Triandis et al., 1986, p. 43), many scholars have tried to define it. Understanding national cultures is important for scholars of marketing and management. Scholars have emphasized the importance of recognize national cultures. The failure to take national differences between countries into account has been the cause of many business failures (Ricks, 1983). The literature review on marketing shows that many of the marketing theories have been developed in the Western countries, particularly in the USA. Hence these theories are a reflection of the culture in which they were developed. Scholars like Hofstede (1980) believe that the management approaches developed in one particular culture have not been deemed valid for any other culture. Jackson (1995) emphasizes that management, as an academic subject, is essentially North American in origin, and in many of its assumptions. A large number of scholars such as Hofstede (1980), Laurent (1986), Jackson (1995), Alpander and Carter (1995), and Evans et al (1995) seem to agree that the implementation of management development activities or the evaluation of existing activities, in different cultures must be undertaken with an understanding of the underlying traditions and values of that culture. These scholars emphasize that management development must be adapted to the requirements of local culture and managerial style.

Cross-cultural communication and management becomes even more substantial in a cross-cultural business-to-business environment. In a B2B setting, suppliers and/or service providers need to understand the nature and circumstances of their buyers because of the unique characteristics of the customers acting as organizations. In general cases, developing individual relationship with buyers helps in achieving a high level of profitability. The objective in relationship marketing is to establish, maintain and enhance the relationship at a profit so that the objectives of both parties are met (Grönroos, 1994). The buyer has to make decisions whether a relationship should be established (first time purchase), or it should be continued (repurchase), and if a relationship should be enhanced in scope (increase commitment with the supplier). Buyers are likely to have expectations towards the supplier regarding their competence, communication, commitment, and conflict handling, and these are likely to affect trust ad communication.

Scholars like Williams et al (1998) believe that the process of interpersonal orientation or bonding helps in understanding buyer-seller relationships, and Wilson and Moller (1988) identify it as an important concept for examining the performance of business relationships between countries. Dwyer et al (1987) and Pfeffer and Salancik (1978) believe that in the development of social bonding, personal factors such as trust or satisfaction with the relationship partner play an important role in making the relationship more binding, stable, and predictable. Jackson (1985) suggests that the personal representatives of the seller may give an indication to the buyer about important business values, and that the personal relationship may be the best available evidence that the representative is interested and committed enough to provide that value.

Literature review suggests that the existing literature is mainly concerned with relationships involving parties within single cultural domains and lacks conceptualization beyond borders; there is a need to develop a framework to address the gap in the literature by introducing the moderating role of national culture dimensions in business relationships in an international context. The proposed study would aim to examine the management approaches to communication and marketing adopted by the international businesses in the UAE setting and the extent to which they remain parochial.

In terms of the U.A.E, there are still many areas that need to be examined in terms of brand building strategies, customer retention, issues of self-concept and self image, customer loyalty, satisfaction, and market entry strategies used by global companies. There is a genuine need to be prepared for and recognize differences in communication style, business expectations, and work behaviour.

RESEARCH METHODOLOGY

Based on a systematic review of key studies, the study has attempted to generate a conceptual framework. Therefore, this paper is expected to discuss the evolving conceptual framework of cross-cultural study of business relationships relating to the construction industry in the UAE.

Moreover, it is important to note that this study is a "*work-in-progress*" and intend to present the preliminary findings of its qualitative investigation at the conference. It also aims to highlight a mixed approach which is selected for the whole research project. More importantly, the authors highlight the key difficulties and challenges faced by one of the researchers, i.e., a woman researcher.

Construction and the built environment draw a wide variety of established subjects/disciplines, including natural science, social science, engineering and management. These are then applied to the particular built environment context and requirements (Fellows & Liu, 1997). Due to the nature of this research topic and as previous qualitative research carried out in Arab countries (Hill et al, 1998), this one will have its challenges. Moreover, as the main researcher is a woman from the UAE, she is expected to overcome barriers of research access to construction companies and senior managers. The research methodology for the proposed study is mixed (or balanced) approach. This emphasis has developed with the growing attention focused on "Triangulation" in research (Yin, 1994). Triangulation is the combination of methodologies in the study of the same phenomena. The weakness in each single method will be compensated by the counter-balancing strengths of another. It combines multiple observes, theoretical perspectives and methodologies. This is very powerful for gaining insights and results, and for assisting in making inferences and in drawing conclusions (Fellow and Liu, 1997).

The first phase comprises qualitative research that would be based on in-depth interviews with 20 senior managers of construction companies in Abu Dhabi and Dubai, UAE. This exploratory phase aims to identify the key determinants of national and organizational culture as well as cross-cultural issues. It also helps understand the influences of these key determinants on business relationships. It is to note that both phases involve around examining the buyer-seller relationships and interactions of the different construction companies (from foreign cultures) with the local environment. However, after conducting 10 interviews, analyzed that the managers avoided comments on cultural conflicts and focused on their own issues with the UAE government. From the initial experience, it appears that the construction industry is one of a sensitive area to do research on and in particular when it touches the "cultural" aspects. Moreover, the interviews have been carried out by the researcher (a lady) which raised further barriers to research access to construction companies. No doubt, the sensitivity of the topic and the gender of the researcher have made the respondents less ready to open up and discuyss key issues related to the topic under investigation. It has long been recognized that purely qualitative research may neglect the social and cultural construction of the variables studied (Richards and Richards, 1994).

Consequently, in order to fill this gap, another research strategy was used that is case studies in built environment research. This strategy is done by interviewing many individuals concerned in a particular project. Three main case studies will be conducted, a mini case, medium-size and a large size case study. It focuses on understanding the dynamics present within single settings (Arnaratunga and Baldry, 2000). Case studies are tailor-made for exploring new processes or behaviors or those which are little understood and gain an insight into behavior and attempts to discover unique features and common traits shared by all persons in a given classification.

One of the objectives of this research is to investigate the current status of Long-term business relationship practice in the UAE construction industry. Bennett et al. (1987) argue that the great success of the Japanese building industry depends on long-term relationships. While the practice of long-term relationship is very common in Japan and its benefits are widely acknowledged in practice and literature, it is not generally considered so in the UK. As a consequence, an opportunity that LTR could offer seems missing in the UK construction industry (Haksever et al., 1995). It would analyze whether LTR is present and not just limiting it between the contractors and the subcontractors, but also the study could be extended to analyze LTR between the managers and the workers.

From the results of qualitative investigation, a questionnaire would be designed and where emerging issues and concepts will be included in the questionnaire. It is also intended to use an online questionnaire. The study will be using SPSS package for statistical analysis and testing the generated hypotheses. Hence in part two of the research, the quantitative survey of a cross-section of managers from different types of construction companies would bring forth the different perspectives and fill all possible gaps.

ANALYSIS AND FINDINGS

As the majority of the workforce in the U.A.E consists of the expatriates, this study aims to study relationships; both within the company and relationship of the company with its clients. The typical clients for a construction company may be owners, consultants, contractors, or subcontractors. Establishing a relationship is not only with a client (contractor-consultant, contractor-sub contractor, contractor-owner, contractor-supplier, sub contractor-supplier or contractor-the local construction governing bodies such as the municipality, ministry of labour, etc) but it may also imply establishing a relationship or inter-personal bonding within the company between the workers / employees from different cultures.

Ten in-depth interviews with managers of construction companies and five in-depth interviews of people involved with a single construction project (owner, consultant, contractor, foreman and a worker) were undertaken. Recognising the importance of the key elements, process and stages of relationships, this section attempts to give a coherent and in-depth analysis of empirical data description of the relationships of the construction companies. This section also outlines the key determinants of diverse cultural relationships and conflicts.

From the qualitative research findings, questions and objectives were used to explain the statement of the research problem and demonstrate from the empirical data generated, the study hypotheses formulated. In an endeavor carried out the tasks, importance is given to identifying the elements of relationships, conflict, current practices of diverse cultures management and the emerging issues.

Following the description of Levinson (Levinson 1994), who defines conflict as “a dispute between two or more individuals or groups over access to or control of resources,” and includes economic, political (power, leadership), social (prestige or status), and personal esteem in the definition of resources, the researcher makes an endeavour to understand the types of conflict in the U.A.E construction industry.

Initially, during stage one of qualitative research, the respondents refused to acknowledge a direct question about conflict. Their immediate reaction to the question was that there were absolutely no conflicts at all. After the first few interviews, the researcher prepared to get more out of them by rephrasing the questions and involving the respondents in discussions. When the respondents were comfortable with the researcher discussing about their role and how they dealt a particular situation, more information started coming out.

Stage one of qualitative research discovered the following styles defined by Levinson (1994) of handling interpersonal cross-cultural conflict through avoidance and withdrawal and Conflict Resolution. Moreover, suggests that the causes of conflict and the lack of management skills to combat conflict, lead to the termination of contracts or relationships. It would be an interesting study to explore further for the causes that lead to termination of contracts or relationships. The construction industry in the U.A.E is an industry where people involved are always in direct contact with people of other cultures. However, none of the respondents under study in stage one seemed to have access to any concrete management approaches for diverse cultures management. This section would present the management styles practiced in the U.A.E observed during stage one. Stage two will further clarify the study and make it more concrete. From the analysis, the researcher reviewed and illustrated the key constructs of the thesis from the conceptual framework. Hence, more research is needed in this area which will be done through quantitative research method.

CONCLUSIONS

This is an exploratory study, which attempts to produce a conceptual framework where suppliers and buyers business relationships in the construction industry are examined. From a systematic review of key literature a theoretical framework has bee generated and the intended mixed approach for the research project is explained.

REFERENCES

Abbas, J.A, Azim, A.A and Krishnan. K.S. (1995). “Expatriates and host country nationals: managerial values and decision styles”, *Leadership & Organization Development Journal*, Vol.16, No.6, pp. 27-34.

Alpander, G.G. and Carter, K.D. 1995. Strategic multinational intra-company differences in employee motivation. In: T. Jackson, ed. *Cross-cultural management,* ed. Oxford: Butterworth Heinemann, pp. 97- 109.

Amaratung D., Baldry D., Sarshar M. and Newton R., (2001). “Quantitative and qualitative research in the built environment: application of "mixed" research approach”, Vol.51 . No.1.

Communicaid (2007), “Doing Business in the UAE: UAE Social and Business Culture”, Communicaid Group Ltd, 2007, http://www.communicaid.com/uae-business-culture.asp, accessed on 01-03-2007.

Coolican, H., 2007. *Research Methods and Statistics in Psychology*. London: Hodder Arnold.

Dadfar, H and Gustavsson, P. (1992) “Competition by effective management of cultural diversity: the case of international construction projects“, *International Studies of Management & Organization*, Vol. 22.

Darwish A. Yousef (1998). “Predictor of decision-making styles in a non-western country”, *Leadership & Organization Development Journal*, Vol.19, No.7, pp. 366-373.

Darwish A. Yousef (2001). “Islamic Work Ethic – A moderateor between organizational commitment and job satisfaction in a cross-cultural context”, *Personal View*, Vol.30, No.2, pp. 152-169..

Das, T.H., 1983. Qualitative research in organizational behaviour, *Journal of Management Studies*, Vol. 20 No. 3, pp. 311.

Dwyer, R.F., Schurr, P.H. and Oh, S.(1987), “Developing buyer-seller relationships”, *Journal of Marketing*, Vol. 51 No. 2, April, pp. 11-27.

Easterby-Smith, M., 1991. *Management Research: An Introduction*. London: Sage Publications.

Evans, W.A., Hau, K.C. and Sculli, D., 1995. A cross-cultural comparison of managerial styles. In: T. Jackson, ed. *Cross-cultural Management*, ed. Oxford: Butterworth Heinemann, pp. 125- 133.

Grönroos, C. (1994), “From marketing mix to relationship marketing: towards a paradigm shift in marketing”, *Management Decision*, Vol. 32 No. 2, pp. 4-20.

Haksever A.M., Demir I.H. and Giran O., (1987). “Assessing the benefits of long-term relationships between contractors and subcontractors in the UK”.

Hill, C.E., Loch, K.D., Straub, D.W and El-Sheshai, K. (1998). “A Qualitative Assessment of Arab Culture and Information Technology Transfer”, Working Paper, Gerogia State University, Atlanta, GA 30303, http://www.cis.gsu.edu/~emonod/detmar-straub/hill-loch-straub98.pdf, accessed on 01-03-2007.

Hofstede, G. 1980. *Cultures Consequences: International Differences in Work-related Values*. Houston: Gulf.

Hofstede, G. 1995. The business of international business is culture. In: T. Jackson, ed. *Cross-cultural Management*, ed. Oxford: Butterworth Heinemann, pp.150- 165.

Jackson, T., 1995. Ethics and the art of intuitive management. In: T. Jackson, ed. *Cross-cultural Management*, ed. Oxford: Butterworth Heinemann.

Laurent, A. 1986. The cross-cultural puzzle of international human resources management. *Human Resources Management*, 25(1), pp. 91-102

Levinson, D. 1994. *Aggression and Conflict - A Cross-Cultural Encyclopedia*. Santa Barbara: ABC-CLIO.

Miles, M.B., and Huberman, A.M. 1994. *Qualitative Data Analysis*. CA: Thousand Oaks, Sage Publications.

Pheng, L.S., and Shi Yuquan. 2002. An Exploratory study of Hofstede's cross cultural dimensions in construction projects. *Management Decision*. Emerald Publications. Vol 40/1 pp.7-16.

Pfeffer, J., and Salancik, G., 1978. *The External Control of Organizations: A Resource Dependence Perspective*. New York: Harper & Row.

Ricks, D. A., 1983. *Big business blunders*. Homewood, IL: Dow-Jones/Irwin.

Simon, J.L., and Burstein, P. 1985. *Basic Research Methods in Social Science*, 3rd ed. London: Random House.

Triandis, H.C., Kashima, Y., Shimada, E., & Villareal, M., 1986. Acculturation Indices as a Means of Confirming Cultural Differences. *International Journal of Psychology*, 21, pp. 43-70.

Trompenaars, F. & Hampden-Turner, C. 1997. *Riding the Waves of Culture*. London: Nicholas-BrealeyPublishing.

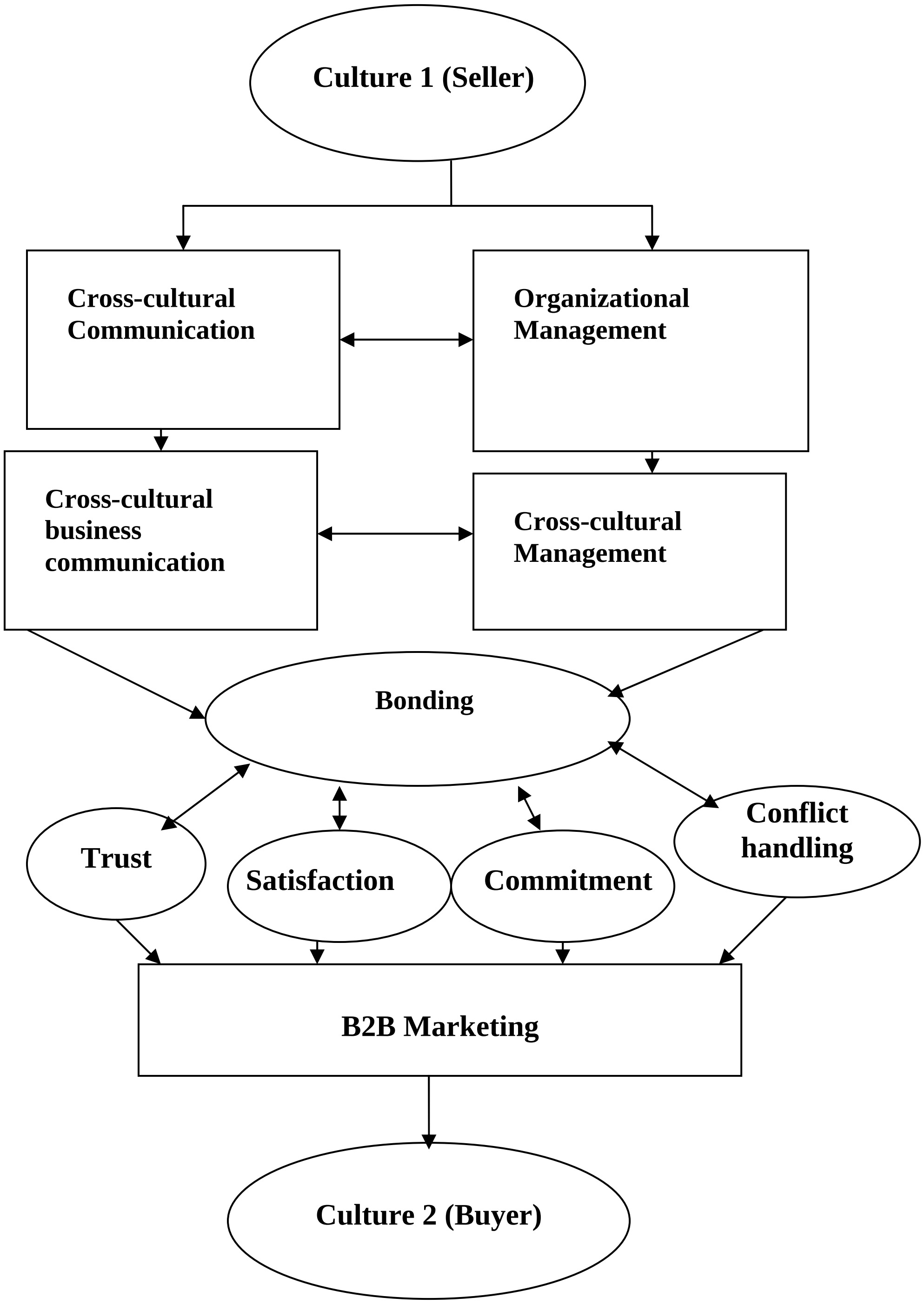
Van Manen, M., 1977. Linking ways of knowing with ways of being practical. *Curriculum Inquiry*, Vol. 6 No. 3, pp. 205-28.

Williams, J.D., Han S-L., Qualls, W.J., 1998. A Conceptual Model and Study of Cross-Cultural Business Relationships. *Journal of Business Research, Pennsylvania State University*, 42, pp. 135-143.

Wilson, David T., and Moller, Kristian E., 1988. Buyer-Seller Relationships: Alternative Conceptualizations. In: *Research Developments in International Marketing*, P. W. Turnbull and S. J. Paliwoda, eds., Proceeding of the 4th IMP Conference, Manchester, England, pp. 573–597.

Yin, R. K., 1994. *Case Study Research: Design and Methods*. CA: Thousand Oaks Sage Publications.

Figure 1: Theoretical Framework for proposed study



Source: Original

ADOPTION PATTERNS OF COMPUTER-AIDED FACILITIES MANAGEMENT IN SCOTLAND

Murray Bainbridge
Scottish Enterprise, Scotland, UK
murray.bainbridge@scotent.co.uk

Edward Finch
School of Built Environment, University of Salford
e.finch@salford.ac.uk

Facilities management professionals have always been early adopters of IT applications amongst other construction industry professionals. The IT applications in use have allowed many such professionals to significantly improve service delivery to clients. The aim of this paper is to examine the contribution that IT makes to the FM activity and the current stage of IT adoption. The research methodology incorporated an in-depth structured questionnaire involving a sample of FM professionals in Scotland, to ascertain the level of use of IT in FM services delivery. In turn, views were gathered on the effectiveness of such systems. The findings suggest that, whilst IT is considered a useful tool in the delivery of FM services, the uptake varies considerably across the FM profession. A significant proportion of professionals appear not to be making use of the diverse range of IT tools now available; reasons include lack of budget, lack of awareness or the opinion that these tools do not provide sufficient benefit to the service delivery to warrant the investment required. As a result of the findings a number of recommendations are suggested, which are designed to inform practitioners regarding the benefits of implementing new technologies. The findings of this study suggest that significant scope exists for improving the adoption rate of IT tools in facilities management.

KEYWORDS: early adopters, computer-aided facilities management, CAFM, Scotland

INTRODUCTION

The practice of facilities management involves the co-ordination and effective use of a wide variety of resources, including people, accommodation, fixtures and equipment. However, the facilities manager’s most important resource, which is needed before any of the others can be properly managed, is information. Without accurate, up-to-date information, facilities managers are unable to function effectively or efficiently (Kirkwood, 1995). Abel & Lennerts (2002) argued that the main purpose of a Computer-Aided Facilities Management (CAFM) system is to support operational and strategic facility management (i.e. all of the activities associated with administrative, technical and infrastructural FM that arise when a building is in use) as well as underlying processes. CAFM tools are popular as a means of improving facilities control and customer service, monitoring planned expenditure against actual performance and recording vital information in a single database. According to Fraser (2004) the future of CAFM is web-enabled systems, allowing multiple users to access the information and input new and updated data in real time, immediately accessible to all who rely on accurate system information. Applied to activities such as condition based maintenance, Finch (2002) demonstrated the significant reduced operating cost of wireless online monitoring which removes the need for labour costs associated with wired systems.

PURPOSE OF THE RESEARCH

The purpose of this research was to examine the significance of IT in the delivery of facilities management services to the built environment and business organisations in Scotland. Secondly, the study sought to gather the views of facilities management professionals regarding the usefulness of these tools in improving the effectiveness of FM.

Objectives

The specific objectives of the research described in this study were:

1. To establish the extent of CAFM use within the FM sector in Scotland
2. To identify the profile of CAFM users amongst FM professionals
3. To identify the scope of CAFM in service delivery
4. To establish levels of satisfaction amongst CAFM users
5. To establish trends for the future use of IT in the FM sector

The hypothesis considered in the study was the assertion that "the use of information technology in the delivery of facilities management services is widespread and effective".

Research Approach

To generate accurate and reliable data, specific information was required from a targeted sample of facilities management practitioners. Access to the study sample was through the members section of the British Institute of Facilities Management (BIFM) website. The main body of data was generated using a structured questionnaire. Data was collected using an online questionnaire system which was then converted into a database for analysis. The database was then analysed and results extracted.

A structured questionnaire provided the primary research tool. This quantitative assessment provided a summary of the FM industries current practices, as well as the perceived effectiveness of IT in the delivery of FM services. The questionnaire used both closed and open questions; closed questions required simple binary tick box responses. The open questions offered the opportunity for the respondents to present their personal views.

The structure of the questionnaire used information obtained from the respondents regarding their organisation and their use of CAFM, along with their understanding and use of other ICT tools within the industry. Respondents were selected using the following criteria:

- Have experience working within the FM sector
- Have experience and/or knowledge of the use of information technology in FM

Members of the British Institute of Facilities Management (BIFM) Scotland region were chosen as the target audience for the questionnaire.

Once the initial questionnaire was created it was piloted to establish functionality and generate feedback relating to the questionnaire. Following completion of the pilot, results were analysed and some amendments made to the layout.

A total of 395 questionnaires were then sent to members of the BIFM Scotland region inviting them to complete the questionnaire posted on the Internet. 121 individuals started the questionnaire giving a response rate of 29.4%. 110 respondents completed the questionnaire giving a completion rate of 91%.

Scope Of The Questionnaire Study

The possibilities of CAFM systems are numerous and the system manufacturers are constantly drawing attention to these. The question is, however, what do their customers actually need and which functions are being used? The research questionnaire encompassed questions of a factual nature, questions relating to specific knowledge and appraisal questions. The results of the survey provide an overview of the current fields of application for CAFM systems and give an insight into the trend for future fields of application in terms of user needs. It also shows the profile of CAFM users by company size and whether it is primarily used by in-house FM departments or external FM providers. The questionnaire seeks to identify the reasons for introducing CAFM systems as well as those reasons given for not using CAFM. An overall evaluation of the systems provides valuable information for the producers on how their systems are perceived by users. Finally the questionnaire looks at what level of knowledge exists within the FM industry in Scotland of some cutting edge applications and technology and seeks to identify the trend for future applications of technology in FM. The findings will be examined under four separate headings:

1. Profile of respondents
2. Organisations using CAFM in service delivery
3. Organisations not using or considering CAFM
4. FM challenges and awareness of ICT applications

Profile of Respondents

As part of the study, respondents were asked to select the job title which best described their job function within the organisation (Figure 1). Half of all respondents fell into one of three categories; Regional or multi-site FM (20.9%), Director/Head of FM (15.7%) and Operations Manager (13.0%). Considering that a further 9.6% described their role as Senior FM (HQ/Flagship site), this indicates that the respondents completing the questionnaire were generally of a senior position within their organisations and were therefore well placed to answer with some authority detailed questions on the use of CAFM and other ICT tools to deliver FM services to their clients (internal or external).

Respondents were given the option to provide answers which were not provided for selection and a significant 18.3% felt that none of the titles provided described their job position enough; amongst the other answers provided were Architect, Property Manager, Maintenance Manager and Estates Manager. Although this may reflect the wide range of posts associated with the delivery of the FM discipline, it reinforced the statement that the respondents consisted of mainly senior professionals with the authority to comment on their organisation's use or otherwise of ICT and CAFM systems.

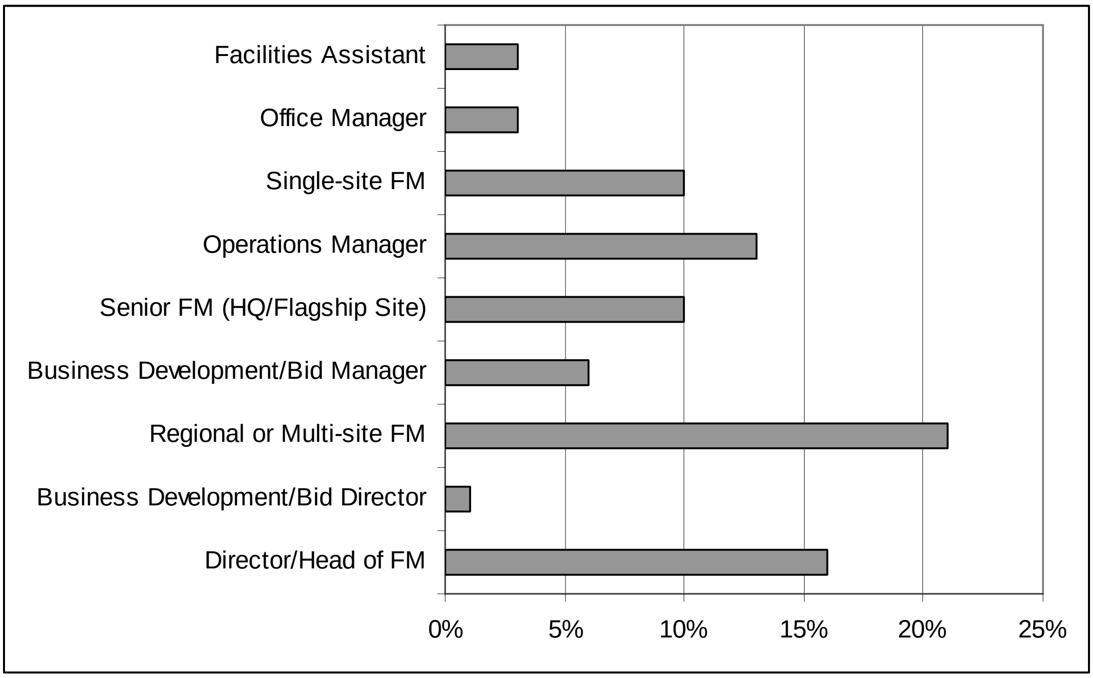


Figure 1: Respondent profile by job title

Respondents were also asked to indicate whether they were already implementing CAFM, considering implementing CAFM or not currently using or planning to implement CAFM in the delivery of the facilities management services they were providing. A majority of respondents indicated that they were either already using CAFM (43.4%) or were considering implementing a CAFM system (12.4%). However, a substantial 44.2% of respondents indicated that they were not using CAFM in the delivery of their FM services. This was a surprisingly high percentage considering that more than 60% of respondents had indicated that they provided FM services at more than 5 locations: the natural assumption being that to deliver an effective FM function across multiple sites would require a large amount of information and monitoring.

CAFM systems in use

Those respondents indicating current use of CAFM systems were asked to select those systems which their organisation was currently using (Figure 2). This question allowed for multiple selections as it recognised that larger organisations may utilise more than one CAFM system across the company's built asset base and for the completion of separate operational tasks. The CAFM system which was selected most often was Concept FM with 24% of respondents indicating its use by their organisation. This was followed by bespoke systems which 20% of respondents indicated as being the CAFM system in use by their organisation. This reflects the nature of the developing usage of information technology in the delivery of FM services, whereby many systems have been specifically designed around existing hardware and software to deliver the requirements of an individual organisation; the off-the-shelf CAFM system is a relatively new phenomenon.

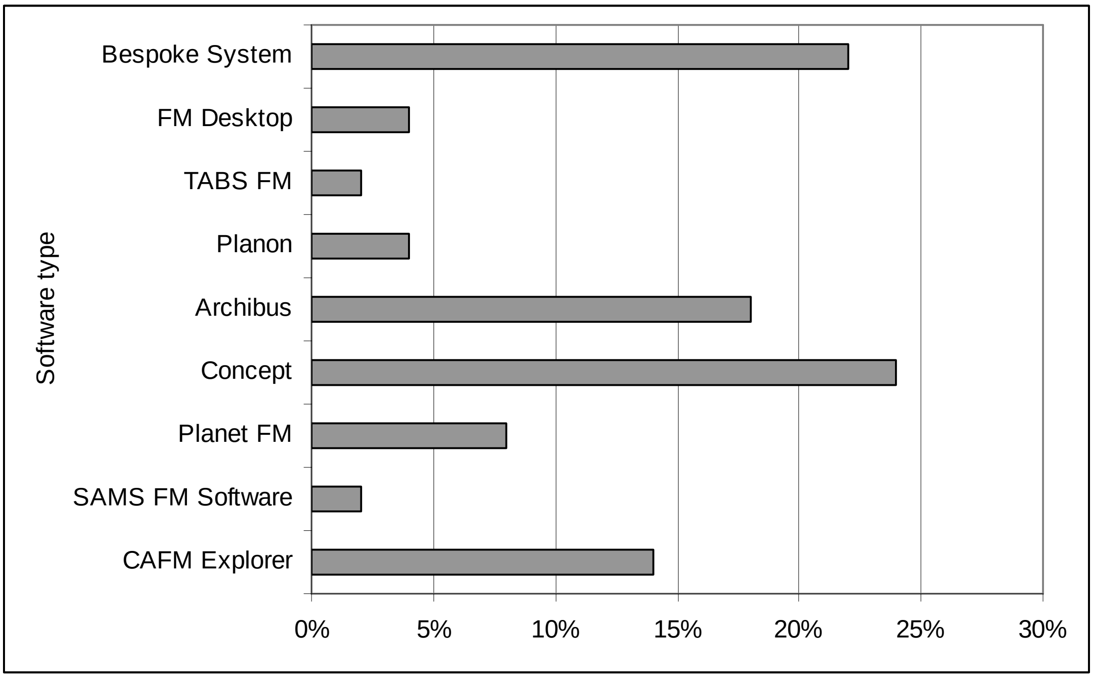


Figure 2: CAFM Application Usage

Perhaps reinforcing this view, 12% of respondents selected ‘Other’ to describe the CAFM system they were using; this suggests that there are a large number of smaller specialist providers of IT services developing CAFM packages tailored to specific industry areas or processes. Amongst the systems listed as Other were included Apollo, Axios and Impact. The other popular “off-the-shelf” products selected were Archibus (18%), QFM (14.9%) and CAFM Explorer (14%). Most popular amongst the less frequently selected systems was Planet FM with 6% of CAFM users indicating its use within their organisation.

In order to examine the level of experience of CAFM use amongst the respondents, they were then asked to indicate how long they had been using CAFM systems (Figure 12). Although CAFM has been around and recognised by that acronym for around twenty years, it was thought unlikely that a large percentage of respondents would have been experienced in its use for more than ten years. This was borne out by the results which indicated only 15.7% of respondents having more than 10 years experience of using CAFM. The largest proportion of respondents, 43.1% indicated they had between 5 and 10 years of experience in the use of CAFM with over a third (35.3%) having between 1 and 5 years experience. Only 5.9% of respondents said they had less than 1 year’s experience of CAFM; this is likely to be a reflection of the profile of respondents indicated in Figure 5 which showed the vast majority held senior posts within the facilities management profession.

Usage Patterns of CAFM

The study presented a list of operational activities which are commonly addressed using CAFM systems. Respondents were asked to indicate which of those operational activities their CAFM system was currently being used to deliver, those they planned to deliver using

CAFM in future and those activities which they did not currently use or plan to use CAFM to deliver (Figure 3).

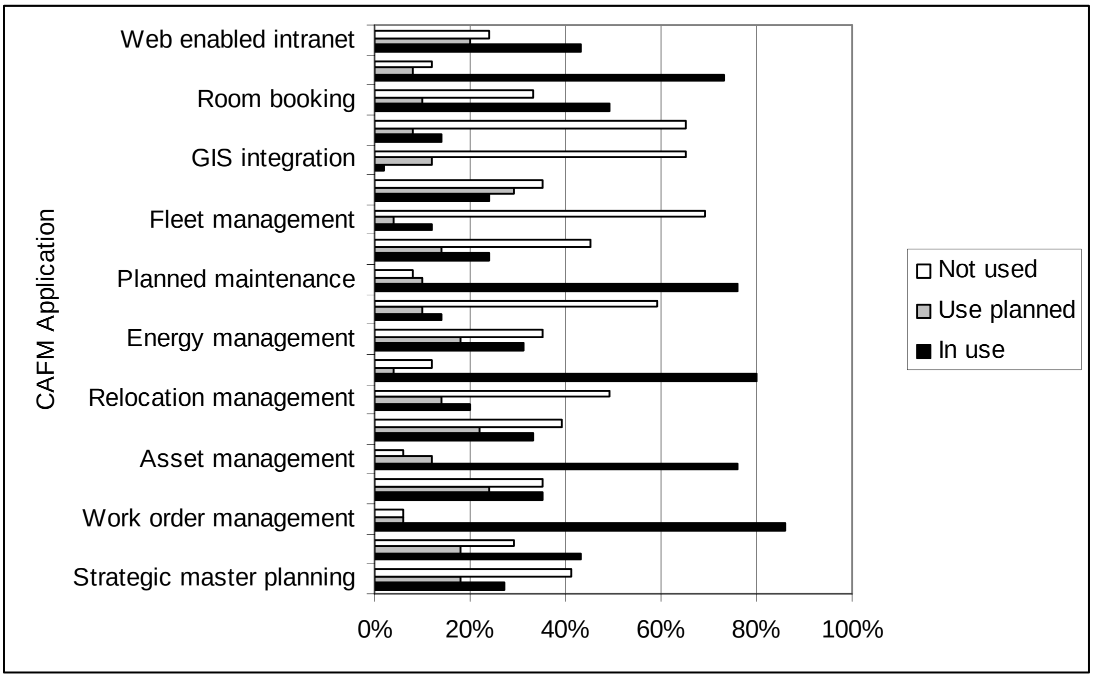


Figure 3: Use of CAFM sytem by functional activity

The activities which were most widely being delivered utilizing CAFM systems, with over three quarters of respondents selecting 'Currently Using', were Work Order Management (87.5%), Fault Management (83%), Asset Management (80.4%) and Planned Maintenance (80.4%). Data gathering and reporting was indicated as currently being a function of their CAFM system or being planned by 87% of respondents.

The integration of geographic information systems (GIS) with CAFM was currently being used by only 2.6% of respondents with only 15.4% planning to utilise this functionality in the future. This may be the result of the fact that GIS focuses on the management and mapping of outdoor information, as opposed to the role of CAFM which is concerned with the management of data relating mainly to the indoor environment. As a result, there may be few FM service providers requiring the detailed external environment information which GIS integration offers.

It is perhaps not altogether surprising that such a large percentage were not currently using CAFM for delivery of personnel management since most organisations separate the human resources function from facilities management, however a significant 29.3% indicated that they were currently using (17.1%) or planning to use (12.2%) their CAFM system for this activity, demonstrating the wide range of hitherto unlikely functions which a CAFM system can be used to deliver.

The finding that less than one third (27.9%) of users were utilizing drawing (CAD) integration within their CAFM system was somewhat unexpected since the development of CAFM systems integrated with CAD in recent years has become almost a standard function within most proprietary CAFM products. It may simply be that the industry is reacting more slowly than anticipated to the adoption of this new functionality as indicated by the large number (32.6%) of respondents who are planning to integrate AutoCAD functionality with their CAFM system or many of the FM services being delivered by the respondents do not require access to and integration with building plan layouts. The lack of interoperability of systems may also be a factor in the gradual integration of AutoCAD with CAFM systems.

With more than two thirds of respondents (69%) indicating that they do not currently use their CAFM system for strategic planning the implication is that facilities management may still be struggling to gain recognition as a driver for wider organisational improvement at the very highest levels within the board room. Selection by more than a quarter of respondents suggests that the short term trend for future use of CAFM systems focuses on AutoCAD integration (32.6%) and Project Management (26.1%).

Perceived effectiveness

CAFM users were then asked to rate the effectiveness of the CAFM system they were currently using (Figure 4). More than 9 out of 10 respondents (91.7%) indicated a positive view of their CAFM system with 16.7% rating it Indispensable, 45.8% considering their CAFM system Effective and 29.2% rating their system Adequate. A total of just 8.4% of respondents considered their CAFM system to be Ineffective (4.2%) or Poor (4.2%). This represents a very high overall satisfaction rating amongst CAFM users with their systems and should be good news for CAFM software providers.

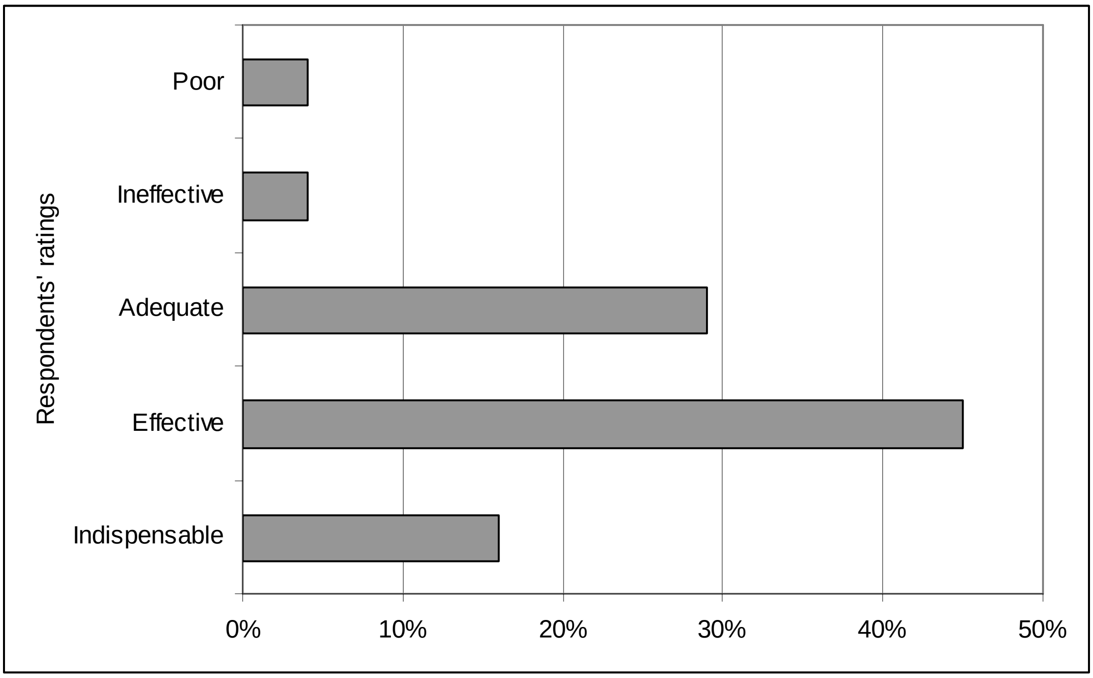


Figure 4: CAFM User Ratings

Reasons for considering adoption of CAFM systems

Previously, it was indicated that half of respondents (55.8%) were currently not using CAFM systems in their delivery of FM services. When the 17.4% of respondents who had indicated they were however considering CAFM were asked to select their objectives for implementing CAFM (Figure 5) more than 9 out of 10 (93%) chose ‘Reduce costs/improve service delivery’ and ‘Implement essential maintenance’ as the reasons for introducing CAFM to their organisation. This suggests that the view of the FM professional in Scotland is that CAFM can assist with making the organisation more effective in terms of cost and quality of service. It also suggests however that without CAFM some facilities may be falling behind on implementing essential maintenance regimes and CAFM is seen as a useful tool in better managing asset maintenance programmes, when compared with more traditional manual methods of data capture and asset tracking.

A large number of respondents (79%) selected Ensure health & safety compliance as an objective of introducing CAFM. This suggests that facilities managers consider CAFM to be effective in addressing health and safety issues.

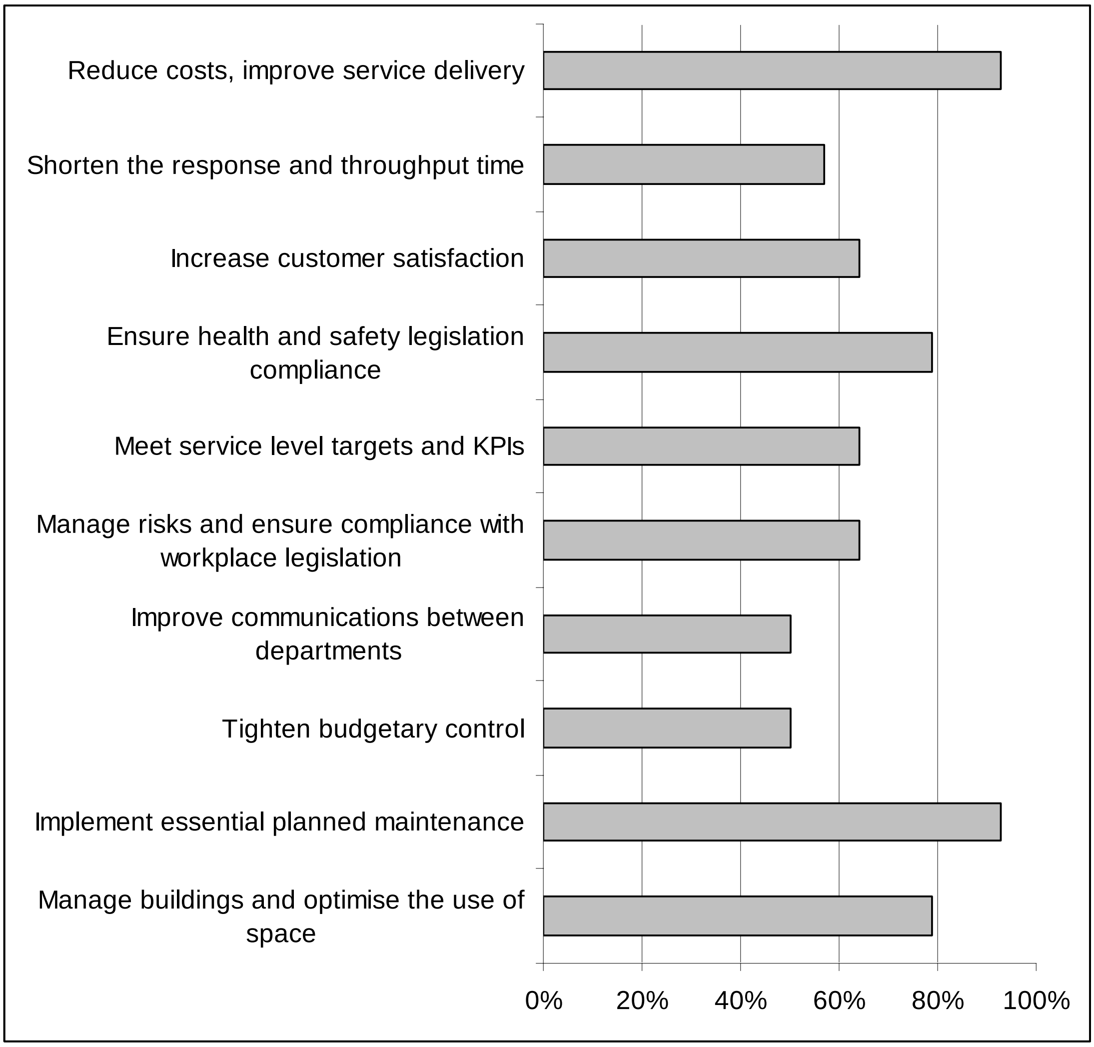


Figure 5: Reasons for considering CAFM

Outstanding challenges

The final part of the survey asked respondents to indicate what they considered to be the most important challenge facing them as a facilities management professional within their organisation (Figure 20). More than a third (35.5%) of respondents selected ‘Meeting customer/tenant expectation’ followed by ‘Senior management’s lack of understanding of FM role’ selected by 19.1% and ‘ack of time to complete work’with 16.4%. Less than one tenth of respondents (8.2%) found ‘balancing the facilities budget’ to be their most important challenge and only one in every twenty (5.5%) were faced with Understaffing as a major challenge.

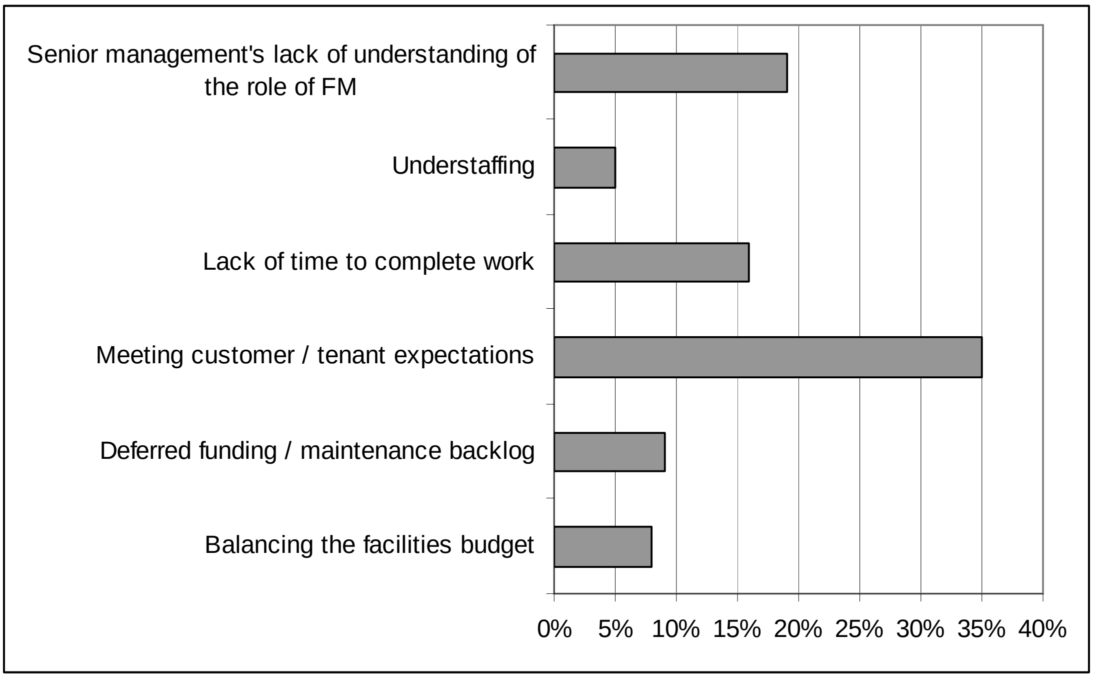


Figure 6: Most important FM challenges

Conclusions

It can be clearly seen from the findings of the survey that the use of information technology in the delivery of facilities management across the built environment in Scotland is somewhat patchy, with a multitude of factors influencing the FM professionals responsible for delivery.

Encouraging for CAFM developers was the finding that more than half of those FM organisations surveyed indicated that they were already using CAFM or were considering its implementation. Software developers would also realise from the findings that they still have a large untapped market in the FM world with forty percent of companies surveyed not yet enjoying the benefits of CAFM, demonstrating that there is room for growth in the market, provided they can target their efforts in the right areas.

The research shows that the use of information technology in the form of CAFM is more likely amongst dedicated FM service providers than organisations with in-house FM delivery and that medium-sized enterprises (between 51 and 250 employees) are least likely to be using CAFM. In terms of size, the organisation most likely to be using CAFM is one with more than 500 employees and working in the public sector. Those considering the use of CAFM are predominantly client organisations with in-house FM provision which suggests that they are following the lead of the dedicated FM service providers who have been at the forefront of adopting CAFM and other information and communication technology tools to improve their delivery in what has become an increasingly competitive market over the last 5 years.

The survey findings showed that of those facilities managers not using CAFM, many consider that the scale of their service delivery does not warrant the use of a CAFM system. This is surprising given the now relatively low starting costs for entry level CAFM software available on the market and most providers offering packages tailored to the individual needs of the organisation regardless of size, with specific products targeting the smaller organisation. This even includes a cost free CMMS programme available by downloading from the Internet which although somewhat limited in scope and flexibility does nonetheless constitute a facilities management tool based on data gathering via computer. This finding demonstrates that CAFM software providers need to be working harder to target the right individuals and convincing them that the investment in CAFM will provide efficiency savings and improvements in the effectiveness of their service delivery, even if the scope of their FM service is limited.

The finding that less than five percent of those respondents not using CAFM considered cost to be a factor in their decision indicates to providers that their products are not perceived by the market to be to expensive. Another potential barrier to implementing CAFM, although not listed here, could be overcoming the inertia that is tantamount with implementing any new IT system. People fear change and overcoming that fear will only be achieved by combating the problem at source. As training improves and the IT literacy of the staff within the UK FM industry increases then the apprehension towards the use of CAFM will be reduced. With almost half of respondents not using CAFM indicating that meeting customer expectation was their greatest challenge, this leads to the conclusion that those organisations who are using CAFM achieve better customer satisfaction and do not see that as their most important challenge because the use of CAFM is a factor which contributes to the higher satisfaction ratings they receive from customers.

The implementation of CAFM has so far focused predominantly on the traditional building services functions such as asset management, fault management and planned maintenance, however the survey findings suggest that increasing numbers are using their CAFM systems to control budgets, manage projects and assist in the development of strategic corporate planning. The system developers are adding functionality to their products at a rapid rate in response to the demands of their users and it is now common for CAFM systems to have add-ons available covering project management, GIS integration, AutoCAD integration and labour resource management.

References

Abel, J and Lennerts, K (2002) Where does CAFM really help? Current fields of application and future trends. A research paper, University Karlsruhe, Germany

Finch, E (2002) Automated information capture in performance measurement. Journal of Facilities Management, Vol. 1 No.2, 188-195

Kirkwood, J S (1995) Network technology: potential applications within facilities management. Facilities, Vol. 13 No.11, 8-12.

A REVIEW OF THE PROJECT MANAGEMENT PRACTICE WITHIN THE CONSTRUCTION INDUSTRY IN U.A.E.

Mohamed Salama
Heriot Watt University, Edinburgh, UK
m.a.salama@hw.ac.uk

Assem Al-Hajj
Heriot Watt University, Dubai, U.A.E.
A.Al-Hajj@hw.ac.uk

Tarek Emara
Heriot Watt University, Dubai, U.A.E.
tse4@hw.ac.uk

The construction industry in the U.A.E has been enjoying an unprecedented boom over the past decade. However, the majority of the projects witnessed delays and cost overruns. This study reviewed the project management practice within the construction industry in the U.A.E. A questionnaire based on the literature review was produced and sent via email to a random sample that comprised 120 practitioners from within the different sectors of the industry. The results indicated that a significant percentage of the project management professionals do neither hold academic qualifications in project management nor do they attend relevant professional training. The results also indicated that the clients do not mandate the application of project management standards and, moreover, do not delegate adequate authority to the project managers. The study identified the main areas of concern and concluded by providing some recommendations for enhancing the current practice in the U.A.E.

KEYWORDS: project management, construction, U.A.E.

INTRODUCTION

Dubai is considered one of the major cities accommodating a huge number of construction projects in the world. This is due to the strategic decision which was taken by the Dubai Government to diversify its economy from a trade based economy to a service and tourism based one. The result of the strategic macroeconomic change in Dubai was that projects were launched in large value and volume and the real estate business is currently witnessing an unprecedented boom. In 2003, the construction industry employed 111,700 employees, which is 15% of the total employees in UAE with a soaring trend to meet the demand due to the increasing volume of construction. During the period 2000-2003, the number of employees in the construction industry in Dubai increased by 33%. Moreover, after allowing expatriates to own property in Dubai in 2002, the freehold market and the property market have witnessed a remarkable growth that has contributed to the expansion of the construction industry. The number of freehold properties is expected to double by 2009. (ASTECO, 2005).

Due to the current boom in the country's economy in general and the construction industry in particular, clients and practitioners alike seem to be less concerned with the issues of best practice. Different stakeholders tend to focus more on trying to catch up with the significantly high levels of demand that shadows and even absorbs all the defects and weaknesses of the current practice manifested in the delays and cost overruns despite the abundance of resources in the U.A.E.

Aims and Objectives

The main objectives of this study are:

- To investigate the level of awareness of the project management tools and techniques by the construction professionals in the UAE construction industry and the effectiveness of its implementation.

- To identify the areas of concern within the current practice and provide recommendation to the industry stakeholders to enhance the current practice.

Literature Review

Different Views of Project Management

Reviewing the literature about the various definitions provided for project management, the Association of Project Management in the UK (APM) states that "*Project management is the discipline of managing projects successfully*"(APM 2000). The Project Management Institute (PMI) in its standard Project Management Body of Knowledge (PMBOK) defines project management as: "*The application of knowledge, skills, tools, and techniques to project activities to meet project requirements*". Harrison and Lock (2004) tried to emphasize the importance of the human factor by setting another definition: "*Project management is the achievement of project objectives through people and involving organization, planning and control of resources assigned to the project*."

The guidance document BS 6079-1 (2002) issued by the British Standard Institute (BSI) for the defined project management as: "*Planning, monitoring and control of all aspects of a project and the motivation of all those involved in, it to achieve the project objectives on time and to the specified cost, quality and performance*."

Kelly and Male (2005) defined project management considering the project success criteria and customer satisfaction by stating that project management is "*The overall planning, control and coordination of a project from inception to completion aimed at meeting a client's requirements and ensuring completion on time, within cost and to the required quality standards*."

The literature review indicates that the wider majority of scholars such as Kliem *et al.*(1997); Baker *et al.* (2003); Kerzner (2003); Cole (2004); Ireland and Cleland

(2004); Vargas (2007); and others agree that the effective application of project management tools and techniques leads to better outcomes.

On the other hand, and as aforementioned, people are the doers and a key factor to achieve a successful implementation of any of the above mentioned methodologies or bodies of knowledge. The Charted Institute of Building (CIOB) Code of Practice for Project Management for Construction and Development (2002) draws the attention to the importance of managing people with respect to: (i) knowledge and background of the assigned tasks; (ii) competence to deliver the assigned tasks; (iii) performance

The relation between the clients and the project managers in the construction industry is seen by Latham (1994) as a principal - agent relationship whereby the project manager acts on the client's behalf in managing the project. The client should give the project manager the full authority to take decisions. Egan (1998) agreed that the clients' expectation from appointing a project manager is to act on their behalf and gain a greater value through the application of project management techniques. (Mayo and Schexnayder (2003) defined the role of the project manager as being: "*in overall charge of the project, responsible for the rate of progress, financial control, safety, and ultimate profitability of the job. Project managers select equipment needed on the site, they negotiate the subcontracts, and they submit the progress and financial reports to the company; they are responsible for all communications with the owner*."

Also, the project manager is expected to manage the relationship with the contractors and other stakeholders and to work on resolving the anticipated conflicts, proactively. However, the literature has recorded that the clients' intervention is one of the main causes for project delays in the UAE. (Salama *et al*., 2007)

Typically the client would be seeking the following objectives (Latham, 1994): (i) value for the money; (ii) end product that has no defects; (iii) Finish on time; (iv) sustain the current environment and (v) Low running cost.

Project Management International Standards

The current associations for project management such as the Project Management Institute (PMI), Association of project Management (APM), and International Association of Project Management (IPMA) aim at providing practitioners with the needed guidance to achieve the above mentioned objectives under what is known as best practice. However, the question that still stands is whether the knowledge of the different methodologies would guarantee a safe and successful delivery of projects towards the sought objectives. Despite the debate that might arise when putting this question forward to academics and practitioners alike, both parties would agree that project management practitioners would benefit from attending training sessions on the basic tools and techniques of project management or by acquiring professional certificates provided by the aforementioned associations (Lock and Harrison, 2004) & (Ireland and Cleland, 2004).

The main bodies of Knowledge agreed on the importance of developing a project plan that mainly reflects the project scope, the set the aims and objects, the key deliverables, the success factors and criteria and the main constraints. In this pursuit, project managers are typically advised to phase out the project life cycle into the following: (i) initiation; (ii) planning; (iii) execution & control and (iv) close out. The

IPMA identified a set of competences classified into contextual, technical and behavioural categories that project managers should be aware of in order to produce an effective project plan and, furthermore, to monitor the implementation of the set plan. In table (1) the first 28 core categories are presented out of the 60 elements listed under "knowledge, personal attitude and general aspects" (ICB – IPMA, 2006). This is just an example of the level of detail provided in the aforementioned bodies of knowledge. It is worth noting that PMI, APM and the others provide a similar level of detail despite the differences.

Table: 1 The IPMA Project Management Competence Elements (ICB – IPMA, 2006)

ICB - IPMA Main Competence Elements	
Projects and Project Management	Resources
Project Management Implementation	Project Cost and Finance
Management by Projects	Configuration and Changes
System Approach and Integration	Project Risks
Project Context	Performance Measurement
Project Phases and Life Cycle	Project Controlling
Project Development and Appraisal	Information, Documentation, Reporting
Project Objectives and Strategies	Project Organization
Project Success and Failure Criteria	Teamwork
Project Start Up	Leadership
Project Close Out	Communication
Project Structures	Conflicts and crises
Content, Scope	Procurement, Contracts
Time Schedules	Project Quality

Research Method

A questionnaire was generated for gathering data and assessing the above mentioned set objectives of the research. The questionnaire was distributed via email where the link to the questionnaire was sent to a random sample of 120 constructions professional with significant experience in different sectors within the construction industry in the UAE (i.e. Clients, Project Managers, Consultant, Contractor, and Cost Consultant). The questionnaire attracted 64 responses classified as follows: 22 professionals working for Project Management Organizations, 9 practitioners working for the Client, 17 representing Contractors, and 16 from consultancy firms. Out of the 64 response, eight of them were incomplete so 56 responses were analyzed.

The questionnaire aimed at investigating the awareness of the surveyed sample about the contemporary bodies of knowledge, the project management methodologies implemented within the construction projects, if any, in U.A.E and whether project management professionals receive adequate training on what is widely known as the best practice. The questionnaire also sought information about the relationship between the client and the project manager in the context of delegation of authority as shown in figures 1 to 4. The list of tools in figure 4 is based on BS 6079 – 1 (2002).

The data collected indicated that nearly 62% of the respondents do not hold any academic or professional qualifications in project management and in average 48% reported that their employers do not provide training or professional developing programmes. The breakdown of this figure is shown in table 2.

Table 2: The % of Professionals who received training on PM Tools and Techniques

Professional Group	*Professionals Received Training*	*Professional had no training*	*Total*	*% of no training*
Client	4	4	8	50%
Project Manager	13	7	20	35%
Consultant	7	7	14	50%
Contractor	5	8	13	61.53%

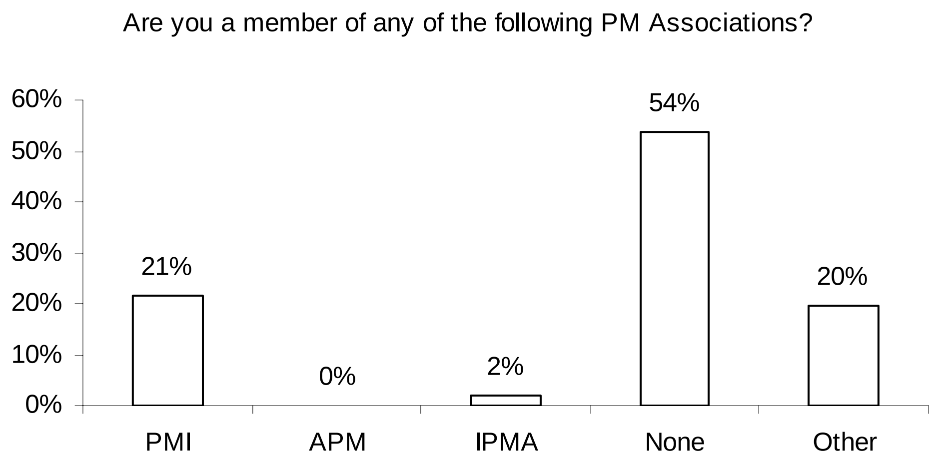


Figure 1: Membership in PM Associations

Figure 1 show that the majority of the respondents are not members in any of the listed project management associations; however, the respondents seemed aware of the existing project management associations as shown in figure 2

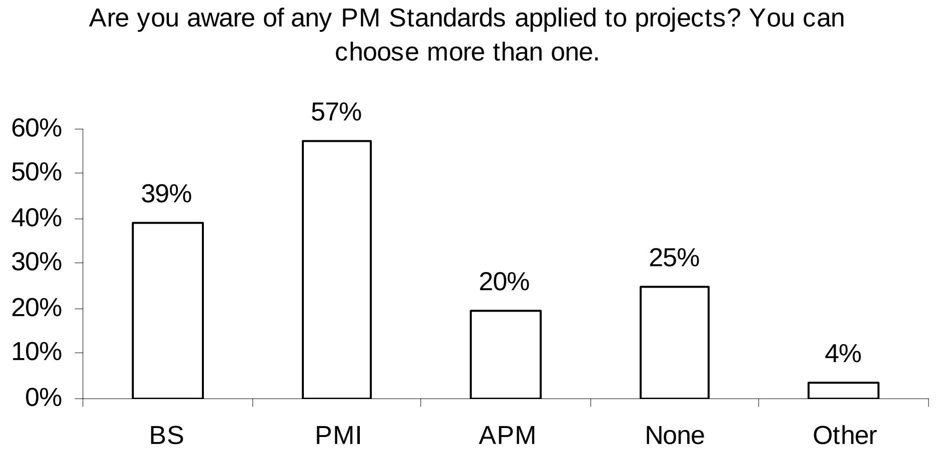


Figure 2: Project Management standards

The results indicated that 46% are not using any of the project management standards in managing projects while only 29% are using standards. Out of the other 25% of the total responses nearly half of them mentioned standards that are barely relevant to project management international standards such as ISO 9001:2000 project quality management; client specifications and regulations; ISO 9000:2000; FIDIC and home-grown specifications and procedures.

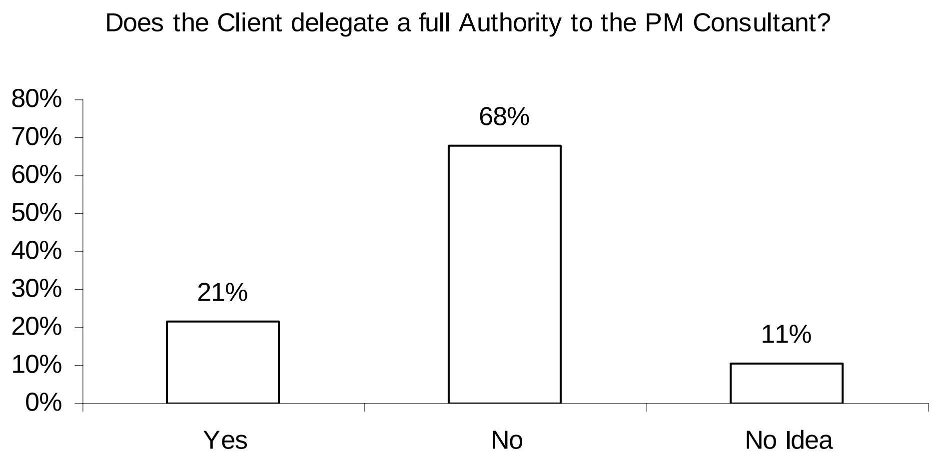
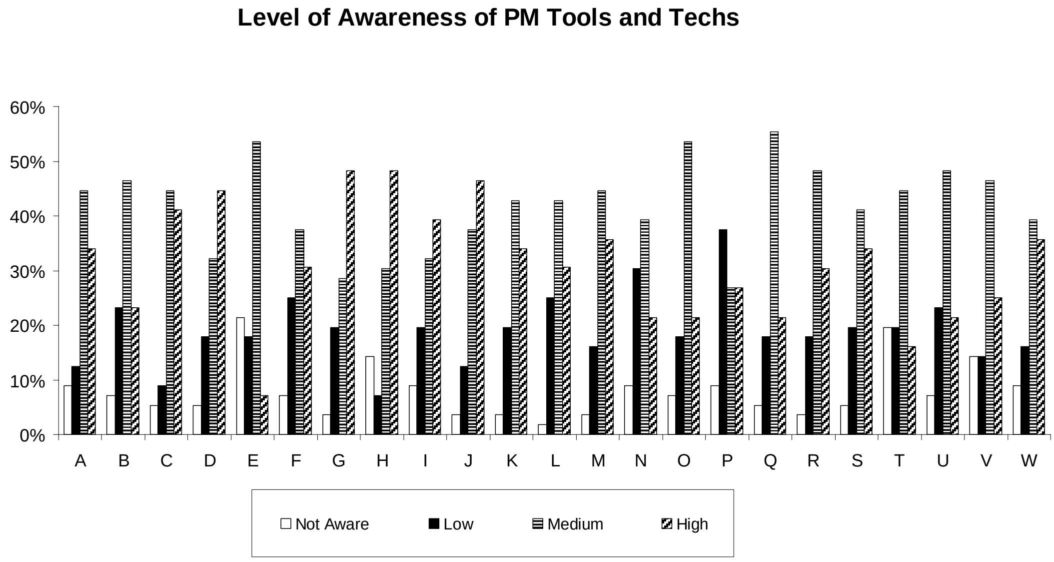


Figure 3: Delegation of Authority

Also, in relation to the delegation of authority as shown in figure (3) the sample was asked about whom they get instructions from within their projects. A majority of 57% mentioned the client and 43% indicated that the project manager was in charge.

In figure 4, two graphs were produced to represent the two sets of data collected using the same list of tools as aforementioned, based on BS 6079 – 1 (2002). In the upper graph, the four categories are (from left to right) “Not Aware; Low Awareness; Medium and High”. In the lower graph, the respondents identified which of these tools are implemented and its effectiveness



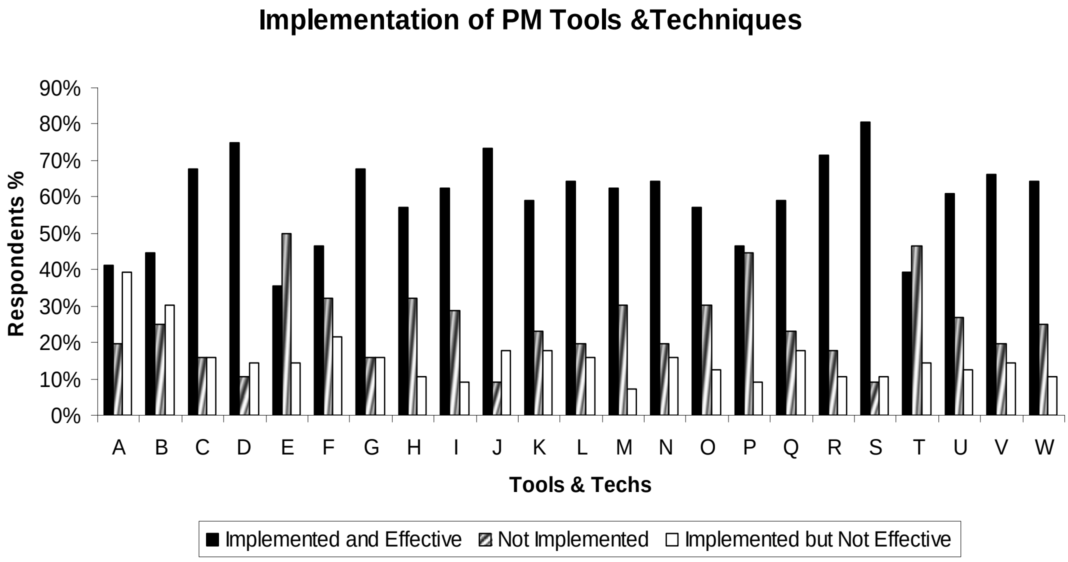


Figure 4: The awareness and implementation of Project Management tools and Techniques*****
A - Preparation of Project Aims and Objectives B - Project Policy C - Project Approvals D - Project Organization (Organization Break Down Structure , OBS) E - Project Harmonization F - Project Implementation Strategy G - Work Breakdown Structure (WBS) H - Task Responsibility Matrix (TRM) I - Acceptance Procedure J - Programme Management K - Procurement Strategy L - Contract Management M - Communication Management N - Financial Management O - Risk Management P - Value Management Q - Project resource Management R - Quality Management S - Health and Safety Management T - Stakeholder Management U - Environmental Management V - Design Management W - Project Close out Review

****Based on the set of tools listed in BS 6079 – 1, (2002)***

Discussion

Project Management Awareness

The aforementioned research findings reflect that a significant percentage of the construction practitioners do not hold appropriate qualifications in project management and meanwhile are not attending relevant training or skills development programmes. The majority of the practitioners in the UAE construction industry gained their knowledge about project management through experiential learning rather than through academic qualifications or professional training

The respondents seemed to have medium level of awareness of the project management international standards. However, these standards are not being widely used according to 47% of the surveyed sample. The clients in the UAE construction industry don't mandate the project manager or the contractor to use any standard for the implementation of project management.

Main Concerns within the Current Practice

On the one hand, nearly 50% of the respondent indicated that 73% of the listed tools are being implemented and effective. On the other hand, over 64% mentioned that their projects will be running over budget and over 50% of the respondent indicated that their projects will be delayed. Also, over 65% agreed that the project manager doesn't have the full authority in managing the project and nearly 55% reported that instructions are received from the client. The surveyed professionals alleged that clients in the UAE construction industry still don't understand the project management approach and the exact role of the project manager.

The main causes of the delays and cost overruns as identified by respondents in descending order are: Contract Management; Preparation of project aims and objectives; Procurement Strategy; Organization breakdown structure; Project Implementation strategy; Work Breakdown structure and Programme management. The above mentioned factors are aligned with the findings of Salama *et al*. (2007) where the project scope was identified as the most significant cause for delays of the construction projects in Dubai. The inefficient OBS and WBS are most likely to be direct consequences of a poorly defined scope. In other words, the findings seem to point out to the planning phase. In the majority of the construction projects in U.A.E., the client would rush the project team towards the execution phase as early as possible, and then projects would suffer the consequences of the rushed up poor planning. This is another direct outcome of the continued intervention by the client and the lack of delegation of authority as aforementioned. For example, the respondents reported that the client would request more flats per floor after the skeleton has been completed seeking higher profits due to the appreciation in the property market. Obviously this will affect both the project duration and total cost. The results indicated the significant lack of awareness of value management and it came as no surprise that the latter appeared as the least implemented amongst the other tools and techniques as shown in figure (4).

Also the results draw the attention to the limited awareness and implementation of effective stakeholder management systems among practitioners.

Recommendations

- It is recommended that the construction practitioners should be encouraged by their organizations to acquire any of the professional qualifications provided by the existing associations of project management such as IPM, APM, IPMA, etc...Alternatively employers should encourage practitioners to pursue relevant academic qualifications.

- Also, employers should exert more effort towards organising seminars and training workshops for the construction practitioners in the UAE.

- Clients are advised to impose the application of any of the project management international standards. Special attention should be given to the planning phase by allowing adequate time and ensuring the clarity of the project scope and the clear definition of roles and responsibilities (Task Responsibility Matrix) through a well developed organisational breakdown (OBS) structure and a detailed work breakdown structure (WBS) before embarking on the execution phase.

- Clients and employers within the different project management sectors should seek enhancing the relevant project team members' skills in the areas of procurement strategy and contract management. This should proactively resolve many of the current disputes, delays and cost overruns according to the findings of this study.

- The client's role should be well defined from the outset and an adequate authority should be delegated to the project manager, meanwhile, the latter should demonstrate the mastery of the essential tools and techniques of project management including value management and stakeholder management.

Conclusions

The study aimed at reviewing the current project management practice within the construction industry in U.A.E. A questionnaire was distributed via email to a random sample of 120 practitioners from the different sectors of the construction industry. The data collected from completed 56 responses indicated that a significant majority of the professionals do not hold relevant academic qualifications in project management nor did they attend any specialised professional training. There seems to be an adequate level of awareness of the project management international standards, however, the effectiveness of its implementation gives rise to concern. The majority of the projects witness delays and cost overruns. The results raised concern about the awareness and the effective implementation of the following elements: scope definition; procurement strategy; contract management; value management and stakeholder management. Also, the results indicated that the clients share the responsibility due to the continual intervention in the decision making and the limited authority delegated to the project managers. The study concluded by providing some recommendation that should enhance the current practice.

References

Association of Project Management (APM) (2000) Body of Knowledge. 4th,ed.

ASTECO Property Management (2005) Why Invest in Dubai. In: www.astecoproperty.com

Baker, S., Baker K. and Campbell G.M. (2003) The Complete Idiot's Guide to Project Management. 3rd, ed. Alpha Books

BS 6079-1 (2002) Guide to Project Management. 2nd ed. London: British Standards Institute.

CIOB (2002) Code of Practice for Project Management for Construction and Development. 3rd, ed. Blackwell.

Ireland, L. R. and Cleland, D. I. (2004) Project Manager's Portable Handbook. 2nd, ed. McGraw Hill Professional.

Cole G. A. (2004) Management Theory and Practice. 6th ed. U.K.: Thomson.

Egan, J (1998) Rethinking Construction: The Report of the Construction Task Force. U.K.: Crown Publishers.

Kelly J. and Male S. (2005) Value Management in Design and Construction. U.K.: Taylor and Francis Group.

Kerzner, H. (2003) Project Management: a systems approach to planning, scheduling and controlling. 8th Ed. New Jersey: John Wiley & Sons.

Kliem, R.L., Ludin I.S.and Robertson K.L. (1997) Project management methodology: a practical guide for the next millennium. CRC Press

Latham, M. (1994) Construction the Team. 1st ed. U.K.: HMSO.

Lock, D. and Harrison F.L. (2004) Advanced Project Management: A Structured Approach. 4th, ed.England: Gower Publishing Ltd.

Mayo, R.E. and Schexnayder, C.J. (2003) Construction Management Fundamentals. 1st ed. U.S.A.: McGraw-Hill Professional.

Salama, M, Gardiner, P and Malikappurayil, H (2007) Investigating the main causes of variation in the construction projects in Dubai. In: Huges, W.(Ed) Construction Management and Economics CME25 Conference Proceedings, University of Reading, UK, July 16-18.

Vargas, R.V. (2007) Practical Guide to Project Planning. CRC Press.

INVESTIGATING THE WEIGHTING MECHANISM IN BREEAM ECOHOMES

Formatted: Different first page

Doug R. Forbes
Whole Life Consultants Ltd, James Lindsay Place, Dundee, DD1 5JJ, UK
doug.forbes@wlcuk.co.uk

Simon D. Smith
School of Engineering & Electronics, University of Edinburgh, Edinburgh, EH9 3JL, UK
simon.smith@ed.ac.uk

R. Malcolm W. Horner
Construction Management Research Unit, University of Dundee, Dundee, DD1 4HN, UK
r.m.w.horner@dundee.ac.uk

The Building Research Establishment's Environmental Assessment Method for Housing (BREEAM EcoHomes) is a commonly used sustainability assessment method in the UK. Initial investigations highlighted concerns among EcoHomes assessors with the weighting mechanism. The effect of the weights was investigated by a questionnaire sent to housing professionals to gauge the relative importance of each of the EcoHomes issues. The responses were transformed to weights using the analytical hierarchy process (AHP). The results showed that there is a remarkable consistency between respondents on the level of the weights which should be applied. Additionally there are some notable differences between the sets of weights produced by the respondents. However, further research demonstrated that the effect of these weights on the EcoHomes score is small. This indicates that the weighting mechanism is not as important an issue as it was perceived to be and that there may be other issues which are more important.

KEYWORDS: AHP; BREEAM; sustainability assessment; weighting

INTRODUCTION

Sustainability addresses social, economic and environmental considerations. The impact of the construction industry and buildings is substantial on all three of these. The actual impact of the built environment varies in the published data, but all agree it is considerable. In the environmental context buildings account for around half of carbon emissions, and one third of landfill waste (Department for Business Enterprise and Regulatory Reform, 2007). Socially, poor physical conditions have been of detriment to communities (Egan, 2004). It is not surprising that in an attempt to meet in particular carbon emission targets buildings have been a principal focus. Sustainability and the process of developing sustainably are global problems. Although the examples provided above relate to the UK the impacts of the built environment on sustainability issues are common throughout the world (Mackley, 2001). One of the main areas for this has been in the housing sector in the UK where the Government aim is for net zero carbon homes by 2016 in England and Wales (CLG, 2007). One of the tools used to measure delivery of this is the Code for Sustainable Homes (The Code) (Communities and Local Government, 2007). The Code is to a large extent based on the BREEAM (Building Research Establishment's Environmental Assessment Method) for housing – EcoHomes. EcoHomes was first developed in 2000 and added to a family of

BREEAM assessment which had previously existed for non-domestic buildings (Rao *et al.*, 2000). BREEAM was the first simplified environmental certification scheme of its kind in the world when it was developed in 1990 (Howard, 2005). The development of BREEAM has influenced the development of other assessment methods throughout the world (Cole, 2006). There currently exist a range of assessment methods for buildings, such as LEED (USA); Green Globes (Canada); HK-BEAM (Hong Kong); CASBEE (Japan); Green Star (Australia) and GB Tool (International). Therefore the research presented in this paper is not only relevant to the UK and BREEAM but has implications for other assessment methods in the USA, Canada, Hong Kong, Japan and Australia. EcoHomes underwent revisions in 2003, 2005, 2006 and was the main environmental assessment method for housing in the UK until The Code was introduced. Since May 2008 there has been a mandatory requirement for all new homes in England to be assessed under The Code (CLG 2008). In Scotland the standard remains EcoHomes 2006. The BREEAM non-domestic schemes, EcoHomes and The Code all function in similar fashions. A range of indicators is measured under a set of headline issues. The scores achieved in each issue are transformed to a single score using a relative weighting of each issue. The weights are set by the current revision of the schemes.

Prior to the research presented in this paper a workshop was held at which the shortcomings and potential improvements to EcoHomes was discussed. There were six key risk areas which emerged from this process. These were 1) Indicators are omitted from the process; 2) Unnecessary indicators are included; 3) Weighting Mechanism is ambiguous/wrong; 4) Sub-total for each indicator creates an additional weighting; 5) Uncertainty in the values of the fixed parameters specified by the process (eg. water use for an appliance); 6) Unable to make allowance for regional variations. There was agreement at the workshop that the third, the weighting mechanism, provided the biggest risk in getting a wrong measurement of sustainability. These findings were confirmed by over 60% of EcoHomes assessors who, when questioned, assigned “Moderately Important”, “Important” or “Very Important” to the risk. Among the six risks this ranked the highest. It is the purpose of the research presented in this paper to investigate the importance of the weighting mechanism. EcoHomes 2006 was selected as a test scheme, firstly, because it is familiar to the assessors who have worked over the last eight years with the scheme. Secondly, the focus was kept on housing because of the introduction of mandatory assessments under The Code, significantly increasing the amount of assessments taking place. This is especially important as the quantity of the housing stock needs to be increased following the recommendations of the Barker Review (Barker, 2004). Thirdly, the similarities between the BREEAM programmes and The Code will assist with the transferability of the results. This research investigates whether the weights which are used in EcoHomes differ from the levels which would reflect the preferences of those working in the housing construction sector. If there are differences this research aims further to investigate the impact of these on the measure of sustainability. The work presented in this paper discusses EcoHomes 2006 unless otherwise stated.

THE WEIGHTINGS

EcoHomes scores are calculated on a site-wide basis. All the dwellings in a development are awarded a combined score from eight issues. These are i) Energy; ii) Transport; iii) Pollution; iv) Materials; v) Water; vi) Land Use & Ecology; vii) Health and Wellbeing and viii) Management. Under each of the issues a set of points is awarded. These are then calculated as a percentage of the total available for each issue. The score achieved from the credits for each issue is then multiplied by the weight. This provides a weighted score. The weights have been

Formatted: Font: (Default) Arial, Not Italic, Complex Script Font: Italic

Formatted: Right, Position: Horizontal: 17.78 cm, Relative to: Page, Vertical: In line, Relative to: Paragraph, Width: Exactly 0.64 cm

Formatted: Font: (Default) Arial, Not Italic, Complex Script Font: Italic

Formatted: Font: Italic, Complex Script Font: Not Italic

Formatted: Right: 0.63 cm

defined through industry consultation, and are normalized to sum to one (Rao *et al.*, 2000). The weights for each of the eight issues are shown in the third column of Table 1. The sum of these weighted scores provides the overall EcoHomes score. An example is provided demonstrating this process in Table 1. As can be seen in the table, Energy, for instance, scored 41.67%. The Energy issue carries a weight of 0.22, which produces a contribution of 9.17% from this issue to the overall score of 53.08%.

The EcoHomes assessment method sets thresholds which define ratings for housing developments. The five ratings are ‘Fail’ (0%); ‘Pass’ (36%); ‘Good’ (48%); ‘Very Good’ (58%), ‘Excellent’ (70%). The numbers in brackets refer to the threshold levels. It can be seen that for the example in Table 1 a ‘Good’ rating would be obtained; the score of 53.08% is approximately in the middle of the good banding.

Table 1: Example of a BREEAM EcoHomes assessment

	Issue Achieved for Issue (%)	BREEAM EcoHomes Weight	Weighted Score- (Issue Score x weight) (%)
Energy	41.67	0.22	9.17
Transport	75.00	0.08	6.00
Pollution	36.40	0.10	3.64
Materials	87.10	0.14	12.19
Water	50.00	0.10	5.00
Land Use & Ecology	11.10	0.12	1.33
Health & Wellbeing	62.50	0.14	8.75
Management	70.00	0.10	7.00
		EcoHomes Score	53.08%

QUESTIONNAIRE

The entire population of 409 EcoHomes assessors was sent a questionnaire. It was noted that the population did not have many assessors in Scotland. To ensure responses were received from Scottish organisations the private and public housing sectors were also issued with a questionnaire. This was sent to all of the Registered Social Landlords (RSLs) in Scotland and all member organisations of Homes for Scotland (HfS). Homes for Scotland members produce 95% of the new built homes for sale in Scotland (Homes for Scotland, 2007). RSLs are landlords provide social rented accommodation and are registered with Communities Scotland (2007). To ensure coverage of the public sector the sustainability managers of the local authorities in Scotland were also sent the questionnaire.

The size of the populations sent the questionnaire is shown in column A of Table 2 for the different groups. The number of responses is given in column B, along with the corresponding response rate in C. Several organisations stated that they were unable to complete the questionnaire due to a lack of time or knowledge, or the address was unknown. Account of this was taken by modifying the response rate using equation 1 (Bryman, 2004). This is given in column E of Table 3.

$$\text{Modified Response Rate (E)} = \frac{\text{Number of Responses (B)}}{\text{Number Sent(A)} - \text{Number Unable to Complete(D)}} \qquad \text{Equation 1}$$

Table 2: Population and response rate from questionnaire

	Sent (A)	Replied (B)	Response Rate (C)	Cannot Complete (D)	Modified Rate (E)
EcoHomes	409	76	18.6%	30	20.1%
RSL	159	16	10.1%	2	10.2%
Homes for Scotland	90	9	10.0%	1	10.1%
Local Authorities	38	6	15.8%	13	24.0%
Overall	696	107	15.4%	46	16.5%

The Analytical Hierarchy process

To determine the relative importance of the eight issues in EcoHomes it is necessary to use a prioritisation method. The analytical hierarchy process (AHP) is a multi-criteria decision making method of assigning weights to different criteria to facilitate complex decision making (Saaty, 1980). For the research at hand each of the eight issues are defined as the criteria, and the AHP is used to define the relative importance of each one. The AHP requires a pair-wise comparison between each of the eight issues. This results in 28 individual comparisons. Comparisons are carried out on a nine-point scale (Saaty, 1980). The scale ranges from "equally important" (1) to "absolutely more important". These values relate to a score of 1 and 9 respectively, with seven intermediary levels. Inverse relationships (ie. "less important" rather than "more important") are imputed simply by the reciprocal value. For example "absolutely less important" scores 1/9.

The scores for each of the comparisons are collected into a matrix. An example for a three issue (A, B and C) assessment is given. A is weakly more important than B (3); A is absolutely more important than C (9); and B strongly less important than C (1/5). This is presented on the left of Figure 1. The reciprocal of these values are given for the alternative comparison in the matrix, as demonstrated on the right hand side of Figure 1.

There are a range of mechanisms available to determine the weights from the matrix and possibly the most effective is by iteration of the matrix Eigenvector (Saaty, 1980). The relative importance of each of the criteria is calculated by determining the Eigenvector associated with the principal Eigenvalue. The Eigenvector is normalised to one to calculate the weights. The Eigenvalue is then used to measure the consistency of the matrix. Saaty

(1980) produced a method by which inconsistent results can be identified. For full details of this process readers are referred to Saaty (1980).

	A	B	C
A		3	9
B			1/5
C			

(1) Pair-wise comparisons are included in matrix

	A	B	C
A	1	3	9
B	1/3	1	1/5
C	1/9	5	1

(2) Inverse values are included for the alternative comparisons

Figure 1: The AHP Matrix

The AHP has been used by previous researchers for application to sustainability assessment (Lombardi, 2007). The examples cited by Lombardi make use of the ability to compare different options on a quantitative scale. There is little published information on the method used by the Building Research Establishment (BRE) to determine the weights for BREEAM EcoHomes. A BRE report published in 2000 (Dickie and Howard, 2000) outlined a weighting process which was undertaken for environmental issues. Experts were provided with 20 points which were to be 'spent' across a range of issues. A second process allowed themes of sustainability to be ranked subjectively and were then weighted using an objective process, but there are no details as to what this was.

RESULTS

Range of Weights

The weights for each respondent from the questionnaire were calculated using the AHP. The responses from all the respondents were averaged for each issue. The effect of the inconsistent results was compared also, firstly by removing the inconsistent results from the analysis and subsequently by including them. The level for each of the issues for these two new sets of weights is given in Table 3. In total there were 96 responses with usable weights; 63 of these remained when the inconsistent values were removed.

The results presented in Table 3 were tested for statistical differences between the weights. All tests were undertaken at a 95% level of confidence. Firstly a Spearman Rank Correlation was calculated to determine differences between the rank orders of the weights. This demonstrated that there was no difference in order between the inclusion and exclusion of inconsistent values. However, both of these lists differed in rank order to the original weights. To investigate these further a Student's t-test was used to determine the differences between the mean of the values obtained from the AHP and the original weights. This was performed in turn for each of the eight issues and showed that the hypothesis that energy and transport had the same mean could not be rejected. However, for the remaining six issues, the alternative hypothesis that the means were not equal was accepted.

Table 3: Mean values of AHP weights from Questionnaire

	Original Weight	Rank	Without Inconsistent			With Inconsistent		
			Mean	St Dev	Rank	Mean	St Dev	Rank
Energy	0.220	1	0.225	0.115	1	0.216	0.112	1
Transport	0.080	8	0.096	0.069	7	0.100	0.069	6
Pollution	0.100	5	0.141	0.073	3	0.142	0.070	3
Materials	0.140	2	0.104	0.042	4	0.108	0.051	4
Water	0.100	5	0.146	0.072	2	0.144	0.070	2
Land Use & Ecology	0.120	4	0.102	0.046	6	0.099	0.046	7
Health & Wellbeing	0.140	2	0.104	0.054	5	0.104	0.055	5
Management	0.100	5	0.083	0.058	8	0.086	0.059	8

The level of the weights was investigated further by reviewing the responses for five UK regions. These regions differentiated between Scotland and four English areas (North England; Midlands; South West England and South East England), defined by Regional Development Agency boundaries. Weights could not be calculated for Wales because there was only one response. Each respondent was placed in the region defined by the region of their postal address. The average weights for each issue were calculated from the respondents in each region. The values of these regional weights are given in Table 4 together with the differences from the original weights.

Statistical tests, again at a 95% confidence level, were carried out to determine the differences in weights among the five regions. Statistically the range of values produced demonstrated a remarkable consistency. In the tests it was not possible to reject the hypothesis that the means were the same in almost all of the cases. The only significant differences occurred in Energy between Scotland and the North of England; Transport between Scotland and the Midlands; Materials between Scotland and the North of England and again in materials between the South West and the North of England.

In a comparison with the original weights defined by BRE, these mean values of regional weights again showed a remarkable consistency. The small differences were: Transport in Scotland was demonstrated as being different, and Pollution in Scotland, South East and the Midlands. Finally the weights across all of the regions for Water differed significantly from the 10% applied by BRE. To investigate again the effect of the rank order of the regional weights the Spearman Rank Correlation Co-efficient was used. This demonstrated that there were no differences between the rank orders of the six regions. However, all six regions differed in rank order from the BRE weights.

Inconsistency, however, existed in comparison of the mean values of the weights from the original weights. Table 4 shows that in some cases (for instance water in the North of England) the weight obtained from the questionnaire differed by over 60% from the original

Formatted: Font: (Default) Arial, Not Italic, Complex Script Font: Italic

Formatted: Right, Position: Horizontal: 17.78 cm, Relative to: Page, Vertical: In line, Relative to: Paragraph, Width: Exactly 0.64 cm

Formatted: Font: (Default) Arial, Not Italic, Complex Script Font: Italic

Formatted: Font: Italic, Complex Script Font: Not Italic

Formatted: Right: 0.63 cm

weight defined by BRE. The effects on the output of the assessment from these changes will be investigated in the following section.

Table 4: Derivation of regional weights

	Mean Weights for Each Region (% Change from Original EcoHomes Weight in Brackets)					
	Original Weight	Scotland	North England	Midlands	South West England	South East England
Energy	0.220	0.185 (-15.9%)	0.29 (31.8%)	0.204 (-7.3%)	0.248 (12.7%)	0.213 (-3.2%)
Transport	0.080	0.122 (52.5%)	0.096 (20%)	0.075 (-6.3%)	0.093 (16.3%)	0.097 (21.3%)
Pollution	0.100	0.163 (63%)	0.126 (26%)	0.144 (44%)	0.117 (17%)	0.143 (43%)
Materials	0.140	0.114 (-18.6%)	0.079 (-43.6%)	0.106 (-24.3%)	0.12 (-14.3%)	0.106 (-24.3%)
Water	0.100	0.132 (32%)	0.164 (64%)	0.136 (36%)	0.137 (37%)	0.161 (61%)
Land Use & Ecology	0.120	0.101 (-15.8%)	0.084 (-30%)	0.118 (-1.7%)	0.100 (-16.7%)	0.092 (-23.3%)
Health & Wellbeing	0.140	0.098 (-30%)	0.087 (-37.9%)	0.122 (-12.9%)	0.100 (-28.6%)	0.103 (-26.4%)
Management	0.100	0.084 (-16%)	0.074 (-26%)	0.095 (-5%)	0.085 (-15%)	0.086 (-14%)

The Effect of the Weights

Further investigation applied each of the regional weights in Table 4 to 30 past examples of EcoHomes assessments, obtained from 11 licensed EcoHomes assessor organisations. All 30 were compared with a reference value using the score from the original EcoHomes weights. The difference between the two was measured using the mean accuracy. This is done in two stages. Firstly, the difference in the measurement as a percentage of the original score was calculated. Secondly, the mean value of this error was calculated across each of the six regions. In addition to the six regions and the UK average weights given in Table 4, an equal weighting of one eighth was applied for comparison. The average difference for eight sets of weights is given in Table 5. The largest differences are +1.15% and -0.66% from the original scores.

Formatted: Font: (Default) Arial, Not Italic, Complex Script Font: Italic

Formatted: Right, Position: Horizontal: 17.78 cm, Relative to: Page, Vertical: In line, Relative to: Paragraph, Width: Exactly 0.64 cm

Formatted: Font: (Default) Arial, Not Italic, Complex Script Font: Italic

Formatted: Font: Italic, Complex Script Font: Not Italic

Formatted: Right: 0.63 cm

Formatted: Font: (Default) Arial, Not Italic, Complex Script Font: Italic

Formatted: Right, Position: Horizontal: 17.78 cm, Relative to: Page, Vertical: In line, Relative to: Paragraph, Width: Exactly 0.64 cm

Formatted: Font: (Default) Arial, Not Italic, Complex Script Font: Italic

Formatted: Font: Italic, Complex Script Font: Not Italic

Formatted: Right: 0.63 cm

Table 5: Difference from original scores when regional weights are applied

	% Difference from Original EcoHomes Score						
	Scotland	North England	Midlands	South West England	South East England	UK Average	Equal
Mean	1.15%	0.89%	-0.66%	0.89%	0.72%	0.42%	1.03%
St Dev	0.038	0.032	0.023	0.020	0.028	0.027	0.040
Max	8.94%	8.24%	4.57%	5.50%	7.38%	6.76%	10.52%
Min	-7.59%	-5.90%	-4.24%	-3.50%	-5.26%	-5.25%	-7.55%

DISCUSSION OF ECOHOMES WEIGHTING MECHANISM

The process of investigating the weights has utilised the AHP. The AHP has allowed the relative importance of each of the eight issues in BREEAM EcoHomes to be re-calculated. The benefits of using the AHP are two-fold. Firstly, due to the pair wise comparisons which are carried out the respondents cannot readily determine the outcome of the relative importance. Secondly, the inclusion of a consistency index allows the effect of responses which are inconsistent to be identified. However, these advantages are offset by a relatively complex response form required.

The overall response rate to the questionnaire was 16.5%. From the weights which were derived from these responses it was shown that there are differences between the mean weights across the UK and the weights set by EcoHomes for six of the eight issues. Further the rank order for these new scores and the original scores is different. This implies that there are differences between the levels of the weights which have been set by BRE in the EcoHomes 2006 process and the perception of the assessors and others working in the housing sectors.

When the weights were calculated for each of the six UK regions there was considerable consistency between the regions. This was partly due to the spread of the weights being relatively large for the means, accounting for the apparently large differences in the values for each issue. This finding was further confirmed by the rank correlation co-efficient, which demonstrated no statistical differences between the regions. The more concerning finding in this process however was that while there was general consistency between all of the weights obtained from the questionnaire and the weights set by BRE, the rank order of these differed significantly. In addition to this all of the regions deemed water to be significantly more important than the value set by BRE. However, despite these differences in rank order and magnitude of the weights the effect on the overall scores was seen to be relatively small. The application of each of the regional weights to 30 examples demonstrated that the score achieved for the assessment difference by a maximum mean value of 1.15% in Scotland to a minimum of -0.66% in the Midlands. Regionally, there were extremes of values which occurred when the new weights were applied. These were all within +9/-8% of the original score defined by BRE. This number is not considered to be large by itself, and the standard deviation of the score shows it to be within a reasonable range. The UK mean weights had the smallest effect on the average difference in score, again demonstrating a consistency between the weights defined by BRE and the general view of assessors across the UK. Interestingly, when the BRE scores were compared with applying an assumed equal weighting to each of the eight issues the scores are within an average of 1% of the original score. However, an equally weighted score has a larger spread in the differences than the regional weights, and has a maximum difference of 10.52%. This is also the largest absolute difference from the original score at 5.72 percentage points.

CONCLUSIONS

The research presented in this paper has shown that the weightings used in BREEAM EcoHomes are generally robust. There are some differences between the weights obtained from assessors across the UK and the weights set by BRE, and the rank order of these is different. However this has been demonstrated to have a minimal effect on the scores. A relatively small range of scores is obtained when different weights are used. Further investigation has shown that there are some differences in the absolute values of the weights when the UK is split into regions. However, the effect of these on the overall score is minimal. Similarly, there is only a small effect on the scores when it is assumed that each of the issues is of equal importance. This research confirms the findings which were originally published by BRE in 2000 showing consistency among those involved in the weighting process. This is further confirmed that where there are inconsistencies these do not substantially affect the overall EcoHomes score. This finding corroborates work previously published by BRE and should encourage EcoHomes assessors to use the assessment with increased confidence.

While the research presented in this paper has been demonstrated on EcoHomes 2006 there is no reason to believe that the findings would not be equally transferrable to The Code or the non-domestic BREEAM schemes. Additionally, the derivation of the weights for other international assessment methods such as LEED and HK-BEAM could also be explored by the approach outlined in this paper. The practical significance of this piece of research in relation to the assessment methods is in demonstrating that since the weights do not have a large affect on the overall score assessors should not be unduly concerned by them. However, the weights do potentially have an impact in directing the focus of designers who give higher weighted issues more attention if a higher rating is required. The authors do not consider that this is a problem as the robustness of the weights has been shown. Therefore areas with the highest weights are the areas which have greatest influence ob sustainable housing.

Overall it has been shown that the weighting mechanism is not a significant issue in BREEAM EcoHomes. This is in contrast to the perspectives of those assessors questioned. The findings in this research should increase confidence in using the EcoHomes. However, there are other potential issues with the process as a sustainability assessment method which should be considered. Most significantly, the assessment only takes account of the environmental and a small amount of social issues. No account is taken of the economic dimension of sustainability. The impact of these on sustainability assessment should be considered. The authors suggest that further research should focus on the extent to which EcoHomes and other assessment methods address all three dimensions of sustainability. It is proposed that an opportunity to incorporate the economic dimension is a critical element which should be urgently considered.

Formatted: Font: (Default) Arial, Not Italic, Complex Script Font: Italic

Formatted: Right, Position: Horizontal: 17.78 cm, Relative to: Page, Vertical: In line, Relative to: Paragraph, Width: Exactly 0.64 cm

Formatted: Font: (Default) Arial, Not Italic, Complex Script Font: Italic

Formatted: Font: Italic, Complex Script Font: Not Italic

Formatted: Right: 0.63 cm

ACKNOWLEDGEMENTS

The support of the Engineering and Physical Sciences Research Council (EPSRC) in funding this work is gratefully acknowledged.

REFERENCES

Barker, K (2004) Review of Housing Supply: Delivering Stability: Securing our Future Housing Needs. Final Report. Norwich: HMSO.

Bryman, A (2004) Social Research Methods. Oxford: Oxford University Press.

CLG (2007) "Building a Greener Future: Policy Statement", available at http://www.communities.gov.uk/documents/planningandbuilding/pdf/building-greener

CLG (2008) "The Code for Sustainable Homes: Setting the standard in sustainability for new homes", available at http://www.communities.gov.uk/documents/planningandbuilding/ pdf/codesustainhomesstandard.

Cole, R. J. (2006). Shared markets: Coexisting building environmental assessment methods Building Research and Information 34(4): 357-371.Communities and Local Government (2007) Code for Sustainable Homes: Technical Guidance. London: HMSO.

Communities Scotland (2007) Scottish Registered Social Landlord Statistics. Edinburgh: Communities Scotland.

Department for Business Enterprise and Regulatory Reform (2007) "Draft Strategy for Sustainable Construction", available at http://www.berr.gov.uk/files/file40641.pdf

Dickie, I and Howard, N (2000) Assessing Environmental Impacts of Construction. BRE Digest 446. Bracknell: IHS BRE.

Egan, J (2004) The Egan Review: Skills for Sustainable Communities. London: ODPM.

Homes for Scotland (2007) "Who we are", available at http://www.homesforscotland.co.uk/pages/layout.asp?did=37

Howard, N (2005) Building Environmental Assessment Methods: In Practice. In: The 2005 World Sustainable Building Conference (SB05Tokyo), Tokyo, 2008-15.

Lombardi, P (2007) The Analytical Hierarchy Process. In: Deakin, M, Mitchell, G, Nijkamp, P and Vreeker, R (Eds.), Sustainable Urban Development Volume 2: The Environmental Assessment Methods, pp. 209-22. Oxford: Routledge.

Mackley, C. (2001). Sustainable Development Sustainable Practices in the Built Environment C. A. Langston and G. K. C. Ding. Butterworth-Heinemann, Oxford**:** 13-24

Rao, S, Yates, A, Brownhill, D and Howard, N (2000) EcoHomes: the environmental rating for homes. London: Construction Research Communications Limited.

Saaty, T L (1980) The Analytic Hierarchy Process. London: McGraw-Hill.

LEADERSHIP AND ITS ROLE FOR THE SUCCESSFUL DEPLOYMENT OF KNOWLEDGE CAPTURE INITIATIVES

Subashini Suresh
University of Wolverhampton, Wolverhampton, UK
S.Subashini@wlv.ac.uk

Charles Egbu
University of Salford, Salford, UK
c.o.egbu@salford.ac.uk

Paul Olomolaiye
University of Wolverhampton, Wolverhampton, UK
P.Olomolaiye@wlv.ac.uk

Popularity in leadership has, unfortunately, not been matched by parallel empirical research in the area of leadership in the construction management research in the UK, even though, the construction industry in the UK contributes around 10% of the GDP and consists of more than 90% Small and Medium Enterprises (SMEs). In the same vein, there are very few empirical construction-related studies that have been focused on knowledge capture in SMEs. This paper discusses the importance of leadership in the context of the challenges associated with implementing knowledge capture initiatives. The empirical study involved twenty six SMEs in the UK construction industry. Grounded theory approach was adopted as the research methodology. The results from the empirical study revealed that the main challenges for implementing knowledge capture initiatives is the lack of leadership support. This is because of a lack of awareness of knowledge capture benefits; lack of vision, mission and strategy; and lack of structure for knowledge capture initiatives.

KEYWORDS: Grounded theory, knowledge capture, leadership

INTRODUCTION

The onset of a new economic system based on knowledge rather than capital, along with the creation of economic value by integrating corporate social and environmental responsibility issues now increasingly pose real profound strategic challenges for construction organisations. As organisations try to address these challenges, knowledge is increasingly being seen as important for innovation and for producing knowledge intensive products and services desired by market so as to maintain competitive advantage. According to Ulrick (1997), a number of capabilities are needed by an organisation if it is to develop competitive advantage and achieve success in a competitive context. It is necessary to develop a shared mindset which will enable the development of a unique identity for the organisation and it is this shared mindset which is an enabler for the creation of wealth for the organisation. Ulrick (1997) also suggested that organisations need to be able to capture the tacit knowledge of its employees and to do this effectively, it is argued that management needs to involve and engage employees fully in the activities of the organisation. The operational definition for knowledge capture adopted in this study is a "process of obtaining and collecting key knowledge (both tacit and explicit) from an individual, group or organisation in order to improve organisational competitiveness" (Suresh, 2006). Knowledge capture initiatives provide opportunities for organisations to innovate, improve project methodologies, cut costs, and save design time. The ultimate key to organisations successfully embracing knowledge capture initiatives into daily business operation is leadership. Edgeman et al (1999) stated that a bad leader provides poor leadership which may be worse than no leadership. According to Deming (1992), leadership must come from top-management and leaders must possess profound knowledge. By profound knowledge, Deming meant that one must have knowledge of systems, knowledge of variation (statistical thinking), knowledge of theory and knowledge of psychology. There are various definitions for leadership but for the purpose of this paper Leadership is defined as "a process whereby an individual supports other group members in learning processes needed to attain group or organisational goals" (Stogdill, 1974, pp. 9-10). Viitala (2004) emphasised that knowledge management (which encapsulates knowledge capture) is still lacking research on leadership issues.

IMPORTANCE OF LEADERSHIP

Hasanali (2002) emphasised that leadership plays a key role in ensuring success in almost any initiative within an organisation. Its impact on knowledge capture is even more pronounced because this is a relatively new discipline. Hasanali (2002) discussed two organisations (Buckman Laboratories and World Bank) to illustrate the importance of leadership. The CEO at Buckman Laboratories, a chemicals company, champions the cause for knowledge capture and sharing within the organisation and personally reviews submissions to its knowledge bank. When he notices that a particular employee has not been active within the system, he sends a message that reads: "Dear associate, you haven't been sharing knowledge. How can we help you? All the best, Bob". At the World Bank, the president's support led to the creation of an infrastructure that promoted and supported the growth of communities of practice (CoPs) not only throughout the organisation, but also around the globe. Today, the World Bank has sustained its knowledge capture and sharing initiative through its CoPs. Its knowledge managers constantly search for new approaches to capture and share knowledge.

Hartman (2003) based on his observations on leadership highlights "4-E's" of leadership: the personal Energy to welcome and deal with the speed of change . . . the ability to create an atmosphere that Energizes others . . . the Edge to make difficult decisions . . . and the ability to consistently Execute. Ramberg (2000) noted that leadership is key to the success of any plan that attempts to change the way an organisation does business. Without the support, participation and leadership of top, mid-level and operational level management and the development of an appropriate infrastructure, any program is destined to become just another fad or the latest flavour-of-the-month program.

For the successful deployment of knowledge capture initiatives leadership attributes serve as a visionary by helping people (employees, members) to understand the importance of knowledge capture. It is suggested that the development of vision and mission is the basis for organisational alignment, coordination and teamwork. The mission statement describes an organisation's basic purpose. The mission and vision give direction to an organisation, and they function as a compass and a road map, leading to better performance (Ram Prasad, 2001). Hansen et al. (1999) discussed the importance of having a strategy for managing an organisation's knowledge. They identified several organisations that had wrong strategy or no strategy to utilise their existing organisation's knowledge. Toftoy and Chatterjee (2004) argue that most businesses operate without a clearly defined strategic plan and an honest, concise and meaningful mission statement.

Welch and Welch (2005) noted that "strategy means making clear-cut choices about how to compete. You cannot be everything to everybody, no matter what the size of your business or how deep [your] pockets". The first step of making strategy real is figuring out the big factor to gain sustainable competitive advantage – in other words, a significant, meaningful insight about how to win. The construction industry is project-based and therefore there is a high degree of interdependency between organisations. Chinyo and Vogwell's (2007) empirical study indicated that effective leadership of stakeholders (owners, users, project managers, facilities managers, designers, sub contractors and suppliers to name a few) in the construction industry can help to harmonise their goals and prevent conflict. However, for knowledge capture initiatives to be implemented there is a need for a champion, a leader who will take charge of running the show after implementation begins.

RESEARCH METHODOLOGY

In the study reported in this paper, qualitative research approach which includes Grounded theory was adopted to uncover many of the complex and intricate issues associated with the challenges for implementing knowledge capture initiatives in SMEs in the UK construction industry and the role of leadership in this regard. Glaser and Strauss, (1967) first described the method of Grounded theory in 1967 as a means of enabling the 'systematic discovery of theory from the data of social research'. Since then two different approaches have emerged; the Straussian and the Glaserian. It should also be noted that a number of other adaptations have been developed as identified by Heath and Cowley (2004). Backman and Kyngas (1999) suggest that the researcher should follow one particular author i.e. Glaser or Strauss and then develop their own method using one of these as a foundation for analysing data. If the researcher was to apply a combination of applications of grounded theory from different texts this would undoubtedly result in confusion and the resulting findings would be lacking in substance. Hence this study chose the Strauss and Corbin methodology for analysis of data.

Sample size is deemed to be satisfactory only when the key concepts that have been identified from the collected data have reached saturation point; in other words, when no new data emerges. However, Morse (2000) suggests that to reach saturation point, the sample size depends on several factors: the scope of the study, the nature of the topic, quality of the data, study design and research technique. A semi-structured interview approach was used as the research technique for this study. Morse (2000) produced a 'rule of thumb' for grounded theory studies recommending approximately thirty to fifty interviews. This research study concluded with 53 interviews in 26 organisations. Data saturation was reached in 48th interviews in the 21st organisation. The participated organisations in the study employed more than 10 people but less than 250 employees. The database for the study was collected from the Small Business Gateway (2003) for the construction industry. Attempts were made to have a sample across architecture; engineering and construction organisations.

Table 1: Representativeness of the sample organisations

	Architects	Engineers	Contractors	Total (organisations)
Small	4	4	2	10
Medium	3	6	7	11
Total	7	10	9	26

The process for data analysis adopted in the study was in three stages.

- Stage 1 included data obtained through semi-structured interviews, which was through notes and the interview contents recorded through Dictaphone. The data was transcribed in a Microsoft word document. The data was imported to the computer-aided qualitative data analysis software (CAQDAS).
- Stage 2 consisted of using CAQDAS (QSR N6). This involved allocating text unit, creating nodes and indexing. This was followed by matrix/cross tabulation, overlapping themes and finding sequences. In this process restructing and collecting codes allowed for a holistic approach. These codes were imported to stage 3.
- Stage 3 involved importing data from step two from matrix/cross tabulation to spreadsheet software such as Microsoft Excel and code imported to "Inspiration software". This software helped to display graphics of codes. The results from both software were integrated to form categories.

The processes that took place between stages 1 and 3 were iterative until new categories did not emerge.

Trustworthiness in grounded theory method

According to Streubert and Carpenter (1999) qualitative research is trustworthy when it accurately represents the experience of the study participants. The four processes described by Lincoln and Guba (1985) for establishing trustworthiness are: credibility, dependability, confirmability and transferability. This has been applied to this study to ensure the trustworthiness.

- **Credibility**

Lincoln and Guba (1985) suggest that to obtain credibility, five processes are involved. These include: prolonged engagement, persistent observation, peer briefing, member checks and triangulation.

Prolonged engagement in the area under study was achieved by the number of interviews which were carried out, and by returning to the participants in order to build on previous interviews. This also contributed towards building trust with the participants; learning about the culture the participants found themselves part of, and being able to check against any misinformation which could be derived from distortions introduced by the researcher (Creswell, 1998). There was an awareness of the need to not prematurely close data and reach assumptions too soon.

Peer debriefing provides a mechanism for checking. Lincoln and Guba (1985, pg 308) suggest that this helps to keep the researcher honest by exposing him or her to inquisitive questions by someone playing the "devil's advocate". In this study this was met by liaising with the second author of this paper who played this part extremely well. He questioned the methods, meanings and interpretations.

Member checks were carried out in this study by returning to a number of the participant and asking them to examine and comment on the interpretation and conclusions which were being drawn from the data. According to Lincoln and Guba (1985, pg. 314)

> "The member check, whereby data, analytic categories, interpretations, and conclusions are tested with members of those stake-holding groups from whom the data were originally collected, is the most crucial technique for establishing credibility. If the investigator is to be able to purport that his or her reconstructions are recognisable to audience members as adequate representations of their own (and multiple) realities, it is essential that they be given the opportunity to react to them".

Triangulation encourages the use of different sources of information methods and theories to provide supporting evidence. In this study the sources included information from participants themselves, company documents and from relevant literature.

- **Dependability/confirmability**

Dependability is the qualitative researcher's equivalent of "reliability". Lincoln and Guba (1985) contend that there can be no dependability without credibility. Dependability is considered once the researcher has determined the credibility of the findings. Both dependability and confirmability of a study may be addressed by the demonstration of an audit trail that records activities over time that another individual can follow. This audit trail would include all documentation: tapes, wave files, transcripts, memos and diagrams; in fact everything concerned with the study. Lincoln and Guba (1985) also suggest that it is necessary that an auditor be able to judge the extent to which the researcher's values and biases may have influenced the findings.

- **Transferability**

Transferability should enable other researchers to transfer information to other settings. However, as a qualitative researcher, the researcher makes no claims that her interpretations can be generalised across other contexts. The researcher has described in detail the participants and the setting under study, therefore allowing others to determine whether the findings could be transferred to other situations with which they are familiar.

- **Reproducibility**

Strauss and Corbin (1998) suggest that the ability to reproduce findings gives the original findings credibility. However, reproducing social phenomena can be difficult because it is nearly impossible to replicate the original conditions under which data were collected or to control all the variables that might possibly affect findings.

They also argue that there are ways of rethinking reproducibility to extend its meaning. By giving the same theoretical perspective of the original researcher, following the same general rules for data gathering and analysis and assuming a similar set of conditions, other researchers should be able to come up with either the same or a very similar theoretical explanation about the phenomenon under investigation. The same problems and issues should arise regardless of whether they are conceptualised and integrated a little differently.

CHALLENGES FOR IMPLEMENTING KNOWLEDGE CAPTURE INITIATIVES

In the semi-structured interviews the subject of key challenges for knowledge capture initiatives was raised in a general context. i.e., what are the main challenges your organisation face in implementing knowledge capture initiative in the work that you do? This stimulated responses about the challenges in different context and more specific information about the various challenges for knowledge capture initiatives. The following analysis reflects the perceptions of individual in construction organisations and there are no general assumptions made. Table 2 shows the five main challenges associated with implementing knowledge capture initiatives as revealed in this study. It also illustrates the number of interviewees, the number of organisations and the relevant percentage.

Table 2: The main challenges associated with implementing knowledge capture initiatives in SMEs in the construction industry.

Main challenges for implementing knowledge capture initiatives	Number of interviewees (N=53)	Number of organisations (N=26)	Percentage (Number of organisation/ total number of organisation)
Lack of Leadership support for knowledge capture initiatives.	50	25	96%
The lack of provision for appropriate training for knowledge capture initiatives	48	24	92%
The creation of an appropriate culture for knowledge capture initiatives	47	23	88%
The need to adopt appropriate processes for knowledge capture.	42	22	84%
The adoption of appropriate tools (techniques and technologies) for knowledge capture.	40	21	81%

From the data in Table 2 it is evident that the main challenge for implementing knowledge capture initiatives is lack of Leadership/top management support. This is followed by adopting appropriate training, creation of an appropriate culture for knowledge capture initiatives, adopting appropriate processes, and adopting appropriate tools for knowledge capture. This paper focuses on the leadership support for knowledge capture initiatives.

LEADERSHIP SUPPORT FOR IMPLEMENTING KNOWLEDGE CAPTURE INITIATIVES IN SMES

In the current study, 50 interviewees from 25 of 26 organisations (96%) noted that lack of leadership support for knowledge capture initiatives is a challenge. This is because of a lack of awareness of knowledge capture benefits; lack of vision, mission and strategy; and lack of structure for knowledge capture initiatives.

Out of the 26 organisations that participated in the current study, only three organisations have any form of vision and mission statements on the use of information technology. None of the organisations in this study noted that there were any forms of vision or mission statements for knowledge capture initiatives. However, some elements of knowledge capture initiatives were evident in all the organisations that participated in the study. This calls for real and urgent attention in the role of leadership in establishing an infrastructure that can actually bring about change and implement the organisation's mission, vision and strategy with respect to knowledge capture in SMEs in the construction industry. The importance of expressing the vision to the rest of the organisation is paramount. There is an urgent need for a long-term vision to be incorporated into the corporate strategy of organisations. This is only achievable if the mission towards knowledge capture is fully understood in the organisation.

One of the interviewees of a small sized organisation study stated that

> "If we did something wrong, there is ninety percent chance it will be done again. This is because lessons learnt from mistakes are not captured and shared in a systematic way".

An interviewee from a medium sized organisation who participated in the study noted that

> "There is a wealth of knowledge within the company. If you know the right person to speak to and the right question to ask at the right time, then you will certainly get a huge amount of knowledge which is informal in nature".

This observation was also reiterated by an interviewee from a small sized organisation who stated that:

> "Any information or knowledge generated is lost because people just pass information or knowledge on to each other verbally. If somebody has up-skilled their experience and they leave the organisation that leaves a knowledge gap".

The above views of the interviewees indicate that there is lack of an effective strategy to capture key knowledge which was evident in all the twenty six (26) organisations. Hansen et al. (1999) discussed the importance of having a strategy for managing an organisation's knowledge and identified several cases where having the wrong strategy or no strategy caused organisations to fail to utilise their knowledge. Toto and Chattered (2004) argue that small businesses operate without a clearly defined strategic plan and an honest, concise and meaningful mission statement. Fifty (50) of the 53 interviewees from 26 organisations noted that having a strategy for knowledge capture is a reflection of leadership; a means of involving all organisational members, and their willingness to capture and use knowledge on a continual basis.

An interviewee from one of the medium sized organisations stated that:

> "In prison service job, they have different halls. For example, hall "A", hall "B", hall "C". We prepared the quantities for the first one. Had we used the billing system, we would have had standards for that type of buildings, and we would have saved lots of time doing the subsequent jobs. We have still not done the hall "E" and somebody new will be starting that from scratch".

This quote informs the amount of time spent in doing the same type of work from scratch. If the organisation had developed a standard billing system, time would be saved; and possibly eliminate the "reinvention of the wheel". This agrees with the empirical findings of Proudfoot Consulting (2002), which concluded that poor planning, inadequate management, poor working morale, IT problems, poor communication and inadequate communications' caused the loss, on average, of 110 days per year in British companies (Proudfoot Consulting, 2002, pp.13-15). This situation was also evident in 25 of the 26 organisations that participated in the current study; where it was noted that lack of leadership support for implementing knowledge capture initiatives in SMEs is a key challenge. Matsumoto et al. (2005) argue that within the architecture, engineering and construction industry, companies recognise they can no longer afford to reinvent the wheel and must learn to better capture the knowledge to improve the quality and effectiveness of the organisation. This seems to suggest that a lack of awareness for knowledge capture benefits is prevalent in SMEs in the construction industry.

Twenty three (23) of the 26 organisations that participated in the current study have adhoc quality systems in place, and it was the role of the owner/partner/managers to ensure quality of work. The analyses of data in this study indicated that consultants were hired in three medium organisations for quality assurance (QA) system. However, QA system is not followed in two companies rigorously as there was no structure in place or a person to review the QA system. It was interesting to note that only in one company was there a person in charge of the QA who makes regular documentation of quality system. The checklists as part of the QA systems were revisited regularly to monitor whether key technical aspects are considered during project execution. The check lists could be considered as a form of knowledge capture where lessons learnt and best practices were incorporated. This seems to suggest that there is a need for a more structured approach to capture knowledge in SMEs in the construction industry. However, the challenge SMEs face is the shortage of resources, especially having a dedicated person for knowledge capture initiatives. Hence, it could be suggested that the owners/partners/managers could act as gatekeepers of knowledge capture activities and institute formal procedures to capture and store knowledge in SMEs in the construction industry.

In one of the medium sized organisations that participated in the current study, it was noted that lack of leadership support was not a challenge in the implementation of knowledge capture initiatives. This is because one year ago (prior to the current study interview) the importance of knowledge capture was realised when one of the key working partners who specialised in construction law had died due to a cardiac arrest. This resulted in a major "knowledge loss" to the organisation. The management team in the organisation tried to fill the job role but failed. One of the partners of the medium sized organisation attended a workshop on knowledge management where a few of the discussed topics highlighted issues of knowledge capture. This raised the awareness of the potential benefits of knowledge capture initiatives. The management of the medium sized organisation developed a strategy which involved allocating resources, and built support and enthusiasm for knowledge capture. Some of the knowledge capture initiatives included the allocation of time to document lessons learnt and best practices during the different stages of project (from peers in the organisation) and templates prepared to capture knowledge during projects (from experts within the organisations). Communities of practice were also formed within the organisations. One of the employees from the manager level was dedicated to ensure formal knowledge capture practices. This person was also involved in the quality assurance systems of the organisation.

The analysis of the 26 SMEs that participated in the study revealed the following:

- Leadership team in 25 SMEs appear to have a poor level of understanding of the potential benefits of effective knowledge capture initiatives.
- Leadership team in 25 SMEs tend to treat knowledge capture initiatives as a separate activity from the day to day running a business. Knowledge capture initiatives appear to be given a low priority in comparison with other activities that can lead to tangible results in the short term.

It could be inferred that without leadership support and commitment, no knowledge capture initiatives will take off in any meaningful way. Leadership in SMEs need to understand knowledge capture as a key business driver rather than as a resource-intensive additional initiative. While introducing knowledge capture, a logical sequence should be used to minimise effort and cost, resulting in products or services being used/implemented more quickly. There is an urgent need for improved awareness and understanding of the challenges and significance of knowledge. In order to fill this gap, a training tool for leadership capability building for implementing knowledge capture initiatives is being developed.

CONCLUSIONS

This paper discusses the importance of leadership in the context of the challenges associated with implementing knowledge capture initiatives. The empirical study involved twenty six SMEs in the UK construction industry. Grounded theory approach was adopted as the research methodology. The results from the empirical study revealed that the main challenges for implementing knowledge capture initiatives is the lack of leadership support. It is evident from this research that adhoc knowledge capture practices predominantly exist in SMEs in the UK construction industry. The lack of leadership support is the key challenge because of a lack of awareness of knowledge capture benefits; lack of vision, mission and strategy; and lack of structure for knowledge capture initiatives.

REFERENCES:

Backman and Kyngas (1999) Backman Kaisa and Kyngas Helvi A. (1999), “Challenges of the grounded theory approach to a novice researcher”, Nursing and Health Sciences, Vol. 1, pp.147-153.

Chinyio, E. and Vogwell, D. (2007), “Towards Effective Leadership in Construction Stakeholder Management”. Proceedings, CME25 Anniversary Conference, Held at University of Reading, UK, 16-18 July, CD edition.

Creswell, J. W. (1998), Qualitative Inquiry and research design: Choosing among five traditions, Sage, London.

Cutcliffe, J. R. and McKenna, H. P. (1999), "Establishing the credibility of qualitative research findings: the plot thickens", Journal of Advanced Nursing, Vol. 30, No. 2, pp. 374- 384.

Deming, W. E., (1992), Four Day Seminar - Charlotte, NC, October 27 – 30.

Edgeman, R.L, Dahlgaard, S. M. P and Dahlgaard, J. J and Scherer F, (1999), "On leaders and leadership", Quality Progress, Vol.32, No.10, pp 49-54.

Glaser, B. and Strauss, A. (1967), The discovery of grounded theory: Strategies for qualitative research, Chicago IL Aldine.

Hasanali, F (2002), "Critical success factors of knowledge management", http://www.providersedge.com/docs/km_articles/Critical_Success_Factors_of_KM.pdf. (accessed May 10, 2007).

Hansen, M. T., Nohria, N. and Tierney, T. (1999), "What's your strategy for managing knowledge"?, Harvard Business Review, March-April 106-116.

Hartman, A (2003), "The Competitor: Jack Welch's Burning Platform", Financial Times Prentice Hall

Heath, Helen and Cowley, Sarah (2004), "Developing a Grounded Theory Approach: A Comparison of Glaser and Strauss", International Journal of Nursing Studies, Vol. 41, Issue 2, February 2004, pp. 141-150.

Lincoln, Y. S. and Guba E. G. (1985). Naturalistic Inquiry. California, Newbury Park, Sage.

Miles, M. B. and Huberman, A. M. (1994), Qualitative Data Analysis: An Expanded Sourcebook, Sage, London.

Morse, J. M. (1994) Designing funded qualitative research. In The handbook of qualitative research, Denzin, N. K. and Y.S. Lincoln(Eds) Thousand Oaks, Sage, 199, CA.

Proudfoot Consulting (2002), Untapped potential. The barriers to optimum corporate productivity. London: Proudfoot Consulting.

Ramberg, S John (2000), "Six Sigma: Fad or Fundamental", Quality digest, http://www.qualitydigest.com/may00/html/sixsigmapro.html

Ramparsad, H (2001) "A visionary management model", The TQM Magazine, Vol.13, No. 4, pp. 211-223.

Small business gateway (2003), http://www.sbs.gov.co.uk, accessed 4th March 2003

Stogdill, R.M (1974), Handbook of Leadership: A survey of theory and Research, Free Press, New York, NY

Suresh S (2006), "Knowledge capture in the small and medium enterprises in the construction industry" PhD thesis, University of Glasgow Caledonian, Scotland, UK

Streubert, H. J. and Carpenter, D. R. (1999) Qualitative research in nursing: advancing the humanistic imperative, Lippincott, Philadelphia.

Toftoy, C. N. and Chatterjee, J. (2004) Mission statement and the small business, Business Strategy Review, Autumn.

Toor, Shamas-ur-Rehman and Ofori G (2007), "Leadership research in the construction industry: A review of empirical work and possible future directions", Proceedings, CME25 Anniversary Conference, Held at University of Reading, UK, 16-18 July, CD edition.

Ulrick, D (1997), Organising around capabilities, In Hesselbein, F., Goldsmith, M., Beckhard, R. (Eds), The organization of the future, Jossey-Bass, New York, NY.

Viitala R (2004), "Towards knowledge leadership", The Leadership and Organisation Development Journal, Vol.25, No.6, pp.528-544.

Welch, J and Welch S (2005), "Winning", Harper Business, USA

MODELLING CONTRACTOR'S AND SUBCONTRACTOR'S TRUST: A SYSTEM DYNAMICS APPROACH

Azmeri Rahman
Stamford University Bangladesh, Dhaka, Bangladesh
azmeri14@yahoo.com

B.H.W. Hadikusumo
Asian Institute of Technology, Pathumthani, Thailand
kusumo@ait.ac.th

Stephen O. Ogunlana
Heriot Watt University, Edinburgh, UK
S.O. Ogunlana@hw.ac.uk

Muhammad Nateque Mahmood
The University of Tokyo, Tokyo, Japan
nateque@ken-mgt.t.u-tokyo.ac.jp

A general mistrust within the contactor and subcontractor companies has identified one of the significant barriers to derive benefits from true downstream supply chain integration. Using the general theory of trust in inter-organizational relations and conducting interviews, this research discusses factors that influence development of trust and cooperation in contractor–subcontractor relationships in construction projects. System dynamics is the simulation method is selected in this theory-building effort, based on qualitative data collected from two projects of a construction company in Thailand. Performance, permeability and system-based trust are found to make significant contributions toward parties' trust level. Three strategic policies such as best value contracting, management of subcontractors as internal team and semi project partnering approach are recommended to stimulate the trust factors as well as cooperative long term relationship.

KEYWORDS: Trust, contractor's and subcontractor's relationship, system dynamics model, construction supply chain management.

INTRODUCTION

The lack of trust between contractor and subcontractor on the adversarial nature of their working relationships has been characterized as a fundamental barrier to the increased understanding of each others' needs and further supply chain integration. This kind of relationship is reflected in projects delays, adversarial attitudes, cost overruns, litigation and a win-lose climate. This appears to be preventing the active involvement of supplier companies to the construction process.

The key barriers to develop trust as well as greater integration seem to stem from the industry's traditional approach of vertically differentiating the construction process, which results adversarial relationships, a lack of transparency and mistrust between the contracting parties (Hinze and Tracey, 1994). Traditional contractual arrangements often generate a climate of mistrust that tends to induce opportunism and hinder co-operative interaction

(Dainty et al. 2001). Moreover, risk is passed down the supply chain, rather than being shared amongst the parties in the spirit of a true partnership. Thus, specialist contractors also identified a lack of risk sharing on the part of the lead contractor as a factor of eroding trust.

From the above statement it can be easily depicted that the fragmented approach of construction project procurement and product delivery process, traditional contractual arrangements regarding payments and retention and information sharing are the main foundation of generating mistrust among the contracting parties. Thus, trust can be regarded as glue that fosters cooperation among organizations and different team members and an essential lubricant that helps to complete the project smoothly (Wong and Cheung, 2005).The primary objective of this study is to address the critical issues in developing trust model for effective supply chain integration between contractor and subcontractor in construction industry using System Dynamics Approach.

The paper is organized is as follows: first, importance of modelling trust as dynamic systems is briefly explained. Then the system dynamics model building steps are described. Due to space constraint, more focus has given on development of dynamic hypotheses. The final section discusses concluding remark and future research scope.

IMPORTANCE OF MODELING TRUST AS DYNAMIC SYSTEMS

In the review of literature, it has been found that researcher in this area have identified several mechanisms associated to trust development such as Institutional trust, calculative trust, knowledge-based trust, and identification-based trust. Institutional trust refers to the existence of an institutional framework that regulates the relationship between the trustor and the trustee (Luna-Reyes et al., 2004). This institutional framework can consist of laws, regulations or certification bodies that provide penalties for a party cheating in the interaction or provide certification of the trustworthiness of the trustee by a recognized third party. Calculative trust refers to the trustee's estimation of the risks and payoffs intertwined in the interaction. Changes in the perception of the institutional framework can result in changed perception of risk, promoting increases in the calculative trust. Knowledge-based trust is related to the ability of the trustor to assess the trustworthiness of the trustee. This assessment of trustworthiness can be based on the recognition of the expertise, the benevolence, ability, and integrity (Mayer et al., 1995), and it is associated with the history or the process of the relationship. Finally, identification-based trust is associated sometimes to emotional bonds, or with the existence of shared values or objectives between the actors. Rousseau et al. (1998), who considers that the calculative trust plays a more important role in early stages of the relationship. This change towards a knowledge-based trust as the relationships matures, and the parties involved develop a history of interactions and get to know each other (Figure 1).

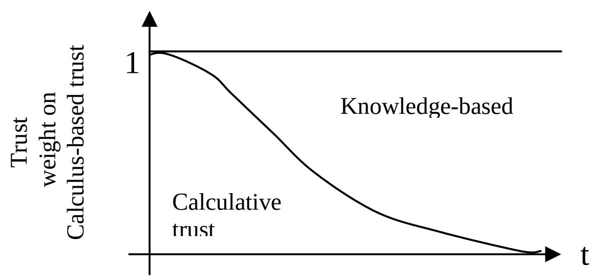


Figure 1: Change over time of the character of trust in an interpersonal relationship. Adapted from Rousseau et al., (1998).

The assumption about the shift from calculative trust to knowledge-based trust is also supported by the observations of reference mode, and from the interview of contractor and subcontractors.

As trust is dynamic e.g. if either one deteriorates, this will have a negative impact on the other, thus a system dynamics model related to trust in creating project team can help to make decisions effectively and encounter the problems related to parties' relationship as it involves two major characteristics: 1) changes over time and 2) allows feedback. System dynamics model are well suited to representing multiple interdependencies, to deal with dynamics nature and involved in significant feedback processes (Ogunlana et al., 1998). This study focuses to develop a system dynamics model of trust from both contractor and subcontractor point of view in order to experience the impact of factors on trust.

METHODOLOGY

System Dynamics is a way of analyzing the behaviour of complex socioeconomic system to show how organization and policy influence behaviour. Several types of model building steps have been described by different authors at different times. For this study, five stages of model building process have been adopted (Sterman, 2002). First step is to identify the problems and goals for the study and to organize historical information into a reference mode. The reference mode leads to formulation of dynamic hypothesis in terms of causal feedback loop existing among the decision elements in the system. In second step, a formal model is constructed which incorporating the dynamic hypothesis along with other structural details of the system related to the problem being addressed. After a model is formulated, simulation aided by computer then can be done. Thus, the fourth step is to test the model until it satisfies the purpose. Final step is to design and evaluate policy for improvement. Powersim ® software has been used for constructing loop diagrams, simulation and policy analysis in this research.

Dynamic modeling of contractor's and subcontractor's trust requires mental data (qualitative data) to gather at different stages of model building. However, expert opinions are also required for several times such as to identify and clarify the problem, to develop the formal model and to validate the model.

The study has been conducted in Thailand in a contractor company, which generally performs the work by subcontracting their work. Information has been obtained through personal interviews of contractor's site manager and some selected subcontractors from two ongoing projects, Project A and Project B. Both of the projects were related with same type of construction work (villa or resort) on the top of hill beside the sea but the client was different. Most of the subcontractors were from the local area. During data collection, 90% of the work of project B and 60% of the work of project A had been completed. Unstructured interview have been conducted that addressed topics related with trust issues such as background information of both subcontracting and contracting firm, practices related to bidding on subcontracted work, practice related to problem in current project progress and practice related to the general contractors' administration of subcontracts.

Trust reference mode has been plotted from the historical and present time data from the view point of contractor and subcontractors. The trust behaviour over time has been plotted in a scale of 0% to 100 % with a range of very poor trust relationship to very good trust relationship by the interviewees.

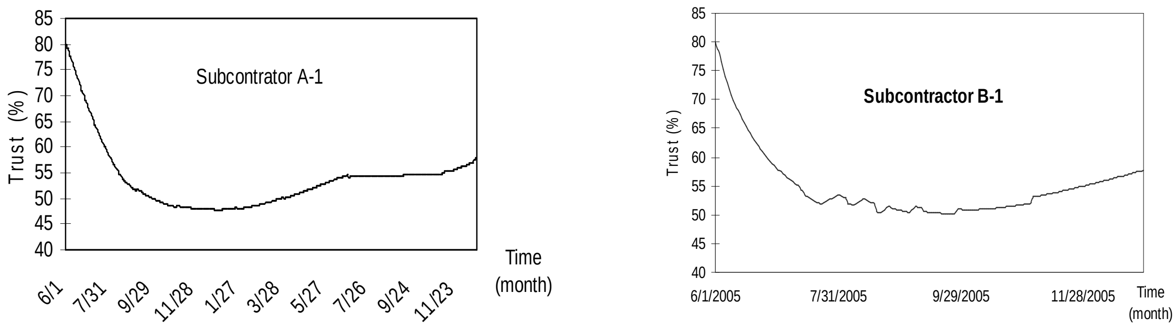


Figure 2: Reference mode (A-1: Project A; B-1: Project B)

Dynamic Hypotheses

The knowledge gain from the literature review, information gathered from the real system and interviewed data has helped to formulate key feedback loops regarding development and diminish of trust between main contractor and subcontractor way of collaboration.

As the main concern of this study is related with observation of trust pattern either developing or diminishing with respect to project progress, thus knowledge based trust and system based trust put greater contribution in developing hypothesises. According to literature, knowledge based trust can be attained with the maturation of relationship which is influenced by performance and permeability and is affected by institutional framework. Therefore to get a better understanding about the causal relationships the feedback loops has been classified in the following three major categories:

- Feedback loops concerning permeability (PL1, PL2 and PL3) (Figure 2)
- Feedback loops concerning performance (PF1, PF2, PF3 and PF4) (Figure 3)
- Feedback loops concerning system based trust (SB1, SB2 and SB3) (Figure 4)

These causal-effect relationships according to their major groups are described in the following sections.

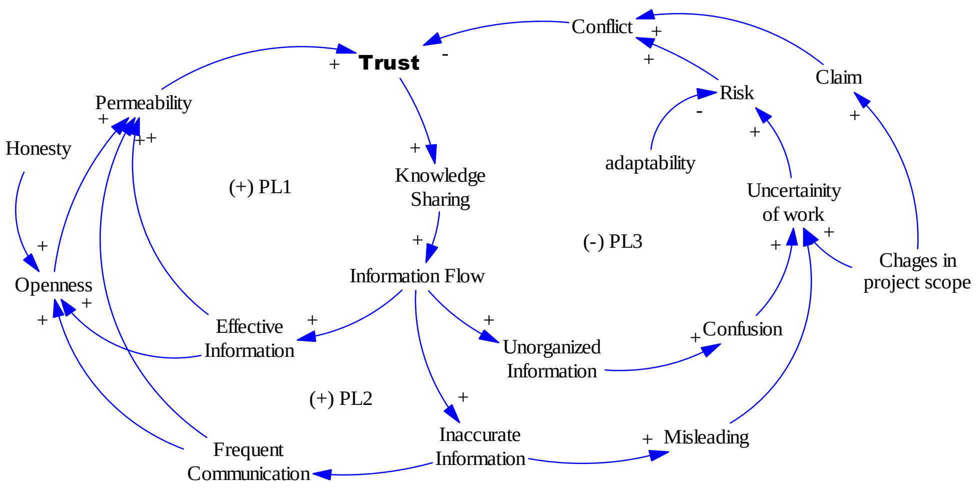


Figure 3: Feedback loops concerning permeability

Permeability involves being open in sharing and receiving information and dealing with others in a straightforward manner (Wong and Cheung, 2005). It represents the level of transparency of the relationship among the contractual parties. *Loop PL1:* Knowledge sharing and trust can interact in a collaborative process. According to Gherardi and Nicolini (2000), knowledge “resides on a team of individuals sharing common experiences”. Working together builds knowledge of one’s own work as well as knowledge of the other’s work; as one knows the other better, it is possible to trust the other more; and as trust is built, parties share more information, making their collaborative work more effective. Effective and sufficient information flow represents openness as well increase permeability. Openness is affected by honesty and provides an access to a greater number of information sources, forces the development of mechanisms that facilitate the information. *Loop PL2:* According to Lau (1999), it is not easy to tell whether trust leads to communication or communication leads to trust. In most of the case, the accuracy rates of information provided by the subcontractors are quite low. This inaccurate information requires more communication as to continue the work. Consequently, open and frequent communication and open-door policies to each other, results from willingness of partners to create transparency in relationship. *Loop PL3:* The inaccurate and unorganized information mislead and create confusions to the decision makers to make an effective decision. However, delayed decision or situation ineffective decisions stimulate work uncertainty as well as risk. The higher the uncertainty or risk, the more a cohesive working relationship is required (Lau, 1999). This allows solving problems in an efficient way, which enhances the adaptability of subcontractor. Moreover, adaptability of subcontractor may help the contractor to manage the risk together. Frequent changes of project scope further increase the uncertainty of work as well as additional work, are likely to generate more claims from subcontractor. Consequently, risk and claim can generate conflicts between the parties. The impact of conflict resolution can be either productive or destructive (Mohr and Spekman, 1994). Such conflict resolution techniques as coercion, confrontation, and outside arbitration are counterproductive and fail to reach a win-win situation often generate distrust between the parties. However, problem solving and compromising attitude bring trust among the parties. Thus, working through the conflict may increase trust. When it gets out of hand it will destroy trust.

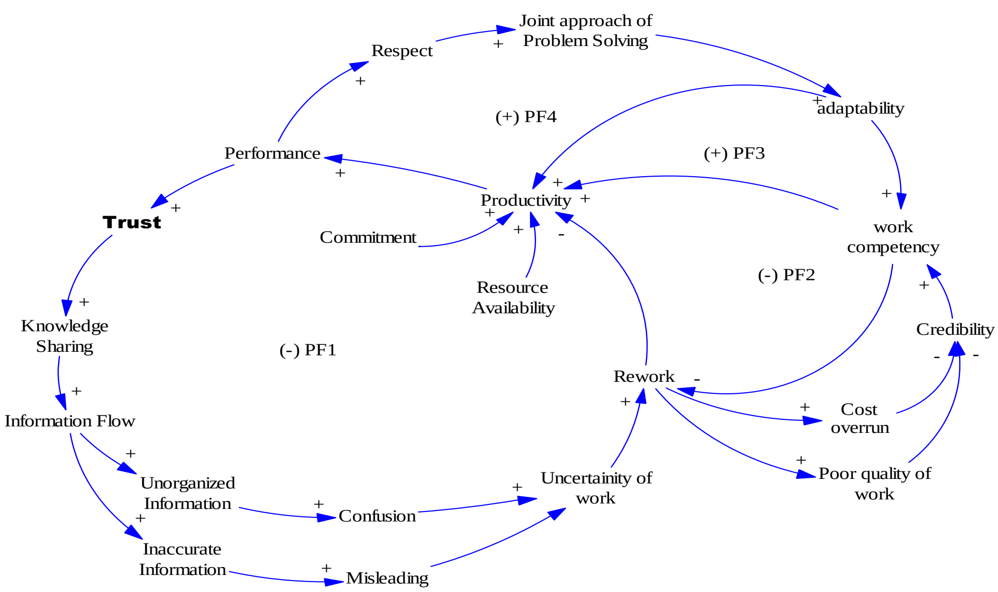


Figure 4: Feedback loops concerning performance

The team members of project will trust each other if both their “behaviours” and “outcomes” are competent. Productivity, work competency, adaptability and rework produce greater influence on performance as indicated in Figure 3. *Loop PF1:* The more uncertain the work, the higher will be the possibility of rework. Rework has a negative effect on productivity. However, more commitment and resource availability increase the productivity level. Alternatively, higher productivity means high performance which has a greater impact on developing trust level. *Loop PF2:* Reworks very often generate poor quality of work and cause cost overrun. Poor quality of work and cost overrun has negative impact on subcontractor’s credibility as well as deteriorate its competency. Moreover, lack of competency causes more rework. Conversely, work competency positively stimulates productivity level. The higher competency level of parties represents high management competency, technical skills and stable financial condition of the parties. *Loop PF3, PF4:* Higher performance of subcontractor attains mutual respect between contractor and subcontractor. Furthermore, this mutual respect enhances them to solve any problem jointly rather than doing it individually. Joint approach of problem solving facilitates the subcontractor to be adaptable to the contractor’s policies and working in unfavourable environment. Moreover, during joint problem solving, parties gather together and share with each other their own views on the conflict issues and their resolving tactics. Such a high level of participation among parties encourages them to keep a commitment to the mutually agreed solution. In addition, adaptability increases their competency as well as productivity.

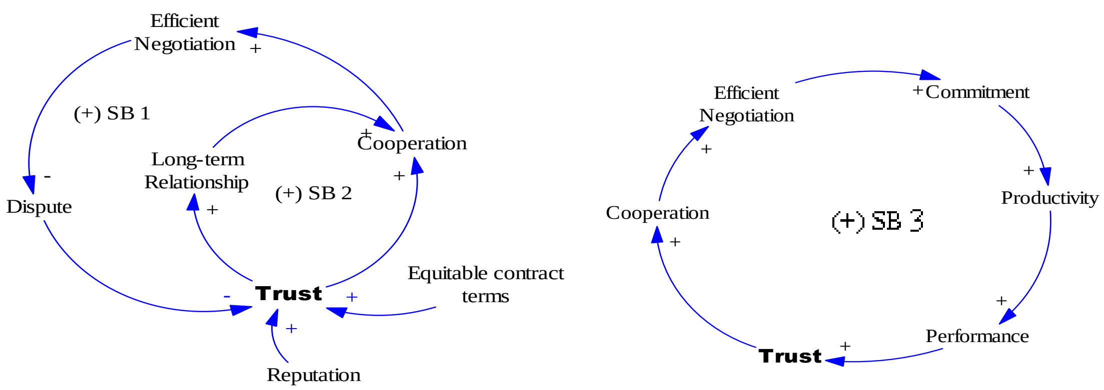


Figure 5: Feedback loops concerning system based trust

Satisfactory contract terms, negotiation process, commitment towards work and dispute solution process normally affect the system based trust as found in literature review. *Loop SB3:* Trust can stimulate a better cooperation. During a negotiation process, a cooperative attitude result efficient solution of problems. Efficient negotiations further motivate the subcontractor to be more committed to their work and consequently increase productivity as well as performance. Develop positive attitude towards other and commitment to the work responsibility; establish a climate of trust and confidence and a sense of responsibility for achieving goal (Lau, 1999). *Loop SB1 and Loop SB2:* Efficient negotiation helps to reduce the conflict between the parties; otherwise it will reach a level capable of generating dispute by eroding trust. On the other hand, companies with higher reputation are more trustworthy as they (contractor company) do not want to lose their valuable asset (Gambetta, 1998). Equitable agreements or contract terms enhance contracting parties establish trust and sustain cooperation since their perceived benefits are secured (Wong and Cheung, 2005). If the contract parties are able to maintain their trustworthiness at high level during the project and up to the end of project, this establishes long-term relationships between them. This long-term relationships among parties will also lead to trust.

Formulation of System Dynamics Model

The complex system described in the reference mode and dynamic hypothesis has been developed in the form of a system dynamics model in Powersim® software, based on the model boundary as shown in Table 1. Due to the level of details covered in the system boundary, the model used us somewhat large. Further details and a machine readable listing of the model written in Powersim® are available from the writers on request.

Table 1: Model Boundary

Exogenous	Endogenous	Ignored
Equitable contract agreements, Management competency, Financial status, Technical skills, Honesty, Reputation, Resource availability, Negotiation process, Changes in project scope, Past experiences	Knowledge sharing, Communication, Openness , Information flow, Permeability , Respect, Commitment, Problem solving, Work uncertainty, Rework, Work competency, Adaptability, Productivity, Performance, Risk, Claim, Conflict, Dispute, Relationship, Cooperation	Dispute Resolution technique, Organizational structures, Compatibility

Model boundary shows the primary features included (endogenous), assumed (exogenous) and excluded from the model. The exogenous factors such as past experiences, management competency, technical skills and the reputation of the organization act as the bases of calculative trust at the early stages of project. Equitable or satisfactory contract terms affect system based trust. On the other hand, honesty, changes in project scopes, these external factors are experienced during project life which has greater impact on knowledge based trust development. Mostly, all of the endogenous factors affect on knowledge based trust as this type of trust has developed during working together. The origin of this type of trust can be measured under two headings such as permeability and performance. Permeability is measured by the degree of willingness of knowledge sharing, openness, information flow and frequent communication. Conversely, respect, commitment, problem solving attitude, work competency, and adaptability, these endogenous factors has positive impact on productivity as well as performances improvement. During negotiation, the way of the parties to negotiate (problem solving, forcing) has greater impact on problem or conflict resolution as the forcing attitude during negotiation may arise dispute between the parties and the problem solving approach may increase the satisfaction of both parties as well as improving trust level. On the other hand, the organizational structure is ignored as vertical trust is not significant in developing trust between contractor and subcontractor. As contractor and subcontractor are assumed to work in the same region thus differences in compatibility is not included in the model boundary. Moreover, adoption of detail dispute resolution techniques is also overlooked here.

The model is preliminarily divided into three sectors as permeability, performance and system; depend on the model boundary, literature review, information gathered from the real system, and interviews conducted with decision makers in the organization. Each sector can be further divided into sub sectors or sections. These subsystems and sectors are interrelated in the form of shared parameters. Information flow, openness and communication can be grouped into permeability subsystem because they have a special interrelation. When a project work is performed, rework which in turns effect credibility of performer by reducing their work competency. Resources consist of manpower, equipment, and material. Productivity is affected by resource availability, work competency, commitment, rework and adaptability and all of these are grouped into a subsystem—performance. Equitable contract terms, negotiation process, conflict and dispute resolution process are grouped into the other sub system- system.

Model Behaviour and Validation

As it is widely stated among modellers, "there is no correct model but there are useful models!" The closer the model represents a real world system, the more accurate decisions can be made by the users. Hence, Forrester and Senge (1980) define validation for system dynamics models as a "process of establishing confidence in the soundness and usefulness of a model." In this paper, both structural and behavioural validation tests have been performed for building confidence in the model. The useful time period of the model simulation has been vary from subcontractor to subcontractor for both of the projects. The results from the baseline of the model are shown in Figure 6. It is seen from the figure that the model replicates the reference mode (Figure 2) very well.

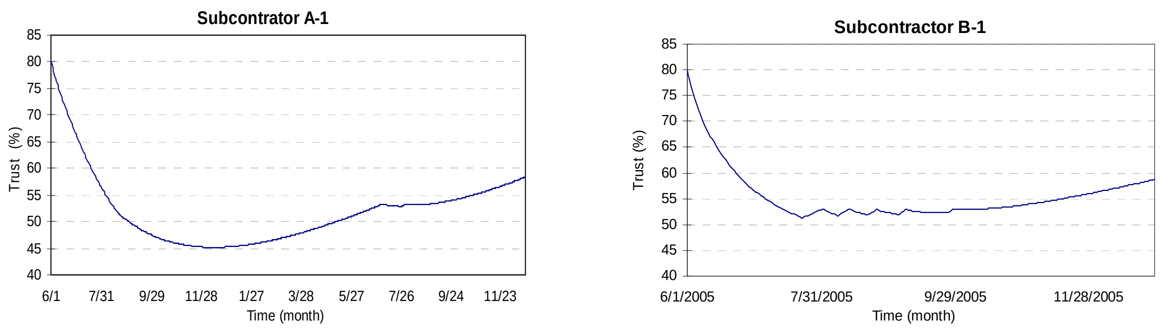


Figure 6: Base run of model (A-1: Project A; B-1: Project B)

In modelling trust, the initial value of each parameter has been established based on the interview from the selected project members. For each important relationship and major assumption, sensitivity analysis has been made. In the sensitivity analysis, the variables that are described with a single numerical value at any time and more complex variables such as task dependencies are investigated. Each simulation with the changed parameters and changed slope of the non linear relationships has been compared with the base run simulation. This extensive process of simulation comparison showed that the model is structurally and behaviourally valid.

Formulation of Sustainable Policies

The prime objective of this research is to formulate of an effective set of policies for increasing trust level as well as improved organizational performance between contractor and subcontractor. Extensive model simulations are made in order to identify a practically effective and implementable policy. Three sets of policies are selected here for an improved and sustained behaviour as shown in Table 2. The policies are generic. From the simulation result (Figure 7), it is concluded that integrating subcontractors into semi-project partnering approach, is a very effective way for stimulating trust level. Partnering aims to reduce the adversarialism which is said to be typical in the industry and which has confounded previous attempts to encourage better integration and cooperation between contractual partners (Kumaraswamy and Mathews, 2000).

Table 2: Policies Considered and their Results

Policy goal	Policy	Remark
Increasing performance as well as productivity, reducing claim and risks	Best value contracting (Policy 1) (Thomas, Skitmore and Chung, 2003)	Shifting from ''Price Only'' single criterion to multiple performance criteria.
Improving collaboration and quality of human resources.	Management of Subcontractors as Internal Team (Policy 2)	Prevents the sense of alienation of the contracting parties
Maximizing resource sharing and increasing commitment	Semi-project partnering (Policy 3) (Kumaraswamy and Mathews, 2000)	A limited form of "competitive" tendering is applied

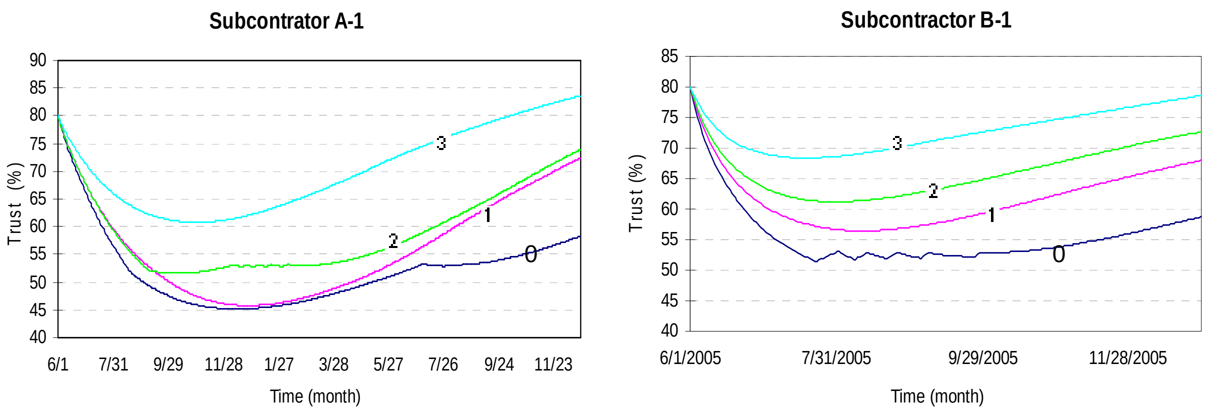


Figure 7: Comparative behaviour of model after implementation of three policies [A-Project A; B-Project B]; Reference – 0; Policy 1-1; Policy 2- 2; Policy 3- 3;

CONCLUSION

As trust is path dependence phenomenon, thus it is extremely difficult to capture the behaviour of trust in a construction project relationship at a holistic view. Therefore, by adopting system dynamics approach, a generic trust model has been formulated in order to facilitate the contractors and subcontractors in understanding trust related issues. This model may help them to attain high level of performance and competitiveness of the construction industry and can bring long term benefits during their contact period. According to the model, three trust factors have significant enhancement on contractor and subcontractors' trust building: participants' performance, participants' permeability and system based trust.

Best value contracting, management of subcontractors as internal team and semi-project partnering-these three policies are suggested for improving trust level bases on the case studies. As the interview companies resolve their dispute by mutual understanding thus impact of several dispute arising in large scale projects and their detail resolution techniques such as litigation, arbitration has not been included here. Thus, the research area could be extended in future for the investigations of detail modelling of contractual agreement.

REFERENCES

Dainty, A.R.J., Briscoe, G. H., and Millett, S. J. (2001) Specialist contractor perspectives on supply chain alliances. Construction Management and Economics, 19, 841-848.

Forrester, J. W., and Senge, P. M. (1980) Tests for building confidence in system dynamics models. TIMS studies in the Management Sciences, 14, 209-228.

Gambetta D. (1998) Trust: making and breaking cooperative relations. New York: Basil Blackwell.

Gherardi, S., and Nicolini, D. (2000) The Organizational learning of safety in community of practices. Journal of Management Inquiry, 1.

Hinze, J., and Tracey, A. (1994) The contractor–subcontractor relationship: the subcontractor's view. Journal of Construction Engineering and Management, 120(2), 274–287.

Kumaraswamy, M. M., and Mathews, J. D. (2000) Improved subcontractor selection employing partnering principle. Journal of Management in Engineering, ASCE, 16(3), 47-57.

Lau, H. L. (1999) Trust as a human factor in management in general and construction. In S. O. Ogunlana (Eds.), Profitable partnering in construction procurement (pp. 117-125). London: E & FN Spon.

Luna-Reyes, L. F., Cresswell, A. M., and Richardson, G. P. (2004), "Knowledge and the development of interpersonal trust: a dynamic Model", available at: http://csdl.computer.org/comp/

Mayer, R. C., Davis, J. H., and Schoorman F. D. (1995) An integrative model of organizational trust. Academy o f Management Review 20 (3), 709-734.

Mohr, J., and Spekman, R. (1994) Characteristics of partnering success: partnering attributes, communication behaviour, and conflict resolution techniques. Strategic Management Journal, 15, 135-152.

Ogunlana, S. O., Lim, J., and Saeed, K. (1998) DESMAN: A dynamic model for managing civil engineering design projects. Computer Structure, 67(5), 401–419.

Rosseau, D. M., Sitkin, B., Burt, R. S., and Camerer, C. (1998) Not so different after all: a cross-discipline view of trust. Academy of Management Review, 23(3), 393–404.

Sterman, J. D. (2002) System dynamics: Systems thinking & modeling for a complex world, MIT: Cambridge, MA.

Thomas, Skitmore, M., and Chung, W. F. (2003) Ten basic factors to identify suitable subcontractors for construction projects, CIB TG 23 International Conference, October, Hong Kong.

Wong, P. S. P., and Cheung, S. O. (2005) Structural equation model of trust and partnering success. Journal of Management in Engineering, 21(2), ASCE, 70–80.

CONTROL MEASURES OF ACCIDENTS: NIGERIAN BUILDING PROJECTS' CASE.

Oladiran, Olatunji Joseph.
University of Lagos, Akoka Yaba, Lagos, Nigeria.
tungybox2000@yahoo.com

Ogunsanmi, Olabode E
University of Lagos, Akoka Yaba, Lagos, Nigeria.
bode_ogunsanmi2004@yahoo.co.uk

Soyingbe, Aliu A.
University of Lagos, Akoka Yaba, Lagos, Nigeria.
Dodoaliu123@yahoo.com

ABSTRACT:
This study explores the various safety and control measures (SCM) of accidents in building projects to minimize accidents' occurrence and consequent waste generation. A research methodology, consisting of a literature review and a field study were used to achieve the research objectives. The field survey involves a designed questionnaire that was administered through convenience sampling technique within Lagos State and descriptive analysis tools were used for the analysis. The field survey reveals different control measures in place and their rate of usage on building projects. On the other hand, the literature survey sheds light on the types of accidents on building projects and their respective control measures with methodologies for accidents' preventions. Reccomendations based on the findings of the two surveys are outlined in the paper.

KEYWORDS: accidents, SCM, waste minimization.

INTRODUCTION.

Mwombeki (2005) defines accidents as an unplanned and unexpected occurrence, which upsets a planned sequence of work; resulting to loss of production, injury to personnel, damage to plant and equipment and eventually interrupting production flow. However, Sotire (1992) defines control measures as an act of limiting or making something to happen in a particular way, stop something from spreading, going out of hand or getting worse. Similarly, Smith *et. al* (1999) identify safety in construction as the process or way of protecting the health and life of those who build, operate, maintain and demolish engineering works; and others affected by those works.

In this regard, Takala (2005) cited in International Labour Office (I.L.O) (2005) argues that the global number of accidents in the construction industry is unquantifiable, due to lack of information and also more hazardous than any other economic sector. Accidents on construction sites, whether minor or fatal, could result to loss of resources i.e. wastes and make the construction industry a deadly working place. Accidents on building sites are inevitable, but could be controlled to prevent minor or serious-consequences on the workers. Thus, control measures of accidents to ensure safety of workers and minimize accident-related waste on sites is essential. Hence, the ultimate aim of this research is to minimize accidents' occurrence and waste on sites. The specific objectives are to identify types of accidents on sites and their control measures, to identify accidents' prevention methodologies, to examine the frequency of usage of control measures on sites and to compare the perceptions of construction organizations on the rate of usage of the control measures on sites.

HYPOTHESIS OF THE STUDY.

A null hypothesis was postulated for the study which is *"there is no significant difference between construction organizations on the rate of usage of safety measures on construction sites."*

LITERATURE SURVEY.

Accidents and Preventions' Methodologies.

According to Lubega *et. al* (2001), the important characteristics of every construction project are the cost, duration, quality and safety of such project. They further argue that there has been a greater emphasis on the first three aspects, at the expense of safety. A lot of people have been exposed to risk situation on building sites, resulting in a high chance of accidents as a result of lack of adherence or inadequate provision of safety requirements. This implies that, a lot of contractors in the building industry are much more concerned about the cost, time and quality of the project delivery but are less concerned about the safety of the workers, who eventually are the facilitator of the project delivery to cost, time and quality. In addition, construction works is by nature a complex and in rapid changing environment in which many different people interact with highly energized equipments, massive material and often-significant heights in a loosely coordinated fashion. As a result of this constant movement and process of carrying out their work, the potential for injuries occurring at any location on the site at any particular time is always high. However, Gangwar and Goodrum (2005) mention that control of accidents on any building site is not the responsibility of just one person, but of everyone that participate in the production of such projects on site. On the other hand, Mwombeki (2005) enumerates four preventive approaches for accidents:

Safety Plans.

Management of any construction firm has the responsibility of developing a comprehensive and written safety programme that is performance oriented. The information should include the basics of personal protective equipments, the proper use of tools and power equipments, safe work practice, company policy on safety, safety responsibilities, emergency procedure, e.t.c. This document must be made available to every worker on site and adherent to it must not be compromised. The responsibility of the safety personnel shall be to draw up a safety plan, setting out the rules applicable to the construction or building site, and shall make any adjustment to the plan, ensure effective distribution and use of safety equipment.

Safety Training and Meeting.

Safety training is an essential part of any safety and health programme. Safety personnel and site workers should be trained in hazard identification, control and method of encouraging safe practices. The safety training and meetings must emphasis the project's safety requirements, review past activities, plan ahead for new operations, discuss the causes of accidents on site and ways of preventing future occurrence. This training should be provided in the language well understood by the workers (Hassanein and Hanna, 2007).

First Aid and Medical Arrangement.

First aid facilities must be provided on site regardless of the size of the project and the number of workers on site. In case of any injury such as cuts, strips or trips; prompt treatment with first aid facility can help prevent further aggravation of such injury. The employer should be responsible for the provision of first aid facility and personnel at all time on site (Hassanein and Hanna, 2007).

Management Policy.

The type of management policy or commitment to safety at workplace is very essential to the prevention of accidents. The various commitment of construction management are in drawing up of an effective safety plans, provision of protective equipments for all site workers and personnel, encourage safe working habits, incentives for safety and regular review of accident prevention or safety programmes.
All of these accident preventive measures and many more are required on site to effectively prevent or reduce the occurrence of accident on building sites.

In the same vain, Tappin *et. al* (2001), Health and Safety Executive (H.S.E.) (2007) and Occupational Safety and Health Administration (O.S.H.A.) (2005) outline preventive measures as:

- Wearing clothes that are appropriate to the work and weather condition on site.
- Wearing of hand gloves.
- Wearing of work traction boots at all times on site.
- Wearing of hardhats or helmet at anywhere on site.
- Provision of eyewear or goggle for welding purposes e.t.c.
- Constant inspection and assessment of equipments, plants, tools and other site materials before use.
- Organizing effective safety training for all site workers and personnel whether on site or off site.
- Provision of effective first aid facility and personnel on site.
- Provision of barriers, signs or reflector around dangerous areas on site (e.g. barrier around trench and so on)

Types of Accidents and Control Measures on Building Projects.

Various types of accidents and their respective control measures from literatures are:

Scaffold Accidents.

Fall of person from scaffold and collapse of scaffolds has constantly been the number one killer in Hong-Kong construction industry (U.S Department of Labour, 2005). Between 2000 and 2004, the department shows that fatal accident arising from bamboo scaffold and working on platform have accounted for nearly half of the total number of fall-from-height fatal accidents in the period. Similarly, O.S.H.A (2005) reports that hazards occur due to improper erection of scaffold. They add that 4,500 injuries and 50 fatalities from 2.3 million construction workers annually can be prevented with proper erection and use of scaffolds.

Various ways of controlling scaffold accidents on sites according to O.S.H.A (2005); H.S.E (2004); and McCann and Paine (2002) are:

- Scaffold must be checked to be sound, rigid and sufficient enough to carry its own weight plus four times the maximum intended load without settling or swaying.
- Scaffold must not be erected, moved, dismantled or altered except under the supervision of a competent person.
- Unstable objects such, as boxes, loose bricks or concrete blocks must not be used to support scaffold or planks on scaffold.
- Scaffold should be used with safety net and belt especially when use for works at height.
- Scaffold accessories such as braces, brackets, trusses or screw legs that are damaged or weakened from any cause must be immediately repaired or replaced.
- A competent person must inspect the scaffold and re-inspect at designated intervals.
- Scaffold must be at least 10 feet away from any electric power lines at all time to avoid any forms of electrocution or contact with live cable.

Accident Due To Slip, Trip and Falls.

Tappin et. al (2004) report that an increase in international and national attention is being placed on occupational strips, trips and falls (STF) as the extent of the problem is recognized. This growing interest reflects an understanding that strips, trips and falls are preventable in lieu of daily occurrence on building sites. More than a million people suffer from these accidents annually. In the same vein, Hinze and McGlothlin (2002) report that slips, trips and falls account for 15% to 20% of all workers' compensation cases; with older ones having higher percentage of falls compare to younger ones. This is as a result of the fact that, regardless of the kind of work to be done or the position of such work, slip or trip falls can occur at any place or point on the construction site, thus, the reason for its control to prevent casualty.

Slip and trip injury could be controlled on sites by the following ways according to Tappin et al (2001), H.S.E (2007) and O.S.H.A (2005):

- The floor must be kept clean and dry always.
- Immediate cleaning of spillage on site.
- Immediate disposal of waste materials from site.

- Avoid causing trailing cables or littering binding wires.
- Constant wearing of suitable and traction footwear on site.
- Immediate removal of any obstructions on the walk way on site.
- Keep the site clear of any obstacle such as debris, broken blocks or concrete.

Crane Accident.

Factors associated with mobile cranes failure include support failure, failure to use outriggers, crane failure or collapses and rigging failure. Though, the collapse of tower cranes is rare, accidents and near misses do occur. Failure of any part of the crane or load carry systems are likely to cause serious accidents, with both crane operators, site personnel and general public involved (Skinner et. al, 2006). Similarly, O.S.H.A (2005) posits that significant and serious injuries of fatality may occur if cranes are not inspected before use and if they are not used properly. Often, these injuries occur when a worker is struck by an overhead load or caught within the crane's swing radius. It therefore implies that, crane accidents are associated with erection or assembling, usage, dismantling and supervision or inspection and are major treat to life of workers on any building site.

The ways of curbing crane accidents on building and construction sites are stated below according to Neitzer et. al (2001), O.S.H.A (2005) and Skinner et. al (2006).

- Checking of all crane control to ensure proper operation before use.
- Inspection of wire rope, chains and hook for any damage.
- Ensuring that the load does not exceed the crate rated or carrying capacity.
- Full check of all rigging prior to use.
- Fully extend of outriggers before full operation.
- Never move a load over a worker.
- The load must be raised few inches to verify balance and effectiveness of the brake system.
- Watch for overhead electrical distribution and transmission lines and maintain a safe working clearance of at least 10 feet from energized and electrical lines.

Ladder Accident.

Ladder falls or accidents increased significantly in 2001-2005, which gives a significant rise in serious injury from ladder falls (Mitra et. al, 2007). This was shown in their investigation of 4553 site workers presented to Victorian Hospital with injuries from ladder fall. Of these, 160 patients were classified as major trauma case. A fall from height, more than one metre, was the most common mechanism of injury accounting for 59% of the total. It was also established that about 20% of ladder-related falls greater that one metre and major trauma cases occurred while people are working on site. Mitra et. al (2007) state further that, despite the knowledge of the dangers of falls from ladders, there has being a significant increase in the number of casualties from ladder falls which resulted into broken limb, fracture and bruises on building sites.

The control measures according to Mitra *et al* (2007) and O.S.H.A (2005) include:

- The use of correct ladder for the task or job.

- Ladders are ensured to be long enough to safely reach the work area without unnecessary reaching to the sides.
- Avoidance of the use of ladder, especially metallic, near electrical work and overhead lines.
- Never load ladders beyond the maximum intended load or beyond the manufacturer's rated capacity.
- Mark or tag (do not use) damaged or defective ladders for repair or replacement to prevent their usage.

Electrocution and Electrical Accidents.

McCann and Paine (2002) reveal electrical and electrocution death on site between 1992 and1998 that, out of the 1,019 deaths (146 cases yearly), 1,002 are electrocution and 17 are electrical arc flashes on sites. It implies that electrical works involving the use of electricity on site is very risky. He further shows that most people affected by electrocution or electrical injuries are electrical workers (i.e electricians; electrical power installers and repairers; their apprentices and their supervisors). These workers had one-third of the electrical deaths or electrocution followed by general labourers on site. In addition, Taylor et. al (2002) also conclude that the majority of electrocution death resulted either from direct or indirect contact with power lines; but having the power de-energized in close proximity to building sites and other settings, where there are potential for power line contact reduces this hazard. Where not possible or practicable to de-energize lines, adequate clearance must be maintained or lines encased in insulated sleeves to prevent electrocution of whatever kind.

The control measure as highlighted by McCann and Paine (2002); Taylor et al, (2002), Cawley and Homce, (2001) include:

- All electrical workers must wear a non-conductive hand glove at work.
- De-energizing of electrical lines in proximity to construction sites
- Ensuring that all cables are in proper conditions before switch in on the machine.
- Adequate provision of personal protective equipments on site

RESEARCH METHODOLOGY.

In the light of the afore-mentioned objectives, a research methodology consisting of a literature survey and field survey is designed to achieve them. Firstly, the literature survey is used to identify types of accidents on sites and their control measures; and accidents' preventions methodologies. Second, a field survey involving 30 building sites in Nigeria to investigate the control measures in place and frequency of usage on sites; and to compare the perceptions of construction organizations on the rate of usage of the control measures on sites. The field survey is based on 30 returned questionnaires out of the 45 copies that were administered through accidental sampling technique within Lagos State. The respondents were mostly site engineers and safety officers (where available) that are undergoing construction works in Lagos.

The questionnaire contains the role of the organizations in the construction industry and their names, the respondents' profession, position, academic and professional qualifications, years of experience. The questionnaire also contains a list of control measures selected from the works of Tappin *et. al* (2001), H.S.E. (2007),O.S.H.A. (2005), McCann and Paine (2002), Taylor *et al*, (2002) and Cawley and Homce, (2001).Their frequency of usage is measured subjectively on a likert scale using 1 to represent never, 2 for sometimes and 3 for always. The data collected from the questionnaire were analyzed using descriptive analyses tools such as frequency, percentage, mean and Analysis of Variance (ANOVA) to achieve the research objectives.

FIELD SURVEY.

Control Measures of Accidents on Sites.

Table 1 shows the response to the provision of safety control measures of accidents on sites. It can be observe that 26 of the respondents (76.5%) claimed to always provide control measures of accidents to workers on site, 8 respondents (23.5%) provide it sometimes while none claim to never providing it. This shows that, most construction organization know the importance of controlling or preventing occupational accidents among workers on site and also valued the life of their workers.

Table 1: Provision of Control Measures of Accident on sites.

Provision of control measures on sites	Frequency	Percent
Always	26	76.5
Sometimes	8	23.5
Total	34	100.0

Table 2: Different Control Measure of Accidents used on sites.

Control Measures	N	Rate of Usage			Mean Value	Rank
		3	2	1		
Provision of First Aid Facility	34	28	6	-	2.82	1.5
Provision of Helmet or Hard Hat	34	28	6	-	2.82	1.5
Provision of Protective Cloth	33	26	7	-	2.79	3
Provision of Traction Boots	34	26	8	-	2.76	4.5
Provision of Hand Gloves	34	26	8	-	2.76	4.5
Use of Signs, Guides, Caution and Reflector	34	24	9	1	2.68	6
Provision of Goggle or Eye wear	33	22	11	-	2.67	7
Use of Protective Equipments	31	12	19	-	2.39	8
Use of Safety Belt	32	15	13	4	2.34	9
Use of Safety Net on Scaffolds	30	11	16	3	2.27	10

Note: N represents total number of respondents, 3 represent Always, 2 represent sometimes, 1 represent never.

Table 2 shows the different control measures of accidents used on building sites as reported by the respondents. It can be shown from this Table that hardhat and first aid facility are often used as control measures of accidents on site. Hard hat or helmet are provided to prevent been struck on the head by falling objects or materials while first aid services are provided to give a first hand treatment to any injury sustained on site, so as to limit its fatality before proper hospital attention is given. Protective cloth, traction boots and hand gloves follow these descendingly. Traction boots are provided to prevent any step-on or slip accident while hand gloves are provided to protect the hand from direct contact with energized cable or circuit, sharp objects or materials, etc. Next are usage of signs, guides, caution and reflectors to give signal of danger ahead to any one approaching; eyes wear; and protective equipment. This shows that protective equipment is not often used on site as control measures of accidents. Provision of safety net on scaffold is least used among other measures as control measures of scaffold accident. Though, it is used to prevent falling-off of workers, tools or materials from a scaffold, its usage are not common on site in Lagos state. Despite the varying of usage of these measures, all of the respondents signified all the control measures as a means of controlling accidents on sites.

Table 3: ANOVA of different organizations on the usage of control measures on sites.

Control Measures	Sources Variation	Sum of Squares	Df	Mean Square	F cal	F tab, X=0.05	Sig.
Provision of Traction Boots	Between Groups	1.589	1	1.589	11.226	4.17	S
	Within Groups	4.529	32	.142			
	Total	6.118	33				
Provision of Goggle or Eye wear	Between Groups	3.098	1	3.098	22.680	4.17	S
	Within Groups	4.235	31	.137			
	Total	7.333	32				
Provision of Helmet of Hard Hat	Between Groups	.412	1	.412	2.913	4.17	NS
	Within Groups	4.529	32	.142			
	Total	4.941	33				
Provision of Hand Gloves	Between Groups	4.281	1	4.281	74.594	4.17	S
	Within Groups	1.837	32	.057			
	Total	6.118	33				
Protective Clothe	Between Groups	2.240	1	2.240	21.209	4.17	S
	Within Groups	3.275	31	.106			
	Total	5.515	32				
Safety Net.	Between Groups	2.912	1	2.912	9.106	4.19	S
	Within Groups	8.955	28	.320			
	Total	11.867	29				
Use of Safety Belt.	Between Groups	1.059	1	1.059	2.243	4.17	NS
	Within Groups	14.160	30	.472			
	Total	15.219	31				
Fall Protective Equipments.	Between Groups	.093	1	.093	.371	4.18	NS
	Within Groups	7.262	29	.250			
	Total	7.355	30				

Table 3's continuation

Provision of First Aid Services	Between Groups	1.095	1	1.095	9.111	4.17	S
	Within Groups	3.846	32	.120			
	Total	4.941	33				
Use of Signs, Guides, Cautions and Reflector.	Between Groups	3.182	1	3.182	16.265	4.17	S
	Within Groups	6.260	32	.196			
	Total	9.441	33				

The ANOVA result of the identified control measures of accidents on sites is as summarized in Table 3. The calculated F value is higher than the tabulated F value except for fall protective equipments, use of safety belt and provision of hardhat. Thus, all the construction organizations differ in their opinions on the frequency of use of the highlighted safety measures except for these three. It should be noted that the mean of the various organizations differ and hence their variance on some of them in Table 3 where F_{cal} is less than F_{tab} and the rejection of the null hypothesis (i.e. first-aid; protective cloth; hand gloves; signs, guides, cautions and reflectors; google or eye wear; safety belt; and safety net on scaffolds). On the other hand the null hypothesis is accepted for protective equipments, safety belts and hardhats or helmets.

CONCLUSION AND RECOMMENDATIONS.

The study reveals:

- The various types of accidents that exist on construction sites and their respective control measures.
- Several accidents' prevention methodologies.
- The types and frequency of usage of accidents' control measures on sites.
- That most of the construction organizations in Lagos, Nigeria know the importance of controlling the rate of occurrence of accidents on sites, as they all provides different control measures to workers on sites.
- That helmet, first aid services, protective clothes and traction boots are the most used safety measures on sites, though their usage differs from site to site.
- That there is significant difference between construction organizations in Lagos, Nigeria on the rate of usage of first-aid; protective cloth; hand gloves; signs, guides, cautions and reflectors; google or eye wear; safety belt; and safety net on scaffolds; while there is no significant difference on fall protective equipments, use of safety belt and provision of hardhat.

The study therefore recommends:

- First aid facility and attendant should be made available on site at all time.
- A safety officer, different from the site engineer or manager, should be employed on site to specifically plan, monitor and ensure adherence to control measures on site to minimize accidents' occurrence and waste.
- The use of safety equipments or control measures of accidents should be highly enforced on all workers on site.
- Warning signs, guides or reflector should be displaced where necessary on site.

REFERENCES.

Cowley, J.C. and Homce, G.T. (2001). Occupational Electrical Injuries in the United State (1992-1998) and recommendations for safety research. Journal of National Institute for Occupational safety and Health, U.S.A.

Gangwar, A.M., and Goodrum, P. M. (2005). The Effect of Time on Safety Incentive Programs in the U.S Construction Industry, Journal of Construction Management (October) 23: 851-859.

Hassaneiin, A,G., and Hanna, R.S. (2007). Safety programs in Large-Size Construction Firms in Egypt: Journal of SH& E Research, Vol. 4, Number 1. 1-33.

Hinze, J., and McGlothin, J.D. (2002). Prevention of fall from Elevations in the Constrution Industry. Poster Session at America Industrial Hygene Conference, San Diego, *CA.*

Health and Safety Executive (2004). Improving Health and Safety in Construction Phase 2 –Depth and Breadth, volume 5 – fall from height. Research Report 234.

International Labour Office (2005). Prevention: A Global Strategy. Promoting safety and Health at Work. The ILO Report for World Day for Safety And Health at Work, International Labour Office, Geneva, 2005. ISBN 92-2-117107-8.

Lubega, H., Kiggundu,M.B., and Tindiwensi, D. (2001). An investigation into the causes of Accidents in the construction Industry of Uganda.

Mwobeki, F. K, (2005). Occupational, Health and safety Challenges in construction Sites in Tanzania. 4th Triannial International Conference. Rethinking and Revitalising construction safety, health, Environmental and Quality, Port Elizabeth. S.A

McCann, M., and Paine, D. (2002). When is a fall not a fall? In Power Through Partnerships: 12th Annual Construction Safety and Health Conference, Proceedings (May 21-23, 2002, Rosemont, IL).

Mitra, B., Cameron, P. A., and Gabble, B. J. (2007). Ladder Revisited, The Medical Journal of Australia, 186 (1) 31-34.

Neitzel, R.L., Seixas, n.S., and Ren, K.K. (2001). A Review of Crane Safety in the Construction Industry. Applied Occupational and Environmental Hygiene, Vol. 16 (120 1106-1117

Occupational Safety and Health Administration (2005). Workers Safety Series (Construction). U.S Department of Labour. U.S.A

Sotire, O.O (1992). A Comparative Study of Safety Measures in Indigenous and Multinational construction Firms in Nigeria. M.Sc Thesis of the Department of Building, University of Lagos, Nigeria.

Skinner, H., Watson, T., Dunklry, B., and Blackmore, P. (2006). Tower Crane Stability, CIRIA C654 (2006), London.

Smith, L.J., Ian, J., and Ian, V. (1999). Increasing Construction Productivity through Total Loss Control. RICS Research Foundation. COBRA.

Tappin, D., Ashly, L., Moore, D., Parker, R., Hide, S., Bentlyel, T., and Legg, S. (2004). Slip, Trip and Falls In Residential Construction. Journal of Centre for Human Factors and Ergonomics, Volume 5, No 4, ISSN 1174-1234.

Taylor, A.J., McGwin, G., Valent, F., and Rue, L.W. (2002). Fatal Occupational Electrocutions in the United States. A Journal Of Occup Med, (52): 102-6.

U.S Department of Labour. (2005). Accidents in construction industry of Hong Kong (2000-2004). Accidents Analysis and Information Division, U.S Department of Labour.

CONSTRUCTION MANAGEMENT RESEARCHERS AS AGENTS OF CHANGE: BALANCING ACADEMIC PRIORITIES AND INDUSTRY IMPACT

Chris Harty
School of Construction Management and Engineering, University of Reading, UK
c.f.harty@reading.ac.uk

Roine Leiringer
School of Construction Management and Engineering, University of Reading, UK
r.leiringer@reading.ac.uk

The landscapes of construction management research and the construction sector are reflexively and recursively linked. Academic research uses real world contexts as sites for both developing research questions and conducting empirical exploration of them. In return for such access, research outputs are expected to have utility outside of academic domains. With this as a starting point, key questions relating the role of construction management research in supporting and shaping the construction industry are identified and discussed. We argue that questions should be raised regarding who the beneficiaries of research are supposed to be, how research is assessed by different constituents, and how impact can be assessed in situations where implications of research offers advantage to one constituency at the expense of another. We advocate an approach to conducting critical research, which goes beyond the critique of more instrumental approaches. It emphasises a commitment to collaboratively conducting research and producing research outputs which recognises the existence of, and engages with, multiple constituents across academic and practitioner communities.

KEYWORDS: **critical research; research impact; research quality; co-production**

INTRODUCTION

Consistently, construction management (CM) researchers find themselves facing numerous challenges and inconsistent demands. Industry seems to want easy, directly applicable solutions. Research funders want industry-engaged, problem-solving research on the one hand and publications in quality journals on the other. Their priorities and funding systems are forever changing in attempts to resonate with industry and government. Universities want quality dissemination of corpus knowledge through teaching and publication of cutting edge research that both addresses industry problems and maintains academic reputation. As a result, a wide range of research activities are undertaken, pure and applied, practical and abstract. The aim of this paper is to explore and discuss the role CM academics can play in shaping the construction sector. It highlights some of the issues involved in producing both relevant and rigorous research outputs.

To start the authors' own position in the debate regarding CM scholars' role in the way the sector is shaped and developed is briefly outlined. The discussion then goes on to address how researchers are forced to 'play the game' of balancing research priorities and how this game manifests itself in practice. Attention is then turned to the concept of research impact and in particular how well suited a performance indicator research impact really is. The point is made that priorities of firms are not always in harmony with those of academic researchers, or indeed with wider society. The argument is progressed by looking at alternative means of assessing research and why it is important to seriously consider who the beneficiaries of research are and who they should be. The role of critical research and the implications thereof are then discussed and the importance of assuring knowledge co-production in collaborative research efforts is introduced.

BACKGROUND STATEMENTS

Debates about the nature of useful knowledge have long since pointed to significant discrepancies between business and academia (cf. Starkey and Madan, 2001; Gulati, 2007). It is clear that conventions, expectations and interests are not easily commensurable across these two constituencies. Questions are typically raised concerning precisely who the knowledge products of research are useful to. Although there is a perceived need to reconfigure existing modes of collaboration wholesale transformations, such as moving from Mode 1 to Mode 2 knowledge production (cf. Gibbons *et al*. 1994), are neither universally desirable nor likely to occur. This is especially true given the intransigence of existing academic practices centred around peer-review and practitioners' equally firm focus on immediate problems and the pursuit of customised solutions. This gap is of course reflected in the large market for consultancy. As such the debate over the role of the academic scholar in shaping the construction sector is not trivial. Normative attempts to fix academia's role in the knowledge production chain invariably masks the reflexive and recursive interactions between bodies of existing practitioner and academic knowledge. Arguments based solely on relevance and rigour, although prevalent in many discussions, are of limited use. Simple dichotomisation between the two does little apart from pointing out the gaps between 'cutting edge' research and emerging problems within industry. It also hides some important questions about the role of academic research in supporting both industry and society in large and its positioning alongside other forms of enquiry.

It is clear that for CM scholars to impact on the construction sector there is a need to go beyond mere academic accommodation of, and orientation toward, industry needs. This involves challenging business expectations and requires a process of mutual re-alignment of aims and objectives. In particular, there needs to be clear recognition of the importance of producing academic insights that are relevant partly because they are not constrained by the immediate pressures of business. The issue of the role of CM research in shaping and developing an agenda for change in the construction sector must be grounded in the understanding that in practice, business and academia reflexively interact and influence each other. Priorities of firms are not always in harmony with wider society, yet CM research cannot escape its connections to both academic and industrial arenas. Simple opposition of academic and industry worlds, approaches and epistemologies neither fully captures the complexities of the issue, nor provides any headway into resolving it. A 'co-production' approach challenges the polarisation of requirements for academic quality against industry relevance, instead treating the two as emerging from collaborative engagement across boundaries. It represents a way of embracing and accounting for the multiple perspectives, approaches and requirements present within any research activity. It is through the explication and exploring of these boundaries that relevance and rigour and, ultimately, the broader 'usefulness' of research can be revealed.

PLAYING THE GAME

It is clear that the criteria that researchers need to align with are different between the landscapes of academia and industry. Within academia, established reputational sources of credibility are underpinned by a disciplinary structuring of knowledge and peer review. As such, judgements of academic outputs revolve around more or less internally consistent and relatively homogenous structures. The status of research within the private sector, on the other hand, is much more heterogeneous. Credibility is conferred by multiple external groups, including advisory panels, research funders, industry spokespersons and practitioners. In general, credibility comes from the practical implications of the research outputs. Particular importance is given to its utility as a resource for controlling, influencing or understanding business arenas. In this context relevance should not be seen as the narrow ability to solve industry problems. Rather, it should be judged on the basis of how well research outputs are able satisfy plural demands and gain credibility in different locations.

No doubt CM researchers are sensitive to the larger contexts in which sectors, businesses and other institutions, such as universities and research councils, operate. Measures are taken to position the research accordingly. For example, researchers have become accustomed to reviews which bemoan the performance of the construction sector. Reports and policy documents prescribing change are constantly circulated throughout industry and academia. In the UK the past decade or more has seen a persistent agenda for change deeply rooted in the mantra of modernisation (cf. Fernie *et al*. 2006). Reproduced and supported by government and industry leaders, it constantly reiterates the notion that research in the construction domain is only valid if it is industry centred and driven by the need for change. It is, therefore, only logical that it becomes rather tempting for researchers to recourse to this dominant discourse and position their research within this popular mantra for change.

It must be noted that CM researchers, in general, are very good at working with industry and getting research funding. Indeed, many researchers and research institutions pride themselves on developing and maintaining long-term relations with both research funders and industry partners. A useful way of conceptualising how researchers have adapted to these different criteria is positioning them as playing multiple games across different stakeholder arenas. It is through concerted efforts to play these multiple games that ideas and outputs are constituted and transformed as they go through processes of funding, researching and publishing. Some researchers do this better than others. Albeit, at times, this comes at the price of drifting away from the epistemic terrains of academic research (cf. Elzinga, 1985). The central problem remains, i.e. that the mechanisms through which credibility is endowed are not the same in the contexts of academia and industry. Arguments could indeed be put forward that successfully playing the game with policy and practitioner constituents comes at the expense of the academic rigour applied in the research.

IMPACT

Notwithstanding the above, there are those who would argue to the contrary and instead point out that playing the relevance game facilitates greater impact of research outputs for industry and society at large. But even discounting the possibilities of weakening the academic quality of research, its impacts on policy and the sector are by no means easy to measure, despite frequent attempts to do so.

In academic circles credibility is increasingly dependent on citation indicators and the 'value' and 'quality' of an academic journal publication is measured against the number of citations it gets. The Web of Science ISI index has become a dominant measure and is frequently used in assessing the impact of research in most countries. However, in CM it is not entirely straightforward as most of the more prestigious journals not are listed. Furthermore, the effectiveness of the resultant outputs in actually impacting on industry and society is not deducible from citation indexes. Of course, few in industry would ever worry about citations. Much more important are the direct benefits that might accrue and the perceived competitive advantages that these might bring with them. Potential impact is good, but easily identified benefits are better and there is little doubt that industry prefers short term impact ahead of potential for long-term impact. It is clear that those who call for CM research to have a greater impact on industry also would prefer to see this happen in the short term. Thus, research closely focussed on solving current industry problems, and hence with supposedly high relevance, is favoured. However, to call for increasing the impact of research is not the same as prioritising relevance ahead of rigour, even if debates tend to polarize the two. There is nothing to say that rigorous research cannot have a significant impact, either in the shorter or longer term. Indeed, the processes through which new knowledge claims diffuse through practitioner landscapes is a complex one, where the potential for and degree of long-term impact is hard to assess.

The desires of CM academics to actively seek to impact upon their surroundings vary. It would be naïve to state that CM researchers share the same ontological and epistemological perspectives regarding the methods they mobilise and the products that their work generates. There is, therefore, no reason to expect universal agreement over how the products of research contribute to academic or practitioner knowledge. Indeed, a variety of different perspectives and approaches shape the efforts made by researchers to affect their surroundings. Ultimately, the utilised mode of research will influence and shape the impact of the research outputs. It will also, at least partially, affect the individual researcher's inclination to actively seek higher and wider impact of his or her work.

One important distinction is that between rational / instrumental modes of research rooted in the sciences and engineering disciplines and more subjective and qualitative approaches to research derived from disciplines such as sociology. The former 'engineering model' positions research as revealing something 'true' about the world it focuses on; uncovering existing but previously unknown causal relationships. The methods drawn upon, and the underlying realist epistemology they imply, are grounded in the experimentation of natural scientists and engineers, deducing the properties of the natural world. They are nonetheless regularly mobilised against more 'humanist' constituents and problems. The basis is that by revealing an objective reality, tools to intervene can be developed and implemented to predict, improve or exploit it. The findings are considered to be generic and widely applicable with identifiable and beneficial results. By contrast, more subjectivist and interpretive approaches focus on the creation and reproduction of meaning and values. In particular how interactions between actors and material artefacts occur and how practices and ideas emerge from them. The utility and applicability of knowledge claims tend to be more modest than those within the harder engineering paradigm, with less expectation of wide generalisability or easily transferable results.

Advocates of subjectivist and interpretive approaches have always been a persistent, although minority, voice within the CM research canon. They are often positioned against an inability to explain or conceptualise the complex and messy realities of construction activity with more instrumental and generic frameworks and methods. Increasingly, industry practitioners recognise the complexities of construction activities, the diversity of its constituents, and the limitations of generic solutions. Nevertheless, this type of research remains limited by the difficulty of producing hard measurements of impact on industry, or quantified evidence of the relevance and utility of its outputs. In contrast, the relevance of generic best practice can easily be endorsed through mobilising the realist world-view of instrumental perspectives. The ‘best way of doing things’ is extracted from particular contexts, stripped down to core tenets and taken to be applied elsewhere (Fernie *et al.* 2006). This approach is so well diffused throughout CM (as well as elsewhere) that often no methodological or theoretical justification or positioning is given, or required. The actual outcomes of applying generic best practice in different contexts, however, remain largely unexplored (*ibid.*).

Judging relevance from a more critical perspective requires a more involved discussion of the sorts of contexts in which research-generated knowledge has to make sense. This includes evaluating the match between the research being conducted and its intended utility. Furthermore, any reasonable assessment of impact needs to consider the questions of: who is paying for the research; who the ultimate beneficiaries are supposed to be; and who might be denied this advantage? It is also necessary to evaluate how well suited the outcomes of CM research is to have an impact. As an applied field construction management is populated by researchers subscribing to both of the above described approaches. It should also be remembered that academic research is just one possible route to new knowledge production, with others typically including consultancy, training, and using the skills of in-house staff. Perhaps academics are best off not trying to fill all the roles.

BENEFICIARIES OF RESEARCH

It follows from the above discussion that in applied fields such as construction management questions remain over who the ultimate beneficiaries of research are supposed to be, and who might be denied any advantage gleaned. In the UK this is especially pertinent in research council funded projects. Funding is provided on the prerequisite of a commitment to enhancing the competitiveness of ‘UK plc’ in general, but often entails researchers working closely with specific organisations. This can lead to a host of philosophical and ethical problems, such as: offering an advantage to some UK firms at the expense of others; and how to balance requirements of confidentiality and wide dissemination of findings and knowledge, within both academic and practitioner domains.

It goes without saying that research outputs could benefit individuals, single firms, sectors, ‘industry’ as a whole, ‘the economy’ or ‘society’ at large. It is, however, important to keep in mind that at each of these levels multiple perspectives co-exist. The products of research and the beneficiaries thereof cannot therefore be conceptualised as unidirectional or asymmetrical. The term ‘impact’, thus, lends itself to a significant degree of subjective interpretation. The same argument can also be made regarding the CM scholars’ role in how the construction sector is shaped and developed. A strong, albeit, idealistic case could be made for the need of judging what research is deemed useful to society to be collectively determined, rather than basing it on its impact on the specific business interests of companies. Furthermore, and equally importantly, there is a need to acknowledge and discuss the implications of academic research offering advantage to one constituency at the expense of another. We would argue that following the path of least resistance of complying with external pressures and aligning research solely with business priorities should be resisted.

Further to the above, it is important to stress that research is not the only, or even the main, activity of universities, either practically or economically. Teaching is central to a university's success, and competition for attracting students is fierce. This too brings with it inconsistent demands regarding the focus of research and dissemination of outputs. Academic teachers and researchers are expected to respond to new and emerging problems and to engage with current non-academic priorities. At the same time, academic institutions are expected to provide a relatively stable platform of knowledge (i.e. text-book learning) in digestible chunks, which informs and sometimes even constitutes the activities, problems and contexts of 'construction' and 'construction management'. There are, indeed, tensions between training students to become effective practitioners, and to provide an academic education. Somewhat paradoxically, according to many managers, university teaching in general often does not provide industry with individuals possessing the relevant skills to increase firms' competitive edge (Linder and Smith, 1992; Pfeffer and Fong, 2004). But it remains the case that the success of university institutions is largely governed by the attraction of students, which is at least partly derived from the employability of graduates with qualifications from specific schools or universities. As such, the broad canvas of university activity, including teaching and research, significantly impacts on and contributes to shaping the construction sector at large.

To further explore this conundrum of satisfying and navigating between multiple beneficiaries of research, the following two sections look at how researchers have an impact through critical research and how a balance can be struck between the needs of industrial partners and industry at large, through a commitment to co-production research.

THE ROLE OF CRITICAL RESEARCH

Within scientific research the most basic form of criticism is the assessment of the validity of knowledge claims (Hammersley, 2005). This is something that researchers undertake individually as part of their inquiries as well as in collective and public arenas. The latter functions most notably through the process of peer review. Much has been written on the various ways the term 'critical' can be mobilised, e.g. critical theory and critical research, and it serves little purpose to reiterate the debates here (see for example: Agger 1991; Hammersley, 2005). Suffice to say that developments in method, theory and philosophy have created extensive debate and multiple, perhaps somewhat nebulous, perceptions of what critical research actually is. In short, the scope of criticism in terms of its targets and the ground upon which critical acts are undertaken are broad, leaving plenty of scope for researchers to be 'critical'. Being critical does, for example, not have to be limited to challenging the validity of knowledge claims. It might just as well take the form of assessing the practical values and political perspectives of institutions, policies, and forms of practice (e.g. Habermas 1989; Reed 1989) and the consequences of these for undertaking and mobilising research and its outputs, and for its impact or relevance. It could also entail scrutinizing the framework of fundamental assumptions and institutional contexts associated with a particular empirical context, or perceived problem.

The stance taken here is that criticism is a means and not an end. It facilitates the possibility for collective production of new ideas, approaches and practices, but more importantly it helps to recognise the limitations of all forms of research, and the possibility of alternatives. Within the academic community criticism is most legitimate in the context of assessing the rigour and validity of knowledge claims put forward as contributions to disciplinary development. Most researchers will during the course of their work both be critics and be criticised. If researchers have reasonable doubts about the validity of knowledge claims made by others then they are expected to put forward, and to justify their criticisms. However, such criticism should not be proffered just for the sake of being 'critical' in some ontological or generic sense, or to discredit individual researchers or specific lines of argument or perspectives being pursued.

From a publishing perspective the last decade has seen an increase in CM papers with titles promising 'critical reviews' or 'critical perspectives'; (see for example Construction Management and Economics vol. 25). In some quarters the word 'critical' has become a term of praise and is used by authors to commend their own work or the particular approaches they have adopted and to dismiss the work of others as 'uncritical'. This of course generates counter-arguments and many 'critical' papers run into opposition along the lines of them deconstructing and critiquing one perspective, but failing to offer recommendations, solutions or viable alternatives. Herein lays the paradox of critical research in CM. Critical work is looked upon as interesting and perhaps suggestive, but consistently fails to dislodge existing views.

The role of critical research does, however, go much further than assessing claims made by other researchers in academic journals. Much more important to the argument developed in this paper is the role that CM academics can play 'externally' in questioning and criticising professionals and policy makers. Critical perspectives can encourage practitioners to reflect on their own actions and assumptions, in order to better judge their expedience and to consider other ways of thinking and acting. It could also encourage them to take seriously a broader range of considerations than those that their professional perspectives might encourage. Through more actively putting forward criticism CM academics can play an important role in counterbalancing tendencies towards inertia and self-interest in organisations. This is equally true in terms of criticism of policies and policymakers. Through offering critique of the factual assumptions on which policies are based academics can make valuable contributions to policy. Value can also be derived from drawing attention to the assumptions relating to the consequences that are likely to follow from various actions and the likely effects on relevant agents. However, it is important to remember that the effects of criticism might not always be beneficial. Policies and practices cannot be completely separated from judgements regarding their desirability. Commonly they are the results of trade-offs between a host of perceived values, different perspectives and political fashions. Thus, whilst a very strong case can be made for a more active engagement in public sphere by CM academics there is also reason to be cautious in giving specific research outputs too much weight. Academics have a responsibility to make clear what can and cannot be concluded from their research findings. Nonetheless, to explicate and unpack multiple influences is a key contribution that critical research can make; whether in the form of re-contextualising abstracted and generic policy statements, or exploring the positive and negative effects of particular policy directives. This is a rather different contribution to that which is derived from a narrow focus on solving specific business problems or generating other generic recipes.

CO-PRODUCTION OF KNOWLEDGE

So far it has been argued that various forms of 'critical' research can contribute to both academic and practitioner understanding by engaging with the plethora of constituents who contribute to producing, positioning, mobilising and measuring research. This goes beyond both a narrow conception of industry focussed, problem-solving research, and of critiquing such efforts as uncritical. Although we would not claim that this is a novel position, it is still a minority one, and we do see benefit in continuing to espouse this position within both the CM research community, and practitioner domains. This resonates strongly with the growing awareness of approaches that bridge across academic and practitioner divides to collaboratively engage in exploring problems, developing potential solutions and generating new ideas, knowledge, and research agendas (cf. Pettigrew 1997; 2001). Indeed, Gibbons *et al*'s (1994) aforementioned seminal text on knowledge production argues that we can make a transition from the highly bounded, disciplinary-based, and academically-oriented mode of research, oriented to producing generic, abstract and universal knowledge (Mode 1), to a much more interactive, contextualised, socially accountable and reflexive process of knowledge production (Mode 2) involving extensive collaboration between academia and heterogeneous communities of practitioners.

What we advocate is the 'co-production' of research, where researchers and practitioners work together to produce new knowledge. This is not just about the end-products of research, but more fundamentally about the process of research itself. Co-production acknowledges the on-going, iterative and emergent nature of engagement between industry and academia, which is something that will make much sense to many researchers in CM. As previously stated, one of the advantages CM researchers have over those in other areas is their extensive interaction, and long-standing relationships with the construction industry. A co-production approach would therefore seem to fit very well with how CM researchers go about their work. Essentially, this approach would embrace the need for demonstrating both research quality or rigour, and its relevance and impact through engaging practitioners and other institutions into the process. Co-production research is underpinned by the exchange of ideas across academic / practitioner boundaries, and recognises the emergent, subjective and dynamic character of such exchanges. It is therefore responsive to changing ideas and challenges as the process unfolds, rather than being fixed around *a priori* objectives or desired or promised outcomes. But perhaps most of all, it implies a commitment to on-going and substantial engagement between researchers and practitioners, both in terms of 'doing' and 'shaping' the research process. It does not follow a format of an incursion into practitioner worlds to collect data, a subsequent retreat into ivory towers, followed by the emergence of journal papers and final reports. Instead insights are shared, debated and shaped as they emerge. The process is one of continual feedback between researchers and practitioners.

Thus, there are considerable implications for assessing and measuring the utility of research, especially in judging its impact. The very nature of co-production research is highly relevant, otherwise practitioners would not be interested in working with researchers – and this in itself is a persuasive argument for the relevance of CM research. However, such interest is difficult to quantify. There are also some practical and conceptual issues, which this approach raises, that need to be addressed. Presenting findings along the way is something that many researchers instinctively might avoid. In the case of working with industry some would argue that mid-process feedback is problematic, as it could be misleading, under-informed and biased. Others would argue that any feedback would contaminate future data samples. We argue that neither of these arguments is sufficiently strong when such feedback is acknowledged as incomplete and partial. In our view, sustained engagement between industry and academia requires regular feedback of findings along the way. Furthermore, such sessions do much to further contextualise emerging findings, and validate outcomes. Decision makers in organisations are interested in knowledge to implement change. They want to use this knowledge in particular types of decisions. Researchers are interested in gaining new insights that will further their awareness of the issues that inform and contextualise their emerging findings. Thus, rather than debate whether or not feedback sessions are useful, a focus on assessing the utility of feedback for both researchers and practitioners is arguably more productive.

CONCLUSIONS

Whilst positioning the activities of researchers as playing games across multiple arenas has experiential resonance for many CM researchers, it does not really help in conceptualising the formulation or transformation of research agendas, activities and outputs. Furthermore, opposing relevance and rigour can neither correct short sightedness and narrowness of values among commercial enterprises nor generate greater industry impact for academic outputs. Rather than offering a choice, this polarisation of industry impact against academic quality only serves to reproduce and sustain the notion that these two constituents are epistemologically distinct and therefore irreconcilable. Instead of rejecting one for the other, or maintaining parallel but distinct streams of research for academic and industry audiences, we argue that multiple perspectives and objectives need to be recognised and accounted for, and that doing so is a productive and useful activity. We acknowledge that there are different audiences for research; academics still have to produce journal papers; practitioners still have problems to solve and value to demonstrate, but these do not have to be mutually exclusive. Indeed explicitly facing and exploring the challenges of producing both relevant and high quality outputs can in itself make significant contributions to both practice and research.

We therefore advocate a role for critical, co-production research which goes beyond either an instrumental focus on solving current industry problems, or critiquing this focus as narrow and un-reflexive. This approach can interweave the two poles of relevance and rigour, or impact and quality. But this is a challenge which should not be underestimated. As well as being a very different epistemological approach for many CM researchers, it also requires industry partners in research to recognise its benefits beyond short-term impact and industry-driven agendas. However, if we take up the challenge of transcending boundaries, and improving both the quality and impact of our research, such efforts are indeed worthwhile.

REFERENCES

Agger, B. (1991) Critical theory, poststructuralism, postmodernism: their sociological relevance. Annual Review of Sociology, 17(1), 105-131.

Elzinga, A. (1985) Research bureaucracy and the drift of epistemic criteria. In B. Wittrock and A. Elzinga (eds) The University Research System: The public Policies of the Home of Scientists. Stockholm: Almqvist and Wiksell International.

Fernie, S., Leiringer, R. and Thorpe, T. (2006) Change in construction: a critical perspective. Building Research and Information, 34(2), 91-103.

Gibbons, M., Limoges, C., Nowotny, H., Schwartzmann, S., Scott, P. and Trow, M. (1994) The New Production of Knowledge: The Dynamics of Science and Research in Contemporary Society. London: Sage.

Gulati, R. (2007) Tent poles, tribalism, and boundary spanning: the rigour-relevance debate in management research. Academy of Management Journal, 50(4), 775-782.

Habermas, J. (1989) The Structural Transformation of the Public Sphere: An Inquiry into a Category of Bourgeois Society. Cambridge, MA: MIT Press.

Hammersley, M. (2005) Should social science be critical?. Philosophy of the Social Sciences, 35(2), 175-195.

Linder, J. C. and Smith, H. J. (1992) The complex case of management education. Harvard Business Review (Sept-Oct), 16-33.

Pettigrew, A. (1997). What is a processual analysis? Scandinavian journal of Management, 13(4), 337-348

Pettigrew, A. (2001) Management research after modernism. British Journal of Management, 12, S61-S70(1).

Pfeffer, J. and C. T. Fong (2004) The business school 'business': Some lessons from the US experience. Journal of Management Studies, 41(8), 1501-1520.

Reed, M. (1989) The sociology of management. London: Harvester Wheatsheaf.

Starkey, P. & Madan, P. (2001) Bridging the relevance gap: Aligning stakeholders in the future of management research. British Journal of Management, 12, 3-26.

An Enterprise Content Management approach to Organisational Information Management for the construction industry

Sheriff Abdullahi, Research Engineer, Loughborough University
a.sheriff@lboro.ac.uk

Dino Bouchlaghem, Loughborough University
n.m.bouchlaghem@lboro.ac.uk

Ashraf El-Hamalawi, Loughborough University
a.el-hamalawi@lboro.ac.uk

Steven Yeomans, Buro Happold ltd.
steven.yeomans@burohappold.com

ABSTRACT

Like all business entities, Construction organisations face internal information management challenges which hamper true collaboration, overall efficiency, innovation, profitability and dynamism, prompting the need to seek better ways of maximising value from information. The recurring challenge is in understanding 'what exactly should be considered when defining an information management strategy for an organisation?' The solution may lie in building on an emerging theme called Enterprise Content Management.

Based on an in-depth literature survey, this paper reviews the concept of ECM and presents an ECM based framework for defining an organisation wide information management strategy. The need for such a strategy is defined with the concept of ECM explained. The model is then presented with the 4 key facets, details of its constituent components and the critical aspects to be considered in each as it relates to the construction industry. It then concludes by outlining specific areas in which further research is required to improve the potency and implement-ability of the proposed framework.

Keywords: *Enterprise Content Management, ECM, information management, document management, construction information, strategic information management.*

INTRODUCTION

Driven by the urge to improve integration, collaboration, productivity, efficiency corporate governance; and mitigate continually emerging business risks, organisations across all industries have made a near complete transition from a paper based work environment to a fully digital work place. While achieving the above goals in relative measure, the volume of electronic information has correspondingly continued to grow, bringing with it high costs of maintenance and new significant risks (Delloitte, 2002). These along with other factors have created the need for a more comprehensive approach to information management for companies, more so in the construction industry.

The construction industry is composed of numerous stakeholders and participants, working together as a "temporary enterprise" in clearly defined roles, with the aim of providing unique services to meet client needs, at various stages of the procurement process. The end product resulting from this often complex (and short term) interaction is a physical built form, produced through the continuous exchange of large volumes of carefully developed information (in the form of drawings, images, reports, etc) by all the parties involved (Caldas, 2003). Typically, construction research into information management focuses on project environments, with the need for improved collaboration and co-ordination between stakeholders frequently highlighted (Bjoerk, 2001; Yeomans, 2005). Often neglected are the internal company specific information management challenges each business entity faces.

Information is the product of the contextual understanding and interpretation of Data. More crucially, it is the essential medium through which knowledge, expertise, judgement, emotions and decisions held by individuals is expressed, shared and communicated with others in pursuit of desired and often shared goals (Davenport and Marchand 2000a). Obtaining business value from information requires a holistic view of information needs across the company and developing strategic 'information intelligence' (Evgeniou and Cartwright, 2005).

An information intelligent organisation is one which understands the value of information and can successfully search, find, assemble, analyse and use all forms of information products which it requires for any task (Evgeniou and Cartwright, 2005). Such capability requires a strategic view of information as a core business asset. Strategic information management is based on a holistic perception of the information needs, capabilities and requirements of the organisation and directly aligning it to its core business and operational strategies, hence addressing the concerns of the past, meeting the needs of the present and anticipating the requirements of the future (Buchanan and Gibb 1998). It requires a fundamental rethink of information, its position within the organisation and its potency as a means of securing long term competitive advantage.

The need for such a strategic approach has been clearly documented in numerous works (Evans 2000; Buchanan and Gibb 1998; Marchand 2000a; Rockley et al, 2003; Evgeniou and Cartwright 2005; Bjoerk 2001; Murphy 2001; Paivarinta and Munkvold 2005; Munkvold et al 2003) and is not the focus of this research. Rather, this research asks the fundamental question 'what should be considered when defining an organisational information management strategy?' The solution may lie in analysing the emerging field of Enterprise Content Management (ECM). But what is ECM?

OUTLINE METHODOLOGY

This research was conducted over an 8 month period in the first year of a 4 year Engineering Doctorate (EngD) program at Loughborough University aimed at defining an information management approach for construction industry based organisations. Specifically this paper reports on a preliminary investigation into information management from an ECM paradigm based on a critical investigation of existing literature around the themes of: Information management; Content Management; Knowledge Management; Data Management; Enterprise Content Management; and Document Management.

ENTERPRISE CONTENT MANAGEMENT (ECM)

ECM is defined as the strategies, tools, processes and skills an organisation needs to manage all forms of recorded information through its complete lifecycle from creation until deletion, organised according to corporate taxonomies, supported by necessary technological and administrative infrastructures (Boiko, 2002; Munkvold et al, 2003; Munkvold et al, 2006). It is holistic in nature, reflecting both the business and organisational concerns, as well as the IT infrastructure required to achieve it (Tyrvainen et al, 2002). ECM encapsulates the management of all types of structured, semi-structured and unstructured data, along with their associated metadata (Nordheim and Paivarinta, 2004; Paivarinta & Munkvold, 2005).

Numerous technologies do exist, which aim to provide this functionality, however critical to the success of ECM is the equal emphasis on corporate wide strategies and policies guiding the use and implementation of the appropriate technology (Paivarinta & Munkvold, 2005). Hence its effectiveness is not merely a measure of the sophistication or the capabilities of the tool, but also a reflection of the robustness and comprehensiveness of the organisational policies which the tool is expected to facilitate. Delloitte (2002) argue that such a strategy must reflect the solutions of the present and anticipate the needs of the future. Therefore, while functionality is crucial, sustainability must be considered in ensuring that the strategy remains flexible and dynamic enough to remain relevant as business goals develop, and as the needs to share data with others (as is typical in construction project environments) continually emerge.

COMPONENTS OF AN ECM FRAMEWORK

Based on the amalgamation of the 5 fingers model of Bridges (2007); the information orientation model of Marchand (2000b); and the framework of Paivarinta and Munkvold (2005), 4 key components can be defined as critical to understanding strategic information management from an ECM paradigm. Each of these components must be comprehensively addressed with equal emphasis while defining a sound strategy. They are: *a) The content model; b) The enterprise model; c) IT infrastructure; and d) Leadership; Implementation and change management.*

Below is a detailed description of each component.

The Content Model

'Content' is a bit of information created by an author e.g. words, phrases, sentences, drawings, charts, graphic images, etc (Rockley et al, 2003). It is contained within media referred to as information products. Hence a document is an information product which contains content within it. The focus of information management is not on managing information products in the form of electronic files or paper, but on effectively managing the content contained within each product.

The content model denotes the nature of the content, its lifecycle, its users, its medium, business applications, structure, attributes and the suitability of the content to meet its organisational obligations (Paivarinta & Munkvold, 2005; Rockley, 2006). Also referred to as an information model, a content model serves to identify all digital knowledge within an organisation and identify appropriate ways to manage and organise it within its lifecycle

(Grosniklaus & Norrie, 2002). Key to this is understanding 'granularity' and deciding on an appropriate level of granularity to meet the organisational needs. Granularity refers to the lowest level to which a piece of content can be divided, while still remaining capable of carrying meaning and be managed (Rockley et al, 2003).

Differences in content granularity have given rise to two distinct approaches to information management:

1. The integrated document management approach: Here, documents and files are treated as individual autonomous content/documents, organised with associated attributes, with the focus of the approach being to support the document through its lifecycle (Bjoerk et al, 1993; Stouffs et al, 2002).
2. The model-based approach: Here, information is contained and updated within a single repository as granular contents (and not documents) with retrieval and access from a single dynamic source. Documents/drawings are assembled when needed using application independent dynamic content in the most appropriate format as and when required (Rezgui, 1994; Rockley et al, 2003; Hamer, 2006).

Other critical aspects of a content model are Metadata and Taxonomies.

Metadata

Simplistically, metadata is often described as data about data. It refers to additional pieces of data or attributes, attached to data, content or documents aimed at enabling users to easily find the data, determine its source and understand its context, hence more easily interpreting it and where required, re-using it (Bjoerk 2001). If defined appropriately, metadata can facilitate easy retrieval; improve navigation; aid search precision; and ensure that data is better understood (Rockley 2003; NISO 2004). In its implementation, Metadata must reflect the business language and provide a link between the content, the infrastructure and the business process (Sun Microsystems, 2005). Hence by its nature, it must remain dynamic, regularly evolving to meet the continual business demands of the organisation.

The design and deployment of a complete metadata solution requires a lot of information including organisational (contextual) information, user specific information and content centric information (White, 2005). Metadata must remain application independent and be clearly defined enterprise wide, not limiting organisational innovation, but used as a tool to facilitate interoperability between multiple systems and also facilitating easy transfer of content across the organisation as required (Bjoerk 2001, Haynes, 2004). It must be flexible enough to adapt to changes in external factors (country or industry); corporate environment; organisational strategy; size and business goals (Sun Microsystems, 2005).

Taxonomy

Sometimes likened to a tree, taxonomy is a logical conceptual structuring of content into a hierarchy of categories (Woods 2004). A well managed corporate taxonomy provides the basis for users to access and navigate through content collections easily, hence allowing organisations to make seemingly significant content volumes readily accessible to all (Woods, 2004; Hienrich et al, 2005; Munkvold et al, 2003). There exists a strong relationship between taxonomy and metadata; with a taxonomy typically built with appropriate Metadata (Paivarinta & Munkvold, 2005). Metadata typically can be very rich, but is simply descriptive information having no associated hierarchy. Taxonomies are then built on the Metadata to organise the content easing navigation, search and retrieval (Woods, 2004; Hienrich et al, 2005). Similar to metadata, designing such a robust taxonomy requires a holistic vision of the content to be managed including the lifecycle, potential users (internal and external) and the overall business processes (Gottlieb, 2005; Woods, 2004). Taxonomies must support business process, therefore while instilling order, must remain dynamic enough to support future innovation and emergent business goals (Woods, 2004). In addition to organising content attributes, taxonomies can provide the added functionality of being able to define and co-ordinate access rights to content collections, through defined user roles and their associated business responsibilities (Munkvold et al, 2003).

A single fixed taxonomy is both undesirable and dangerous as it enforces undue rigidity on the organisation (Hienrich et al 2005). In developing taxonomy, a flexible approach capable of allowing content to be organised and viewed from varying viewpoints should be employed. These are referred to as Multi-faceted or relational taxonomies. Multifaceted taxonomies allow users to navigate through a number of different ways to reach the same content, while allowing cross referencing for narrowing and widening of browsing categories (Munkvold et al, 2003; Woods 2004). The aim of taxonomy is to provide an easily navigable, intuitive and logical platform from which users can easily browse through and find the desired information, with optimum accuracy.

Enterprise Architecture

The principal aim of an enterprise model is to gain a holistic view of content across the organisation. McNay (2002) explains that the basis of any well organised and well defined information management initiative is an information model based on the organisation, its processes, its business goals, culture, ethics and prospective strategy. Enterprise architecture represents a detailed analysis of the organisation including the distinct business processes, work ethos, organisational culture, support operations, partners, supply chain and customer networks based on their interaction with information throughout its lifecycle (Munkvold et al, 2006). Thus all the processes which create, store, retrieve, review, update and distribute content must be reviewed, analysed in understanding the key question, i.e. what does the organisation do? (Hamer, 2006; McNay, 2002). Also analysed in defining an enterprise model is the content lifecycle which refers to the comprehensive instances, which content typically go through including the capture, distribution, registration, storage, retrieval, transformation, security and destruction of electronic content (Munkvold et al, 2003). It requires a reflection on each individual information producer as well as consumer within the organisation; their roles; their tasks; the processes through which such tasks are performed and the detailed information needs within each task, across the whole organisation (Reimer 2002; Gottlieb 2005; Paivarinta & Munkvold 2005; Rockley 2005).

IT infrastructure

The primary function of technology within an ECM initiative is to facilitate the effective deployment of the predefined strategy. Selecting the tool therefore is a delicate process based on a through analysis of the 3 facets explained above and determining the most appropriate tools to support the organisation. Schaeffer (2002) warns that buying the wrong software can be worse than buying none at all. Along with functionality and scalability, any technology employed must be user-friendly, intuitive, and readily adoptable by all potential users; while also being secure and conforming to the organisational quality management regulations (Munkvold et al, 2003).

An ECM based solution does not in itself produce or edit information, but provides a broad platform from which information produced in often heterogeneous IT architectures can be shared, transferred, stored and managed for easy and effective re-use and retrieval, independent of the applications with which it was produced (Reimer, 2002; Ross, 2003; Munkvold et al, 2006). It must facilitate organisation wide content integration, while also be flexible and scalable to cater for increasing content volumes and also new content types and/or information products (Paivarinta and Munkvold, 2005).

Implementation, Leadership, & Change Management

The scale of such an organisation wide initiative may require a completely new and different way of working, alien to the users and personnel of the organisation. Consequently, along with the procedural, technical and technological perspective of ECM, administrative guidelines, policy frameworks, organisational standards, regulations, clear responsibilities, coupled with a focus on leadership, implementation and change management are crucial to the success of information management (Paivarinta & Munkvold, 2005). The complexities in achieving the above must never be under-emphasised. Implementation is a gradual process and must be tailored to ease the transition and meet the exact needs of each information consumer within the organisation. Sound information behaviours and values must be articulated and enshrined across the organisation with sufficient feedback mechanisms to create a continuous relationship between information managers and information consumers.

In a recent white paper, HP (2007) argue that this process is best achieved via a team, mandated with defining policies for the functional protection and management of all corporate data assets, along with ensuring optimum quality control. The responsibilities of this team will include: ensuring data quality (including accuracy, integrity, correctness); defining, implementing and continuously upgrading the metadata and corporate taxonomies; defining; developing and reviewing corporate information management policies; developing sustainable content models in line with the business needs; and managing change to ensure user buy-in (Paivarinta & Munkvold, 2005; HP, 2007).

BENEFITS OF AN ECM APPROACH

1. The strategic approach will empower organisations to make more intelligent, accurate and effective decisions improving business performance and supporting innovation (Delloitte, 2002, Rockley et al, 2003).
2. It provides a platform for improved information transparency and accountability (Sprehe, 2005).
3. Consistency in the structure of information improves find-ability and retrieval across the organisation yielding significant savings in time and effort (Stouffs et al, 2002).
4. An effective ECM strategy will support workflows and thus allow rapid and automated electronic movement of information across the organisation (McNay, 2002)
5. If implemented strategically, ECM will provide a means for consolidation of company data management practices, giving organisations the means to become more agile, dynamic, robust and innovative, improving the ability to react rapidly to unforeseen and emergent business challenges (Delloitte, 2002; Dilnut, 2005).
6. Provides improved collaboration within groups, between groups and across the organisation, enhancing knowledge sharing and pro-active decision making (Giandon et al, 2002).

7. It provides a framework for ensuring the organisation wide compliance to emerging regulations (including Sarbanes Oxley and Moreq 2), and the enforcement of consistent corporate information governance policies (Dilnut, 2005; Sprehe, 2005).
8. By critically analysing the information work flow, ECM provides a means to appraise and eliminate seemingly non value adding activities and providing a faster turnaround between tasks (Giandon et al, 2002)
9. It provides cost savings through easier access to information and less time wasted on searching, and duplication, freeing knowledge workers and professionals to focus on business critical value creation (Woods, 2004; Sprehe, 2005; Hamer 2006).
10. Through relevant metadata and taxonomies, it ensures the retention and effective management of the organisational memory for records purposes (Sprehe, 2005).
11. Metadata and taxonomies can improve which heterogeneous content can be retrieval, tracking, assembly and accessibility of heterogeneous content to multiple users, without duplication of content across the organisation (Rockley 2003).

BARRIERS TO AN ECM APPROACH

Despite these benefits, barriers also exist limiting the growth and effectiveness of ECM. These include:

1. There remains an insufficient understanding of the distinct facets in most organisations and how such a strategic approach can be effectively deployed.
2. There exists an overdependence on technology and the resultant neglect of the information consumer as the central key within a strategic information management initiative.
3. Users remain unwilling to populate metadata fields and provide the necessary information to enable the content to be managed effectively (Bjoerk, 2001).
4. The scale of the initiative can be a difficult and complicated process involving numerous stakeholders and significant resources in cost and time (Gottlieb, 2005; Paivarinta & Munkvold, 2005).
5. The magnitude and scale of this initiative, implies a large number of stakeholders and information consumers with diverse requirements, magnifying the risks considerably (Gottlieb, 2005)
6. Existing organisational cultures can inhibit the migration to such a complete ECM based work environment (McNay, 2002).
7. With ECM IT architecture still at its infancy, it remains relatively unproven beyond doubt, making the risk of consolidating all corporate data into a central repository to still be perceived as high (Gottlieb, 2005).

The research suggests that the scale of an ECM initiative makes it a large complicated venture, which should by no means be seen as trivial. Consequently, if inappropriately defined and enforced, an ECM initiative can impose undue rigidity across organisations, stifling innovation and rather than provide a solution, may ultimately serve to hamper the long term development and business growth of the organisation (Gottlieb, 2005).

DISCUSSION - CONSTRUCTION INDUSTRY CONTEXT AND EMERGING CRITICAL RESEARCH ISSUES

In-spite of the benefits and capabilities highlighted by this research, there remain fundamental issues which arise in implementing such a strategic view of information within construction industry based organisations for which further research is required.

The construction industry, acknowledged for its complexity and size, involves numerous stakeholders working together in varying roles and capacities along a procurement supply chain, providing unique solutions to sometimes new and bespoke problems. Broadly, the industry may be deemed to comprise mainly of three groups: the Clients (including client organisations); Consultants (ranging from Architects and Engineers to include specialist consultants) and Contractors (including main contractors and smaller specialist trade sub-contractors). Each group fulfils different roles and hence will inevitably develop information management initiatives in manners most appropriate to their respective practices. Can a single standard approach be developed to meet the needs of the above three groups? Further research is required to determine if a standard set of metadata and taxonomies is possible for all, and if so, what these elements should be.

Within individual organisations, while project teams may work using certain terminology, examples of which are drawing number and sheet number, support services, and non-project related divisions of organisations such as Human resources (HR) and finance will not use such identifiers and may require a different set of metadata. This highlights a critical need for further research aimed at determining if one standard metadata schema across a construction organisation is both possible and indeed desirable. This, considering that any compromise on specificity aimed at achieving generality, may render the standard too ambiguous to achieve precision and hence make the ECM initiative inappropriate; while conversely too much specificity may not adequately reflect the breadth of organisational activities. While the result and impact of this decision may differ from organisation to organisation, this, remains a core issue for which further research is required.

Another concern which emerges is the question ‘what level of granularity is appropriate for construction organisations?’ Granularity refers to the lowest level to which content should be divided to meet the user’s needs, while still being capable of carrying meaning and supported by the available technology (Rockley et al, 2003). For construction documentation, further research is required to define what level of granularity will be deemed adequate and acceptable; and whether the decision on granularity is organisation specific or applicable industry wide? While the proposed framework provides a platform for which information management can be understood, further research is also required to determine an effective method through which the framework can be implemented.

CONCLUSION

This paper is a product of an 8 month investigation into analysing ECM as an approach to organisational information management. The 4 facets of an information management strategy were presented with the key elements of each clearly defined. While considerable further research is required to analyse the various critical issues raised, vis-à-vis the working ways of the construction industry, the findings suggest that if used appropriately, an ECM approach may provide a holistic platform from which general organisational information initiatives can be pro-actively defined, strategically.

REFERENCE

1. Bjoerk B, Huovila P. and Hult S, 1993, “Integrated construction project document management”, Proceedings of the EuropIA'93 conference, Elsevier, Delft, Holland, 135-146.

2. Bjoerk B, 2001, "Document management- a key IT technology for the construction industry", European council of civil Engineers, (ECCE) symposium, Finland.
3. Boiko B, 2002, "Content Management Bible", Hungry Minds, New York, USA.
4. Bridges J D (2007) Taking ECM from concept to reality. Information Management Journal 41 (6) Pg 30.
5. Buchannan S and Gibb F, 1998, "The information audit – an integrated strategic approach". International Journal of information management, 18 (1) Pg 29-47.
6. Caldas HC, Soibelman L, 2003, "Automating hierarchical document classification for construction management information systems", Journal of Automation in construction, Issue 12, pg 395 - 406.
7. Davenport T and Marchand D (2000), "Is Knowledge Management just good information Management?" In Marchand D, Davenport T and Dickson (Eds.), Mastering information Management. Financial times, Prentice hall, UK.
8. Delloitte research, 2002, "Enterprise content management: Taming the content chaos, a viewpoint", white paper, available at www.deloitte.com, last accessed 25/02/08.
9. Dilnutt R, 2005, "Surviving the information explosion", IEE Engineering management journal, Volume 16, issue 1 pages, 39-45.
10. Evans P, (2000) "Strategy and the economics of information". In Marchand D, Davenport T and Dickson (Eds.), Mastering information Management. Financial times, Prentice hall, UK.
11. Evgeniou T and Cartwright P, 2005, "Barriers to information management". European Management Journal, 23 (3), Pg 293-299.
12. Giandon A C, Junior R.M and Scheer S, 2002, "Implementing electronic document management system for a lean design process", Proceedings IGLC – 10, Gramado, Brazil
13. Gottlieb S, 2005, "From Enterprise Content Management to effective content Management", Cutter IT journal, Vol. 18, No. 5, available at www.cutter.com, last accessed 25/02/08.
14. Grosniklaus M, Norrie M.C., (2002), "Information concepts for content Management", Proceedings of the Third International conference on Web Information systems engineering, Singapore. Pg 150-159.
15. Hamer C E, 2006, "Six Sigma reasons to embrace enterprise content management", from customer centric content management, The Rockley report newsletter, Rockley group.
16. Haynes, 2004, "Metadata for information management and retrieval", facet publishing, London, UK.
17. Hienrich J, Pipek V, Wulf V, (2005), "Context grabbing: Assigning Metadata in large document collections", Proceedings of the Ninth European conference on computer-supported co-operative work, 18-22, September, 2005, Paris, France, Pg 3667-386.
18. Hewlett Packard, 2007, "Managing data as a corporate asset: Three action steps towards successful data governance", white paper, available at www.hp.com last accessed 25/02/08
19. Marchand D, (2000 a), "Competing with information - A manager's guide to creating business value with information content" Wiley.
20. Marchand D, (2000 b), "Company performance and Information Management – the view from the top. In Marchand D, Davenport T and Dickson (Eds.), Mastering information Management. Financial times, Prentice hall, UK.
21. McNay H E, (2002), "Enterprise content management: An overview", Proceedings of the International professional communication conference IPCC, Portland Oregon, Pg 396-402.

22. Munkvold B E, Paivarinta T, Hodne K A, Stangeland E, 2003, "Contemporary Issues of enterprise content management: The case of Stat Oil", Proceedings of the 11TH European conference of information systems.
23. Munkvold B E, Paivarinta T, Hodne K A, Stangeland E, 2006, "Contemporary Issues of enterprise content management", Scandinavian Journal of information systems, Volume 18, Issue 2, Pg 69-100.
24. Murphy, L.D, 2001, "Addressing the Metadata Gap: Ad-hoc digital documents in organisations", Text databases & document management: Theory and practice, A. G. Chin (ed) Idea group publishing Hershey, PA, Pg 52-57.
25. National information standards organisation NISO, 2004, "Understanding metadata" NISO press: Bethesda, Maryland, USA.
26. Nordheim S, Paivarinta T, 2004, "Customisation of Enterprise content management systems: an exploratory case study", Proceedings of the 37th International conference on system sciences, Hawaii, 2004.
27. Paivarinta T, Munkvold B.E, 2005, "Enterprise content management: An integerated perspective on information management", Proceedings of the 38th International conference on system sciences, Hawaii.
28. Rayport J.F. (2000) "Information resources – Don't attract, addict". In Marchand D, Davenport T and Dickson (Eds.), Mastering information Management. Financial times, Prentice hall, UK.
29. Reimer J, 2002, "Enterprise content management", Datenbank-Spektrum, 4, Pg 17-22.
30. Rezgui Y, Debras P, 1995, "An integrated approach for a model based document production and management", ITCON, Vol. 1, Pg 1-24.
31. Rockley A, Kostur P, Manning S, 2003, "Managing Enterprise content, a unified content strategy", 1st edition, new riders, California, USA.
32. Rockley A, 2006, "Building a content Framework", from customer centric content management, a Rockley report newsletter, Rockley group.
33. Ross J, 2003, "Creating a strategic IT architecture competency: Learning in Stages", MIS quaterly executive 2, (1), Pg 31-43.
34. Schaeffer, B 2002, "Navigating the content management jungle: A survival guide", The Intranet journal, available at www.intranetjournal.com, last accessed on 25/02/08.
35. Sprehe, 2005, "The positive benefits of electronic records management in the context of enterprise content management", The Government information quarterly, 22, 297 – 303.
36. Stouffs R, Tuncer B, Sariyildiz S, 2002, "Empowering individuals to design and build collaborative information spaces". Proceedings, international council for research and innovation in building and construction, CIB w78, Aarhus school of Architecture.
37. Sun Microsystems, 2005, "Metadata Management: An essential ingredient for information lifecycle management", white paper, available at www.sun.com, last accessed, 25/02/08.
38. Tyrvainen P, Salminen A, Paivarinta T, 2002, "Introduction to the Enterprise content Management Mini-track", Proceedings of the 36th International conference on System Sciences, (HICSS), Hawaii, Pg 104.
39. White M, 2005, "The content management handbook", Facet Publishing, London, UK.
40. Woods E, 2004, "Building a corporate taxonomy: benefits and challenges", Ovum white paper, available at www.ovum.com, last accessed 25/02/08.
41. Yeomans S, 2005, "ICT enabled collaborative working methodologies in construction", EngD thesis, Loughborough university, UK.

MINIMISING THE CAUSES OF CONSTRUCTION DELAY VIA IMPLEMENTING LEAN CONSTRUCTION

Abdullah AlSehaimi, University of Salford, Manchester, UK (email: A.O.Alsehaimi@pgr.salford.ac.uk)
Lauri Koskela, University of Salford, Manchester, UK, (email: L.J.Koskela@salford.ac.uk)

ABSTRACT

Over many years, delay has emerged as one of the most significant problems in construction industry, so much so that the causes have been investigated in numerous studies in different developing countries. Poor project management has been cited by a number of investigators as the main reason. However, despite such consensus, there are usually no clear recommendations demonstrating how project management practice could be improved. Moreover, the majority of recommendations made in the existing studies are general in nature and do not lead to a focus on a specific area. None of them are devoted to solving the difficulties associated with particular causes. The work in this article highlights the main causes of delay in construction with an aim to evaluate critically the former studies concerning the delay causes. It is further argued that delays do not arise purely because of tangible causes, as usually assumed in delay studies, but rather the underlying theory of project management may play a role in this regard. Finally, the paper argues that the utility of further traditional studies on delay is limited. Consequently construction industry must adopt innovative management techniques such as Lean Construction in order minimise waste, better productivity improvement, promote team building, and optimise learning process therefore delay causes can be minimised.

KEY WORDS: Delay, Conventional Project Management Theory, Last Planner, Lean Construction, Production Theory in Construction.

INTRODUCTION

A traditional contract document normally identifies the commencement date and completion date for the project. If, however, problems occur during the construction, the project duration is extended beyond the agreed scheduled completion date, and delay arises (Lewis and Atherely, 1996). Delay can be defined as the difference in time between the date of project completion stated in the contract and the date of actual completion. Assaf and Al-Hejji (2006) define delay as the time over-run either beyond the contract date or beyond the date that the parties agreed upon for the delivery of a project.

Over many years, delay has emerged one of the most significant problems in the construction industry, so much so that the causes have been investigated in numerous studies in different developing countries. This paper has been prepared to serve three purposes. The first is to present some analysis and then evaluation of previous studies on delay; and the second is to discuss the causes of delays in the light of the criticisms of the conventional project management theory. The third is to recommend the theory of Lean Construction as alternative production theory in construction and give an example of its best known techniques.

The contents of the paper are as follows. Firstly, the studies concerning the causes of construction delay in developing countries are explored in order to examine what causes have been identified and what solutions have been proposed. Then and acting from the sense that these are controllable factors, attention is given specifically to delay causes related to project management (i.e. poor site management, and ineffective planning and controlling). Secondly, having highlighted the problem, this paper argues that it does not arise purely because of tangible causes, but rather that the underlying theory of project management plays a role in this regard. Consequently, Lean construction theory is recommended as alternative production theory in construction. Thirdly, the paper argues that the utility of further traditional studies on delay is limited. Accordingly, this paper argues that rather than solely explanatory research, constructive and action research need to be implemented to the construction industry more efficiently.

CAUSES OF DELAY

Studies on construction delay in different developing countries (table 1) have revealed several causes, the most frequent, together with their occurrence, being presented in Table 2. Ineffective planning and controlling is a common feature identified in most studies (87%), with disparities only in the degree of importance from one study to another. Most of the reported investigations have concluded that poor site management (56%) and problems of supply chain and procurement (69%) are considered as other main causes for delay. Delay in materials delivery, damage to materials when they are needed urgently and late procurement of materials, which are all related to poor project management, also worsen the problem. Taken together, these findings indicate that either the fault lies with those responsible for planning and management, or with the planning and management techniques themselves. However, in either case, the important role for the project plan and management system in the attempt to overcome such causes of delay in construction is clear.

Another cluster of problems leading to delays covers labour shortage, problems in material supply and financial difficulties, all related to the immaturity of the economy, financial institutions and labor market in a developing country. These are external factors that have to be taken as given in a project.

Table 1 Previous Studies on Delay in Construction

Study	Number
Assaf and Al-Hajjij, 2006	1
Assaf et al. ,1995	2
Faridi and El-Sayegh, 2006	3
Koushki et al., 2005	4
Odeh and Battinah, 2002	5
Sweis et al., 2007	6
Abdul-Rahman et al.,2006	7
Alghbari et al.,2007	8
Mezher and Tawil, 1998	9
Lo et al., 2006	10
Fimpong and Oluwoye, 2003	11
Mansfeild et al.,1994	12
Kaming et al., 1997	13
Ogunlana and Promkuntong, 1996	14
Arditi et al. 1985	15
Long et al., 2004	16

Table 2: Summary of Delay Causes in Previous Studies (Note. number between brackets refer to previous delay studies, see table 1)

Delay Causes	SA (1,2)	UAE (3)	Kuwait (4)	Jordan (5,6)	Malaysia (7,8)	Lebanon (9)	Hong Kong (10)	Ghana (11)	Nigeria (12)	Indonesia (13)	Thailand (14)	Turkey (15)	Vietnam (16)	No. of Occ.
Poor planning and controlling	**	*	*	**	*	*		*	*	*	*	*	*	**14**
Poor site management	*	*		*	**	*	*	*					*	**9**
Labour shortage and productivity		*		**	**		*		*	*				**8**
Material Supply chain and procurement	*		*	**	**		*	*	*		*	*		**11**
Financial difficulties	**			**	**				*		*	*		**9**
Change in design	*			**	*	*	*				*	*		**8**
Sub-cont. related problem	*				*	*	*							**4**
Poor commun. and co-ordinati.				*	**		*	*			*			**6**
Weather	*			*	**		*		*		*			**7**
Others	**	*		*	*		*	*	*		*			**9**

Table 3 Summary of Recommendations from Previous Delay Studies (number between brackets refer to delay studies see table 1)

Recommendations	SA (1)	SA (2)	UAE (3)	Kuwait (4)	Jordan (5)	Jordan (6)	Malaysia (7,8)	Lebanon (9)	Hong Kong (10)	Ghana (11)	Nigeria (12)	Indonesia (13)	Thailand (14)	Turkey (15)	Vietnam (16)	No. of Occ.
Improve planning and controlling	*	No recommendations	*	*		No recommendations	*		*	No recommendations					No recommendations	**5**
Improve site manag. & supervision	*		*				*						*			**4**
Minimise design change	*			*			*									**3**
Improve financial support	*			*			**		*		*					**6**
Improve materials supply and procure.											*	*		*		**3**
Improve productivity							*					*				**2**
Improve human resource manag.			*		*		*	*	*				*			**6**
Improve commu.& co-ord.							**	*	*		*		*			**6**
Adopt new manag. techniq.								*						*		**2**
Adopt new approach to contract award					*											**1**
Others	*		*	*	*		*					*				**6**

CRITICAL EVALUATION OF DELAY STUDIES

Different recommendations have resulted from these studies (Table 3). Recommendations where made are: only 31% of studies mention improving planning and controlling, and only four studies out of sixteen (25%) recommend improving site management. Improving human resource management has been recommended by 37.5% of the examined studies. Other recommendations such as improving communication and collaboration between the parties involved, improving financial support, and minimising design changes were made by 37.5%, 37.5% and 19% of studies respectively.

In the following, previous delay studies are criticised regarding three aspects. First, not all studies made recommendations. Second, as ineffective planning and controlling was to be found common factor on the majority of the studies, it is expected that recommendations produced to overcome its impact but unfortunately this did not happen. Thirdly, even few studies have recommend improvements; they have not proposed the necessary tools to facilitate such improvements.

Recommendations not made

From table 3, it can be shown that not all studies made recommendations; 25% of the studies did not recommend solutions to the problematic causes of delay. Different reasons for this may be given, such as that the aims of the respective research were limited to finding or causes or the funding of the research problem was limited. However, it can be hardly argued that a delay study would have other motivations than to facilitate the removal of those delays, and from this angle, the failure to discuss solutions to delay problems is disappointing.

Recommendations do not match findings

In the majority of the studies, it can be noticed that recommendations derived do not match the findings. Figure 1 shows the frequency of delay causes and corresponding recommendations in delay studies. Returning to Table 1, let's consider one particular factor, ineffective planning and controlling, as an example. It is interesting to note that fourteen cases out of sixteen (87%) mention this, thereby indicating that this factor should be focused on and recommendations produced to overcome its impact. Another example, the problem with supply chain and procurement, was found to be mentioned in 69% of studies, giving the impression that this is a particularly problematic area. The third example, poor site management, was cited in 56% of studies, featuring as the third main cause of delay, yet few studies proposed solutions to improve site management.

Recommendations do not contain practical advice

Although a few studies have recommended improvements, they have not proposed the tools to facilitate such improvements, and how the recommendations could be implemented. The following are some examples.

Over a decade ago in Nigeria, Ogunulana et al. (1996) proposed that owner associations, designers, contractors, suppliers, finance houses, educational institutions, manufacturers and the government should co-operate to provide the infrastructure necessary for efficient project management. However, the research fell short of determining the nature of such infrastructure, and the question therefore, remains, as to what constitutes this, and how to adopt it within the construction industry.

Two years later in Lebanon, Mezher and Tawil (1998) stated that the construction industry must adopt innovative management techniques, team building and value engineering, in order to become more efficient and effective. However, the researchers did not specify their understanding of innovative management techniques, nor did they offer examples of techniques that could be used to improve team building.

In a similar vein, in Jordan, Al-Momani (2000) argued that the findings presented in his study provide good guidance for managerial intervention, but did not specify what kind of intervention, in what area of project management, and how this intervention could be put in practice on a construction site.

More recently, in Saudi Arabia, Assaf and Al-Hejji (2006) recommended contractors to consider planning and scheduling as continuing processes during construction, and to match these with the resources and time to develop the work to avoid delay, cost over-run and disputes. This necessitates some clarification as to how this could be carried out and what kind of planning tools might assist in achieving this recommendation.

And in the same year, in Hong Kong, Lo et al. (2006) recommended that comprehensive strategies need to be formulated to minimise variations, whether client-initiated or consultant-initiated, wherever possible. A clear and thorough client brief is considered the most useful strategy for reducing variations. Contingency allowances may be incorporated for inevitable variations. The question that arises here is what kind of methods could help minimising variations? Figure 1 shows the frequency of delay causes and corresponding recommendations derived from the different studies.

Discussion

To sum up, from the recommendations (Table 3), it can be clearly stated that the majority of suggestions do not contribute to problem-solving. For instance, they are neither specific to a particular problem, nor to particular causes. It can be clearly concluded that the majority of these studies did not recommend practical solutions or methods to improve the situation. Moreover, they did not explore the reasons for the causes. For example, a common delay factor is ineffective planning and controlling, yet none of the researchers examined the reasons behind this cause, which could be just one, or several, since planning may be ineffective because of inadequate planning tools and techniques and/or because of incompetent/untrained people with responsibility for formulating and facilitating the plans.

Given that problems with management in general, and planning and controlling specifically, were identified, it is to be expected that recommendations in these areas would be made, but unfortunately, the majority of studies do not provide any. Taken together, the findings from all these studies are that the problems in construction projects are either management problems or related to environment of the project. Consequently, these management problems in particular, should be understood and efforts directed towards developing solutions and more efficient methods of operation. In the next section, we consider the possibility of a deficient theory of project management, which has been largely overlooked in conventional delay studies aiming to introduce the concept of Lean construction as alternative management theory. Then, selected case study examples demonstrating the implementation of Last Planner system (the best known Lean Construction technique) will be cited. The interested readers may consult the original references.

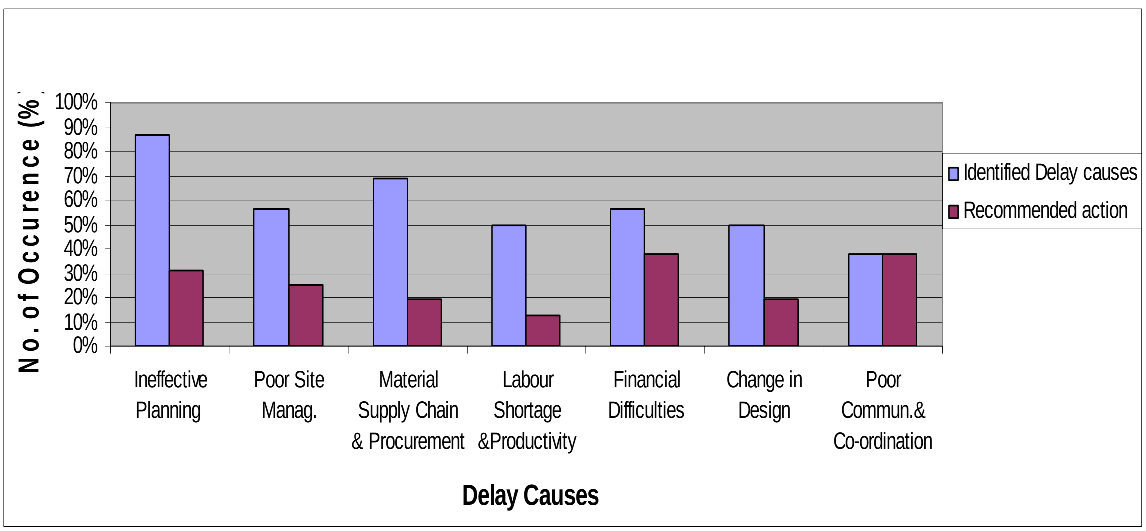


Figure 1 Frequency of Delay Causes and Corresponding Recommendations in Delay Studies

CAUSES OF DELAY AND PROJECT MANAGEMENT THEORY

Scholars (Koskela, 1992; Ballard and Howell, 1998; Santos, 1999; Koskela and Howell, 2002) argue that the theory of production control in construction is based on a deficient theory and this leads to added costs and the reduction of overall performance. Thus, in the light of the causes of delay, this paper argues that the problems are not only related to the reported causes themselves, but also to the theory of project management. Hence, the causes of delay identified in previous studies will be discussed according to the two main criticisms of the traditional theory of project management, which are: firstly, that project management theory is based on management as a planning function and not management as an organising function, and secondly, that project management theory focuses on the transformation concept without considering the flow concept.

First: Project Management Theory is based on Management-as-Planning

Construction project planning is the key aspect in managing and controlling construction projects. It is considered by many in the construction industry, as the core competence of the discipline of project management (Callahan, 1992; Harris and McCaffer, 2006; Mawdesley et al, 1997; Chitkara, 1998; Laufer, 1990; and others). Thus, for a project to be successful there is a need for effective project management, which implies better planning and control over the project.

Acting from the sense that planning is crucial; the focus here will be on the two causes of delay: ineffective planning and controlling and poor site management. The question that arises is what are the reasons behind these causes?

The PMBOK Guide divides project management processes into initiating, planning, execution, controlling and closing processes. Howell and Koskela (2004) show that the core processes of planning, execution and controlling form a closed loop (Figure 2): the planning processes provide a plan, that is realised by the executing processes, and variances from the baseline or requests for change lead to corrections in execution or changes in further plans. In other words, the emphasis is firmly on planning, and little guidance is provided on executing.

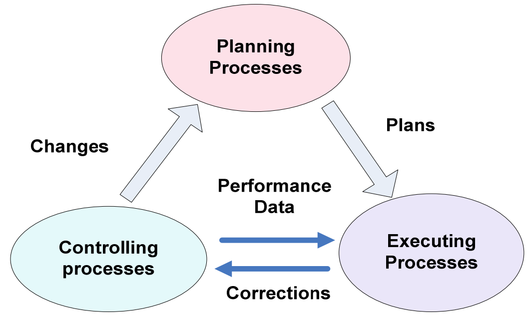


Figure 2: The Closed Loop of Managerial Processes in Project Management according to the PMBOK Guide (Howell and Koskela, 2004).

Howell and Koskela (2004) argue that the present approach to project management, as described in the PMBOK Guide, is based on two underlying theories: management-as-planning (for planning and execution) and the thermostat model (for control). They perceive the main weakness of this approach to be that it is insufficient from the viewpoint of project management reality, and argue that the practice suffers from three shortcomings:

- The role of planning is not logically defined, and short-term planning is normally poorly carried out or simply neglected.
- Execution is not managed efficiently. In other words, action is taken for tasks to be pushed by the plan without considering the real conditions as higher level plans are translated into short-term plans and then into action.
- Control is too narrowly seen as measuring and taking corrective action, rather than as a process of learning.

These claims are in agreement with Laufer and Tucker (1987), who two decades ago, pointed out that the primary internal motivation for planning is often control, rather than execution. Thus, the significance of control is corrupted by the separation of execution from planning, and in practice planning becomes a way of explaining what has happened and trying to find a way to recover.

Hence, it can be claimed that projects are delayed because of not being implemented using a theory that emphasizes control over the plans on construction sites. Poor site management may results from absence of effective short term planning and management which considered as one of the key components of site management. The difficulty is not in producing plans but in their execution, control and in keeping them up-to-date. It is the fact that plans are not properly implemented, that renders them ineffective. For example, a plan becomes ineffective when tasks are pushed by it without considering the availability of all resources. The availability of tools (i.e. Lean Construction tools including Last Planner system) would be reasonable approach to tackle this issue. The successful implementation of such tools will assists in:

- Making tasks ready before they start which could be achieved by means of look ahead plan with an emphasis on tasks flow.
- Minimising interruption in the weekly planning caused by unplanned tasks which could emerge and affect planned tasks.
- Checking of task completion and percentage planned completed weekly as well as investigating reasons for non-completions.

Second: Project Management Theory is based on the Transformation Concept and Neglects the Flow and Value Concepts

It has been well documented that construction is managed according to the transformation concept (Santos, 1999; Koskela, 2000; Koskela and Howell, 2002), in which management efforts are centred on task management. However, task management is not implemented systematically across all phases, resulting in added variability. Even where there is an intention to implement systematic task management, it corrupts, due to the high level of inherent variability, to become unsystematic management. Thus, bad control (i.e. deficient attention in control to the principles of production) across all phases, results. Koskela and Howell (2002) criticised production based transformation for its mistaken assumption that the inputs to a task and the resources to execute are ready at the time of authorisation to start it.

According to Koskela (1999), the transformation concept is helpful in discovering which tasks are needed in a project; thus, it is perfectly possible to realise projects based on this view. However, the transformation concept is not especially helpful in deciding how not to use resources unnecessarily. Instead, the principles of the flow view explain how, for example, the variability of production impacts on resource use. Koskela (2000) suggested that production could be conceptualised from three points of view: transformation (realize value-adding activities efficiently), flow (reduce the share of non-value-adding activities) and value (improve customer value). Table 4 shows the new theoretical foundation of project management which considers transformation, flow and value. Moreover, it considers management as planning, execution and control.

Table 4: Ingredients of a New Theoretical Foundation of Project Management (Koskela and Howell, 2002)

Subject of theory		Relevant theory
Project		Transformation, Flow, Value generation
Management	Planning	Management-as-planning, Management-as-organising
	Execution	Classical communication theory, Language/action perspective
	Control	Thermostat model, Scientific experimentation model

On the light of former discussion, it can be argued that in addition to the reported causes of delay, project management itself, if it follows the prescribed theory, also plays a role in project delay. This argument has been verified by evidence from the practice point of view (practical problems) and from a research perspective (criticisms of the conventional project management theory by various scholars). Thus, project management theory should consider the transformation, flow and value concepts which represent the basic fundamental concept of Lean Construction theory. This is in agreement with Koskela's argument; the Transformation, Flow, and Value (TFV) is the most acceptable theory of production available (Koskela, 2000).

DISCUSSION

Based on findings from previous delay studies, it can be concluded that there are two arising important issues:

1. Poor implementation of the existing project management methods and practices in developing countries due to lack of development and training.

2. Existing project management methods and practices contended to lead to self-inflicted problems because they stand on inadequate theory.

Such above findings suggest several courses of action for planning practice in construction. The most significant is that there is a definite need for tools or techniques that take into account the two strands of criticism against the conventional theory of project management (management-as-planning and not as organising and focusing on the transformation concept and neglects flow). In this respect, Howell and Koskela (2000) stated that “in the present big, complex and speedy projects, traditional project management is simply counterproductive; it creates self-inflicted problems that seriously undermine performance”. Accordingly, addressing these two criticisms to project management provides for one possible starting point for improvement. As this paper argues that the utility of further traditional studies on delay is limited, it recommends that rather than solely explanatory research, constructive and action research (Jarvinen, 2007) need to be implemented to the construction management more efficiently. This can assist in achieving the following purposes (Alsehaimi and Koskela, 2008):

- To explore the industry problems such as delay causes, low productivity and others and then working to overcome such problems.

- Such research methods may help in improving the practice and tackle some of the managerial problems.

- Contribution could be made to improve the practical concerns of people in practice and the theory of construction project management.

Evidently, the implementation of some Lean Construction techniques such as the Last Planner approach to construction planning in different developing countries (Junior et al., 1998, Fiallo and Revelo, 2002, Thomassen et al.2003, Lim et al, 2006) can be pinpointed as examples of such constructive and action research.

CONCLUSION

In this paper, a simple quantitative analysis of the findings and recommendations in different studies of delay has been carried out. The outcome of this analysis shows that the findings on causes revolve around two issues, management and project environment, and that recommendations only in a rather limited way contribute to problem solving. In addition, the recommendations do not match the findings. Moreover, it is contended that delay studies do not reach one of the root causes to problems, namely that the theory of project management is inadequate. Thus, it can be argued that the utility of conducting more traditional studies on delay is limited, as their contribution to knowledge and practice is modest at best. In this context, this paper recommends that rather than solely explanatory studies, Lean Construction techniques could be successfully implemented in non-traditional research approaches such as constructive and action research to enhance the performance of the practice, contribute to knowledge and tackle some of the persistent managerial difficulties in construction.

REFERENCES

Abdul-Rahman H.; Berawi M.; and Othman M., (2006). Delay mitigation in the Malaysian construction industry, J. Constr. Eng. Manage., 132(2):125-133.

Alghbari, W., Kadir, M., Azizah, S. (2007). Factors causing delay of construction projects in Malaysia, J. of Eng., Constr. and Archit. Manage, 14(2):192-206.

Al-Moumani, H. A. (2000). Construction Delay: A Quantitative Analysis, Int. J. of Proj. Manage., 18(1):51-59.

Alsehaimi A. and Koskela L. (2008). Critical evaluation of previous delay studies in construction, proceedings of 8th international postgraduate conference, Prague, Czech Republic, June 2008.

Arditi, D., Akan, G., and Gurdamar, S. (1985). “Reasons for Delays in Public Projects in Turkey”, J. of Constr. Manage. and Econ., 3(2):171-181.

Assaf, A., and Al-Hajjij, S. (2006). “Causes of delay in large construction projects in Saudi Arabia”, “Int. J. of Proj. Manage”, 24(4): 349-357.

Assaf, S., AL-Khalil M., and Al Hazmi M. (1995). Causes of Delay in Large Building Construction Projects. J. Manage. Eng., 11(2): 45-50.

Ballard G. and Howell G. (2003). An update to Last Planner, Proceedings of the 11th IGLC Conference, Virginia, USA.

Ballard, G. (1999). “Improving Work Flow Reliability”, Proceedings of the 7th IGLC Conference, 275– 286.

Ballard, G. (2005). “Construction: one type of project-based production system”. In: Proceedings SCRI Forum Event Lean Construction: University of Salford, Salford.

Ballard, G., and Howell, G. (1998) Shielding production: essential step in production control, J. Constr. Eng. Manage., 124(1):11–17.

Ballard, G., Howell, G., and Casten, M. (1996). “PARC: A Case Study”, Proceedings of the 4th IGLC Conference, Birmingham, England.

Bertelsen S. and Koskela L. (2002). Managing the Three Aspects of Production in Construction, Proceedings of the 10th IGLC Conference, Gramado, Brazil.

Callahan, M. T., Quackenbush, D. G., and Rowings, J. E. (1992). Construction Project Scheduling, McGraw–Hill, New York.

Chan, D., and Kumaraswamy, M. (2002). Compressing Construction Durations: Lessons Learned From Hong Kong Building Projects, Int. J. of Proj. Manage., 20(1):23-35.

Chitkara, K. (1998). Construction Project Management: Planning, Scheduling and Controlling, Tata McGram: London.

Cooke, B., and Williams, P. (1998). Construction planning, programming and control. London: Macmillan.

Faridi, A. S., and El-Sayegh, S. M. (2006). "Significant Factors Causing Delay in the UAE Construction Industry,” Constr. Manage. and Econ., 24(11): 1167-1176.

Fiallo, C., and Revelo, V. (2002). "Applying the Last Planner Control System to a Construction Project: A Case Study in Quito, Equador”, 10th IGLC Conference, Gramado, Brazil

Fimpong, Y., and Oluwoye, J. (2003). “Significant factors causing delay and cost overrun in construction of groundwater projects in Ghana”, Construction Research, 1(2):175-87.

Harries, F., and McCaffer, D. (2006). Modern Construction Management, 6th Edition, Blackwell Science, London.

Howell, G., and Koskela, L. (2000). Reforming project management: the role of Lean Construction. Proceedings of the 8th IGLC Conference, Brighton, UK.

Howell, G., and Koskela, L. (2004). Reforming project management: the Role of planning, execution and Controlling, 9th IGLC Conference, Singapore.

Järvinen, P. (2007) Action Research is Similar to Design Science, Quality and Quantity, 41(1):37-54.

Junior, A., Scola, A., and Conte, A. (1998). “Last Planner as a Site Operations Tool”, Proceedings of the 6th IGLC Conference, Guaruja, Sao Paulo, Brazil.

Kaming, P., Olomolaiye P., and Harris F., (1997) Factors influencing construction time and cost overruns in Indonesia, J. Constr. Manage and Econ., 15(1): 83-94.

Koskela L. and Howell G. (2002). The underlying theory of project management is obsolete, Proceedings of Project Management Institute Research Conference.

Koskela, L. (1992). The Application of new Production Philosophy in Construction, Technical report, No.72, Stanford University, Stanford, California.

Koskela, L. (1999). Management of Production in Construction: a Theoretical View, Proceedings of 7th IGLC Conference, Berkeley, USA.

Koskela, L. (2000). An Exploration into a Production Theory and its Application to Construction. Doctoral Thesis, VTT Publications, VTT, Espoo.

Koskenvesa, A., and Koskela, L. (2005). Introducing Last Planner: Finnish Experiences, CIB Conference, Helsinki, Finland.

Koushki P., Al-Rashid, K. and Kartam, N. (2005). Delays and cost increases in construction of residential. projects in Kuwait, Constr. Manage. and Econ., 23(3):285–294.

Laufer, A. (1990). Essentials of project planning: Owner’s perspective, J. Manage. Eng., 6(2):162-176.

Laufer, A. and Tucker, R. (1987). Is Construction Project Planning Really Doing its Job? Constr. Manage. and Econ., 5(3): 243 - 266.

Lewis, T., and Atherley, B. (1996). Analysis of construction delay, The organisation and management of construction: shaping theory and practice (Vol.2), Edited by Longford and Retik, Published by E and EN Spon, 1996.

Lim, C., Yu J., and Kim, C. (2006), Implementing PPC in Korea’s Construction Industry, Proceedings of the 14th IGLC conference, Santiago, de Chile.

Lo, T. Y., Fung, I. W., and Tung, K. C. (2006). “Construction Delays in Hong Kong Civil Engineering Projects.” J. Constr. Eng. Manage, 132(6):636-649.

Long, N., Ogunlana, S. and Quang, T., (2004). Large Construction Projects in Developing Countries: a case study from Vietnam, Int. J. of Pr. Manage, 22(7):553–561.

Mansfield, N. R., Ugwu, O. O., and Doran, T. (1994). Causes of delay and cost overruns in Nigerian construction projects. Int. J. of Pr. Manage., 12(4):254-260.

Mawdesley, M., Askew, W,. and O’Reilly, M. (1997). Planning and Controlling Construction Projects, Addison Wesley Longman Limited, London.

Mezher, T., and Tawil, W. (1998). Causes of delays in the construction industry in Lebanon, J. Eng., Constr. and Archit. Manage., 5(2):252-260.

Odeh, A. M., and Battinah, H. T. (2002). Causes of Construction Delay: Traditional Contracts, Int. J. of Proj. Manage., 20(1):67-73.

Ogunlana, S. and Promkuntong K. (1996). "Construction delays in a fast-growing economy: comparing Thailand with other economies". Int. J. of Proj. Manage., 14(1):37-45.

Santos, A., dos (1999). Application of Flow Principles in the Production Management of Construction Sites, PhD Thesis, School of construction and Property management, University of Salford, 463 pp.

Sweis, G., Sweis R., Abu Hammad, A., and Shboul A. (2008). Delays in construction projects, the case of Jordan, Int. J. of Proj. Manage., 26(6): 665-674.

Thomassen, M., Sander, D., Barnes, K., and Nielsen, A. (2003). Experience and results from implementing Lean Construction in a Large Danish contracting firm, proceedings of the 13th IGLC Conference, Virginia, USA.

PFI: AN UNDERSTANDING OF PUBLIC AND PRIVATE SECTORS THROUGH FINANCIAL MODELS

Hagir Hakim
Heriot-Watt University School of Built Environment
h.hakim@hw.ac.uk

This paper is an investigation into the two main financial models of the Grove Village PFI project: the public sector model that has been prepared by the local authority client (Manchester City Council) based on public assumptions and the private sector Harvest Housing model based on assumptions from all the private stakeholder organisations. The aim of the analysis is to provide a deeper understanding of the sources of risk and their management from the perspective of each stakeholder. Cross comparison between the two models will extract the key differences between the two models and in turn between the perception of different parties of the same project. Interviews with all stakeholders and in-depth documents analysis were used to identify and examine the underlying reasons for the "gap" in assumptions between the initial public model and the private model n the Grove project. These reasons include project scope/role of the partners, objectives of the parties, contractual and financial issues and unforeseen conditions.

Keywords: PFI, Financial Modelling, Social Housing

BACKGROUND ON PFI

Despite being around for almost fifteen years the validity of PFI as procurement option for public services remains controversial. The main concern with PFI is that it arguably provides an opportunity for huge profits for the private sector without direct improvements in the public services provided, all at the expense of tax payers. According the treasury statistics, in April 2008, 628 PFI projects has been signed in different sectors including health, education, transport, public buildings and housing, with a total value of £77.8 billion. Although the National Audit Office has produced several reports on PFI, there has never been a single assessment exercise of PFI performance to date. There are several reasons for this the most important being the confidentiality with which the private sector involved handles their accounts. Different sectors and the time span involved also means that assessment is done on a project by project basis. (Broadbent (1999), Shaoul (2001), Akintoye (2003), Demirag et al (2004).Some of the main justification for the use of PFI to deliver public sector projects rest on transfer of risk, increased innovation, higher standards and better efficiency. However in their report on PFI in hospitals and roads, Shaoul et al conclude that very high risk premium is paid only to ensure that projects are delivered to budget and within time. They also demonstrate that innovation is limited to ensuring timely delivery to avoid penalties and finally projects have not been around long enough to determine a sufficient level of efficiency during operation.

The nature of PFI/PPP projects implies the involvement of two main parties: public sector body and a private sector organisation. These two bodies have different often contrasting aims: the public sector is seeking to provide a service with maximum efficiency and minimum cost to ensure value for money, and private sector bodies want to maximise their profit possibly through greater efficiency and also through financial structures.

PFI in the Social Housing Sector

The UK social housing sector has diminished considerably and now accounts for less than 20% of the overall housing sector. Today the sector is made up of a large amount of poor quality housing occupied mostly by unemployed, retired and economically inactive households and a large proportion of younger and older households. The sector suffers from two main problems:

- Lack of investments: the 2004 English House Condition Survey identified a £19 billion backlog of disrepair in the local authority housing sector alone.
- Lack in high quality management practice: non efficient housing management has resulted in poor quality housing with low demand and lack of choice.

Of all options available for local authorities to deliver social housing involve some sort of government subsidies. PFI is the sole route to providing social housing without reliance on the highly constrained government funding. A PFI social housing contract is an agreement between the local authority and another party that undertakes to refurbish all properties within the scheme up to a defined Standard and maintain them at or above the standard for the duration of the contract term (thirty years). The party will receive an annual payment "PFI credits" based on performance throughout the contract term.

The government started a pathfinder programme to test the viability of PFI or PPPs to fund social housing projects in 1998. Since then, thirty two projects have been identified and approved by government for PFI funding. Despite this only 6 projects have since been sanctioned, with most projects still under negotiations and few totally abandoned. In addition to problems and uncertainties involved with PFI projects in general, social housing PFI projects are further complicated by the conflicting economic and social elements involved in them. The reason is that social housing, by definition, implies a funding gap between tenants (who pay rent below the market rate) and private investors (who require the market rate of return). The conflicting objectives of public and private sector parties, the high level of perceived risk and the nature of projects have made it very difficult for parties to reach agreement in most projects. Private investors face the challenge of providing value-for-money public facilities and services through innovative economically viable means. The government faces the challenge of enabling and facilitating the private sector to perform public functions in a socially responsible fashion. The process is onerous for both parties with contracts taking over 8 years to reach signature at a bidding cost that can reach over £4 million in some cases.

Grove Village PFI Project

The Plymouth Grove/Stockport Road estate lies at the edge of Manchester City Centre just under a mile (1.5km) from the City Centre. The estate is bounded by some of the City's main arterial routes and a strategic public transport corridor. The estate is made of 1090 social housing units, owned by Manchester City Council; 62 former social housing units, now owner occupied; and 43 English Churches Housing Association units As with a large number of social housing estates in the UK, the Estate has not benefited from any significant capital works since first constructed in 1974 and had been falling into progressively worse disrepair. The estate had high vacancy levels which generated a high cost to the City Council to keep homes available and secure vacant ones. The general environment is run down and

intimidating and has actually become a centre for crime both in the residential and commercial parts.
The project proposes a contract with a private sector partner to refurbish, manage and maintain 661 housing units over a 30 year period. The main objective of the local authority is to enhance the area image and increase demand for properties in the area. This is to be achieved through the remodelling to improve access and circulation; the provision of green areas, improving security to reducing crime. The project involves the demolition of about 40% of the existing homes to make way for new private homes for sale and a better environment. This provides additional income to the private party which will result in reducing the unitary charge. This will also create social mix by attracting tenants other than social housing to the area. The Project Area also includes: retail units, an educational and social centre, a nursery, public houses and a church. These amenities and services need to be integrated into the regeneration and redevelopment effort. The local authority remains the landlord and retains the responsibility of rent setting.
Grove Village was the first pathfinder to reach signature. It took 5 years for the contract to be signed. An initial report (Puckett, 2004) of one the sector's first PFI projects, the Grove Village PFI in Manchester, reveals: 1) 298 performance indicators to be met on a monthly, quarterly or annual basis; 2) fearsome negotiations to the spread a PFI project's risk between all the parties involved; 3) a 232-page project agreement, and 4) more 300 signed documents.

Grove Village PFI Financial Models

NAO (2008) defines financial models used in PFI project appraisal as 'spreadsheets designed to show the financial outcome of a particular set of estimated costs, revenues and fixed and capital charges for delivering a service over time'. Public and private parties to a PFI project, each construct a financial model during appraisal in order to set up and test a project's financial structure that will meet their objectives, help evaluate different project options, and develop the best solution during negotiations. The two main parties in Grove Village PFI project are: Manchester City Council and Grove Village Consortium (referred to hereafter as the public and private models respectively).

Public Sector Model

The local authority used three different financial models in Grove Village project appraisal:

Model 1: is used calculate total project costs and revenues. Cost breakdown includes details of refurbishment and capital repairs requirements, new build costs, cost of re-planning the area, provision of roads, green areas, demolition costs and management and maintenances costs. Revenues include proceeds of land sale for properties that are demolished and proceeds of sale of properties that are phased out of contract.

Model 2 (PFIPSC Model) is used to perform the public sector comparator test. This model is used for an options appraisal exercise where different options for delivering the project are appraised. These options include: retaining properties within the local authority's ownership and management, large scale transfer to a housing association or PFI. Total net present value (NPV) of each option is deduced and divided by project duration to arrive at annual cost to local authority. Annual cost (unitary charge in the case of PFI) is compared to arrive at the option that offers maximum value for money. It has to be noted that this exercise is about calculating the cost TO the local authority and not the project cost per se.

Model 3 (MCC HRA Affordability Model): is used to test the affordability threshold of the local authority. This means testing if local authority through its Housing Revenue Account (HRA)and government subsidies should be able to sustain the unitary payments demanded by the private sector party over the project term of 30 years.

Private Sector Model

The primary objective of the private party is profit and they need to forecast potential returns against their expenditure to ensure they can make the required level of returns. The private sector party uses their model to:

- ensure there is sufficient cash to meet anticipated demand
- determine the level of unitary charge required annually from the local authority to cover their expenditure and meet their profit requirements
- provide a guide to lenders on project's cashflow robustness
- assess project profitability and level of returns

Private and Public Sector Financial Model Comparison

The key areas where differences can be seen between public and private sector models as discussed in the following sections.

Input Assumptions

The results and outputs of a financial model are highly dependent on the inputs and assumptions made by the financial modeller. The resulting outputs in the form of investment criteria such as NPV or IRR are limited by those assumptions (Shaoul, 2002). The public sector party needs to estimate the cost of the project to the private sector party in order to deduce the level of unitary charge required. The private sector party needs to place a bid that is within or as close as possible to the affordability level of the local authority.
Model inputs and assumptions are seen to vary widely between the public and private sector parties. Some areas of major disparity will be discussed in the following sections.

Project Scope

One of the main areas that created this disparity is the difference in treatment of land remaining after demolition of properties.

Table1 – Project Scope as defined in public and private sector financial models

<table>
<tr><th colspan="2">Project Scope in Public Sector Model</th><th>Project Scope in Private Sector Model</th></tr>
<tr><td>Year 0</td><td>1091 Properties at Contract Start</td><td>1089 Properties at Contract Start</td></tr>
<tr><td>Year 1</td><td>Demolish 430 properties& sell land</td><td>Demolish, 430 properties</td></tr>
<tr><td>Year 2
Year 3</td><td>661 properties in local authority ownership and subject to PFI contract</td><td rowspan="2">Rebuild and sell 615 private properties
Construction Cost = £21M
Property Sale Revenue =£49.5M
(Net Revenue = £28.5M)</td></tr>
<tr><td>Year 4
Year 5
Year 6
Year 7
Year 8</td><td>Demolish, Rebuild Sell 32 properties /annum

Net property sale Revenue to LA = £0.398M</td></tr>
<tr><td>Years 9 -30</td><td>500 properties remain in local authority ownership
591 private properties within project area</td><td>663 Properties are refurbished, remain in local authority ownership
615 private properties within project area</td></tr>
</table>

Project scope as defined in public and private sector financial model is described in table 1.The private party assumed land will be used to rebuild properties as new private housing for sale. The public sector party assumed land from properties demolished in year 1 will be sold in the same year. An additional set of properties will be phased out of contract (demolished) at the rate of 32 properties per annum (in years 4 to 8). These properties will be rebuilt and sold through a private developer. Proceeds from the sale will be retained by the local authority and split equally to offset unitary charge, pay private developer and deliver community benefits.

A disparity can be seen between public sector initial requirements and final solution provided by the private sector party. (Difference between total numbers of properties is attributed to the fact that the private sector party redesigned the project area). Consequently cost and revenue assumptions varied widely between the two parties.

The cost of new build properties in the private sector model was assumed to be about £21m and revenue generated from proceeds of sale in excess of £49.5m including the sale of key worker accommodation and retail units. Therefore net revenue from sale of private units is about £28.5m. Because this revenue contributes to the private party's final profits, the amount of unitary charge required from the local authority can be reduced.

Cost and Revenue Assumptions

Figure 1 shows the annual cost assumptions of the two parties for the project duration. There is a consistent difference between total costs in the two financial models with the private sector assuming higher costs than the public sector throughout. This difference can be attributed to:
Cost of area redevelopment such as redesign of roads and paths was not considered in the public sector model.
The private sector party include the cost of insurance and the cost of SPV management (£5.8m). These costs are not accounted for in the public sector model,
Although both parties have included a provision for transaction costs the estimate also varies widely between the two parties. In the public sector model the assumption is for a transaction cost of (£1.25m). In the private sector model transaction costs are shown in detail such as legal fees, advisory fees etc to a total of (£2.8m) which is more than double the cost assumed by the public sector.

Overall private sector total costs are £59M while the public sector estimate for total project costs is £27.3M (both costs are discounted at the same rate of 8.65% annual and include capital, management and maintenance costs). The public sector assumes less cost for the same items than the private sector. It is thought that the public sector model includes a high element of optimism bias. Bids have come in much higher than the Local Authority estimate and central government did increase the level of PFI credits than what was initially awarded to Manchester City Council. Although the private party is also bidding to win the contract they still have to remain realistic so that they do not commit to a non financially viable project.

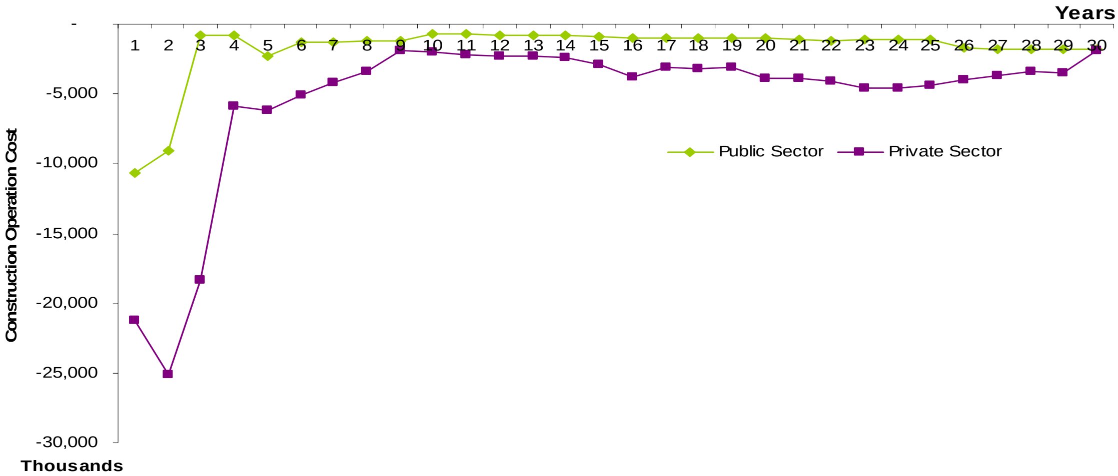


Figure 1 - Public and private sector costs over project duration

Another difference between the two models is the large gap between the two curves in the first 4 years of the project. This is largely due to difference in project scoping between the two parties i.e. private major new build programme against the publics land sale programme.

Another difference between sectors is the nature of capital refurbishment works. According to the public sector model there will be an ongoing periodic capital programme throughout the 30 years project duration in addition to the initial refurbishment works programme. The periodic capital works programme is designed to complete a particular type of works at certain project periods. For example kitchens and roofing for all properties will be refurbished between years 5 to 10 and bathrooms from years 21 to 30. The private sector party assumes a major capital refurbishment programme from years 1 to 3 that includes all types of works for all properties in the project. For the remaining project term only routine maintenance and management works are envisaged.

In general it can be seen that the public sector party has given details of their requirements in terms of the type of works they expect such as decoration, kitchens, windows, door, landscape, roads etc. The private sector party gives an overall cost simply broken down into new build, refurbishment, site clearance and infrastructure. This distinction is due to the difference between requirements of the two parties: the public sector is concerned with level of refurbishment while the private sector party needs to keep costs details confidential from the client to gain possible cost advantage in certain items during the bidding process.

In the private sector model assumptions for the sale price of properties are given more accurately with different sale costs for different property types, while the public sector party gives an average sale price per property. Still the average value per property in the private model is £59.6k which is almost double the public sector assumption of £30.2k.

Project Funding

From the perspective of a local authority PFI represents a means for using private finance to renovate social housing without the need for large, up-front capital payments (Grubnic and Hodges, 2003). PFI comes under the broad heading of private finance which involves raising finance against expected projected future revenues (Grimsey and Graham, 1997). From the perspective of the private sector consortium this means that they need to create a financial structure with minimal recourse to the sponsors while satisfying lenders against credit risk (Grimsey and Graham, 1997).

The cost of finance is a significant cost in any privately financed project due to the non recourse high risk nature of such projects (in the case of Grove Village accounted for 15% of total project cost). Therefore omitting the cost of finance can greatly distort the view of the project's profitability and viability.

Project finance also gives rise to a series of decisions about repayments and raising of finance such as interest rate, debt repayment profile (annuity or sculpting), capitalising or rolling interest, creating reserve accounts and making transfers. All these activities involve decisions which have a major impact on the project's cashflow stream and profitability.
The public sector did not include any calculations on project funding and their cashflow was based on project revenue and cost only. This omission resulted in a significant part of difference in the value of the unitary charge calculated the public and the private sector.

Cashflow in Public and Private Sectors

The outputs for both models are the project net present value and internal rate of return. Additionally in a project with limited recourse finance lenders look primarily at the project's cashflow robustness to determine whether their loans will be repaid. Harries (1990) defines project finance as lending to a project in which the lender expects to be repaid only from the cash flow generated by the particular self liquidating project.

An important issue that needs to be considered is the time value of money or discounting process. PFI projects similar to Grove village run for 30 years. The financial model is a forecasting tool used before contract signature and therefore to represent cashflow in real terms cash needs to be discounted using an adequate discount factor that reflects both time value of money and the risk involved in the project.

The public sector model does not show a lot of consideration for timing of cash and generally they assume an overall total cost or total revenue which is divided by the number of years to deduce an annual cost. In reality costs and revenues will be paid and acquired according to project development and programme.

The private sector model goes into great detail to show the incomings and outgoings of cash as well as the timing of payments. The private sector model tries to achieve this in several ways:
By dividing the model into two distinct phases reflecting different cash treatment and nature. In the first three years the project is divided into monthly periods to reflect the major construction works ongoing and the resulting high and variable demand for cash. The second stage extends from the fourth year to the end of the project. At this stage works are limited to the provision of management and maintenance services and the model is divided into semi annual intervals to reflect a steadier and more stable demand for cash.
The private sector model includes additional considerations for cash management such as:
Reserve accounts which need to be sustained by the cashflow to ensure the project can meet its obligations to creditors and has sufficient reserves for future operations.
Working capital is included in the cashflow calculations and covers all aspects of both current assets and current liabilities, so as to minimise the risk of insolvency while maximising return on assets. The private sector model also includes details of the profit and loss account and balance sheet. This is to ensure that there are no areas of hidden cash which may question the robustness of the cashflow.

In the private sector model incomings and outgoings of cash are in line with the project programme for added accuracy. Revenue is calculated in each period for properties that have been completed in the preceding period. Unitary charge payments are made in accordance to number of properties to be made available and offering full service as shown in the project programme. Costs are calculated based on the number of properties to be refurbished or built at any period. Other time related cashflow items include payment of loan fees made at financial close as well as payments into the reserve accounts.

Public and Private Sector Model Outputs

The objectives of the two parties from their financial models are clearly different. The public sector party is interested in assessing the unitary charge payments and their affordability while the private sector party is interested in assessing profitability or shareholders returns while maintaining lenders requirements or constraints. The public model is designed to make very simple calculations aimed at computing project NPV unitary charge.

The private sector model is more sophisticated giving a range of output criteria such as project IRR and shareholders IRR. Cover ratios such as Loan Life Cover Ratio (LLCR) and Debt Service Cover Ratio (DSCR) are also calculated as outputs as required by lenders to determine project's ability to repay debt.

Risk Modelling by the Public and Private Sectors

The project appraisal process naturally involves a degree of forecasting and as such decisions at appraisal stage are made under uncertainty. Organisations try to find ways to predict project outcomes taking into account the uncertainty associated with construction, operation, interest rate, inflation, maintenance costs etc. such that all major risk factors are included in project appraisal and assessment In order to ensure project completion, most organisations have to engage in risk management in some form or another. Although both public and private financial models did not include any risk analysis, both parties have engaged in some form of risk management to ensure their objectives will be met. Below is a discussion on each party's approach to risk management.

Public Sector Risk Management

The public sector party is required to prepare a risk report to be submitted to central government as part of their outline business case. For Grove Village risk management process in this report was limited to a risk identification exercise with elementary risk analysis that outlines probability of occurrence (high/low) and impact (high/low). The two main risks identified by the local authority were to lose central government bid (no PFI credits awarded, PFI unaffordable) and lack of private sector interest in the project (low competition high cost).

Interviews by the author with Manchester City Council PFI project manager, showed that the public sector party was confident that if the private sector bids were too high the central government would grant additional funding. On this basis the main challenge for the public sector is to win the bid for credits from central government. The public sector therefore had an incentive to minimise the required level of unitary charge calculated in their model which explains the very low unitary charge calculated in public sector model
The other area of concern for the public sector party became to ensure the project is marketable by providing the private party with a project that is profitable and bankable. The

risk in this case is that there will be no or little interest in the project and that the PFI option is removed or project costs become too high due to lack of competition. In order to maximise competition the local authority does not disclose its affordability level to potential private sector bidders. Although bankability and profitability are both issues that can be assessed by using a financial model, the local authority did not carry out this exercise.

Private Sector Risk Management

Two risk assessment exercises were carried out by the private sector party:
A qualitative assessment by the bidding consortia: this assessment did not rely on a formal analysis of risk and was limited to risk identification
A quantitative assessment: this was carried out by lenders who need to ensure the debt will be repaid under worst case scenarios. This assessment was a sophisticated risk analysis exercise using Monte Carlo simulations.

Several mechanisms were used to mitigate project risks to lenders and consortia such as swaps to mitigate interest rate risk, guarantees to mitigate risk to lenders and project revenue risks and reserve accounts maintained by the private party's to ensure that debt is repaid and maintenance and management obligations are met. The main risk that had to be retained by the private parties was delay to construction works which can result in delay in receiving revenues from house sales and revenues from local authority unitary charge payments.

CONCLUSION

The model used in any particular situation depends on the purpose for which the model is required'. Generally spreadsheet models flow from inputs through calculations to results or outputs. The logic behind this is that objectives drive the results required, results drive calculations and calculations drive the required inputs (Read and Batson, 1999). This can be clearly seen in the two different models used to appraise the Grove Village project where each party created a model in line with their objectives. The result was two completely different views of the same project. Public sector objectives are to appraise different procurement options and to assess affordability while private sector party's objective is to maximise profit within lenders constraints.

Ho (2004) asserts that *'all models belonging to the same set of assumptions will be consistent with each other'*. Therefore consistency is largely missing from Grove village public and private sector models. Both parties require cashflow calculations that rely upon input assumptions on the same three variables: project scope, costs and revenues. Assumptions on these variables differ widely between the public and private sector parties and this can be largely attributed to the different nature of the parties. The most obvious aspect of this difference is the project scope particularly the utilisation of commercial opportunities by the private sector which accounted for £31million of difference in project revenue. . the definition and treatment of periodic works accounts for about £20milion of difference while refurbishment works account for about £12 million of difference. The result is that the unitary charge calculated in the public model is half of the charge calculated by the private sector party and the actual charge agreed at project financial close.

The local authority has an incentive to reduce the unitary charge to ensure they win the bid for PFI credits from central government in the hope that once they win the bid the government will increase the level of PFI credits to meet contract requirements. In this way they are sure to meet their primary social objective of community improvement. PFI enables the private party to innovate and exploit possible commercial opportunities for the benefit of all parties involved. The main problem then is that the lack of realism in the local authority's view of the project becomes a barrier to marketing the project to the private sector which perceives high risks attached. Additionally the process of negotiation is prolonged and becomes complicated because of the wide gap between the two parties that needs to be closed.

Central government through its Department of Communities and Local Regions concludes from its own audits of PFI pathfinders that a clearer understanding of objectives of each party is vital to the success of a PFI project. The nature of PFI involves delivery of a certain expected outcome for parties of a very different nature (public and private) and as such Local Authorities need to be clear about the outcome they desire of their schemes and make sure that bidders understand this vision at outset. Similarly Local Authorities need to clearly understand the market objective and pressure on the private sector to try and maximise profits.

REFERENCES

Adair A. (1998) Accessing Private Finance: The Availability and Effectiveness of Private Finance in Urban Regeneration, Royal Institute of Chartered Surveyors, London

Akintoye A., et al (2003) Achieving best value in private finance initiative project procurement, *Construction Management & Economics*: 21, 5, 461 – 470

Barker K. (2004) *'Delivering stability: securing our future housing needs'* at www.barkerreview.org.uk

Broadbent J., Laughlin R. (1999) The Private Finance Initiative: Clarification of a future Research Agenda, *Financial Accountability and Management*, 15, 2, 95-115.

Froud J., Shaoul J. (2001) Appraising and Evaluating PFI for NHS Hospitals, *Financial Accountability and Management*, 17, 33

Grimsy D and Graham R, 1997, PFI in the NHS, *Engineering Construction and Architectural Management*, volume 4, issue 3, pp 215 – 231

Grubnic S. and Hodges R. (2003) Information, Trust and the Private Finance Initiative in Social Housing, *Public Money and Management*, 13, 3, 177-184

Ho T., 2004, The Oxford Guide to Financial Modelling, Oxford University Press, Oxford,

Padiyar V. et al, 2008, *Financial Models as a Tool in PPP projects*, available at http://persmin.nic.in/otraining/undp_modules/PPPID/

Pfaff P, 1989, *Financial Modelling*, Allyn and Beacon

Puckett, K (2004). "Work to rules (private finance initiative)", *Housing Today*, 28, 30-31

Read N and J Batson, 1999, *Spreadsheet Modelling Best Practice*, Business Dynamics, IBM

THE ECONOMICS OF PARTNERING

Johan Nyström
Confederation of Swedish Enterprise*, Sweden
johan.nystrom@svensktnaringsliv.se

A theory of partnering in the construction industry from an efficiency perspective is absent. Some conceptualisations of partnering have been made but they are lacking in precision. Based on empirical observations and contract theory, the existence of partnering can be theoretically justified as efficiency enhancing in two ways. The first way of understanding partnering covers the case where it is used in combination with an incomplete contract. Similar to a relational contract, partnering can then be seen as something that neutralises opportunism. The second and more innovative interpretation is based on paradoxical observations of partnering and complete contracts from the Swedish construction industry. Partnering is in this case interpreted as something that incorporate reciprocity, which facilitate renegotiations of complete contracts when new information arrives. Hence, partnering lowers transaction costs and enhances the probability of pareto-sanctioned renegotiations.

KEYWORDS: partnering, contract theory, relational contracting

INTRODUCTION

The U.S. Army Corps of Engineers used structured partnering to avoid litigation in the 1980s (Gransberg et al. 1999). Since then at least three governmental initiatives have been taken in Europe to endorse partnering as a way of improving problematic construction industries. Both the Latham report (1994) and the Egan report (1998) have, in a powerful way, promoted partnering in the UK. Similar schemes have been introduced in Denmark by By- og Boligministeriet (1998) and in Sweden it has been promoted in several governmental reports (SOU 2000:44; SOU 2002:115). The concept has also been a frequent topic in construction managerial journals in recent years (see Naoum 2003 for an overview). Most of this work is done with an optimistic view about the consequences of partnering, adding to the growing consultancy literature on the subject, which by nature is even more optimistic. One important question is then whether partnering should primarily be seen as a new fad or, if partnering can be given a theoretical explanation, from an efficiency perspective. The aim of this article is to approach partnering from the perspective of economic theory in order to find logical explanations for the advantages of using partnering in construction projects. Human or cultural intentions of partnering are disregarded in this paper.

In the theoretical literature partnering has usually been seen as a part of an incomplete relational contract and as a way of neutralising the risk of opportunism when there is an incomplete contract. An empirical study of partnering in maintenance contracts in Sweden (see Nyström, 2005a) has, however, shown that partnering is also used when the contracts

* The views expressed in this paper do not reflect those of the Confederation of Swedish Enterprise. The paper was written at the division of Building and Real Estate Economics, Royal Institute of Technology (KTH).

incorporating partnering are relatively complete, and when the risk for opportunistic behaviour is rather small. A new theoretical explanation of partnering must therefore be found that can explain the combination of partnering and (relatively) complete contracts. The hypothesis developed in this article is that new information and changes in circumstances create a need to reduce the cost of renegotiations during the contract period. Partnering, which fosters reciprocity, can then be seen as a way of facilitating renegotiations for risk-averse clients.

This paper argues that there are two different types of settings in which partnering is used from the perspective of contract theory. One is to reduce opportunism in the standard incomplete relational contract and the second one is to reduce the cost of renegotiations in relatively complete contracts.

The paper begins by introducing the concept of partnering, which is followed by an interpretation of partnering as a relational contract. Based on observations in the Swedish construction industry a further explanation of the concept combined with a complete contract is given. This combination is then illustrated in a game theory setting and the last section concludes.

CLASSIC PARTNERING IN THE CONSTRUCTION INDUSTRY

Partnering has been portrayed as both the saviour of an ailing construction industry and as another trendy term to describe “common sense” business relations. There are numerous definitions of partnering and, despite the fact that they point in a similar direction, there is no consensus of how the concept should be defined. For this multifaceted concept a general definition, given necessary and sufficient conditions, is problematic, but a common starting point for discussing of partnering is still needed. A possible solution is offered in Nyström (2005), which presents a flexible but structured definition based on Ludwig Wittgenstein’s idea of family resemblance. According to that paper a partnering project always includes trust and common goals and some of the additional components such as economic incentive contracts, relationship-building activities, continuous and structured meetings, facilitators, choice of working partners, predetermined dispute resolution methods and openness.

The main difference between a traditional construction project and a partnering project is that the latter strives for incorporating a more positive interaction between client and contractor. Partnering is often characterised as proactive, whereas regular construction projects are reactive concerning problems that might arise.

There have been some attempts to conceptualise partnering in models, e.g., Crowley and Karim (1995) and Cheng and Li (2001). Crowley and Karim use an organisation theory approach and make a good point in seeing the partnering group as a new organisation. Cheng and Li develop a process model supported by an empirical survey. However, both papers are somewhat lacking in precision concerning the gains that partnering leads to.

Partnering, as used in the construction industry and construction managerial journals, has not yet been analysed from an efficiency perspective within a contract theoretical, or transactions cost setting, and the basic purpose of this paper is to present such an analysis.

PARTNERING AND RELATIONAL CONTRACTING

Coase (1937) posed the question of what determines the boundaries of the firm, a question that could not be answered by the neoclassic theory, where the firm was seen as a black box transforming inputs to outputs. Transaction costs came up as an explanation, which presupposed a theory of incomplete contracts. Contracts are incomplete in the sense that they cannot be completely enforced, cannot include all contingencies and are costly to write. Accepting this view entails that contracts can be understood as more or less complete contracts on a continuous scale, i.e., the set of contracts is bounded but open. Where to draw the line between complete and incomplete on this scale is neither obvious nor relevant in this paper. It is only assumed that contracts can be compared and ranked as more or less complete – no absolute scale is needed.

The motive for making a contract less complete is to avoid transaction costs ex ante, i.e., writing costs, but it can lead to ex post bargaining, i.e., a hold-up problem. This trade-off was formalised by Grossman and Hart (1986) and can be represented by an incomplete contract, one that does not entail large costs for identifying and writing contingencies, versus negotiation over (quasi) surplus ex post since the contingencies are not regulated. This is the situation that is often referred to as the hold-up problem, where the party making relationshipspecific investments ex ante finds itself in a vulnerable position ex post and risks being exploited by the other party. Williamson (1975) called the exploitative behaviour opportunism, self-interest-seeking with guile. Even if no investments are made ex ante, the problem of opportunism is always present with incomplete contracts due to asymmetric information and gaps in the contract. If, for example, the contractor has superior information on a non-regulated aspect in the contract, there is a risk that the client will be cheated.

Hence, a trade-off is apparent between the risk for opportunism and having to spend resources on making the contract more complete. In a construction project the client always makes the first move, which means the client faces the problem of designing the contract.

The problem with incomplete contracts creates an incentive to reduce the risk of opportunism, e.g. through some sort of trust, repeated interaction or, in the extreme case, vertical integration (Grossman and Hart, 1986). A more incomplete contract based on trust and repeated interaction is usually referred to as a relational contract (Macaulay, 1963; Macneil, 1978). The relational contract, in comparison with what Gibbons (2005) calls formal contracts, is based upon outcomes that only can verified ex post by a third party, e.g. a court, and not specified ex ante. In a construction project, this could be exemplified by both parties starting with an unspecified contract not consisting of more than, for example, that a house should be built. The contract will then be filled in during the project.

The relational contract is a more incomplete contract, which disregards the task of specifying contingencies and instead focuses on developing a framework for handling information as it comes up during the contract period. What hinders the parties from deviating and cheating can be explained in two different ways, or a mix of the two, either by repeated interaction or by trust. Repeated interaction is often modelled in a game theory setting. The conclusion is that both parties realise that there are surpluses to make over a long time period by not cheating each other during the current contract (see e.g. Kreps, 1990). Trust is the other way of explaining why the parties do not take advantage of each other in an incomplete contract. Both parties trust that the opposite party will not act opportunistically for ethical reasons. In reality there is probably a mixture of moral and economic motives that keeps the contract together.

A straightforward interpretation of partnering in the construction industry is to see the concept as a relational contract, which includes the ingredients of trust and repeated interaction. This comparison has also been made by Chueng et al. (2006).

Economic theory suggests that more incomplete contracts have lower transaction costs but entail opportunism, and that partnering (as a relational contract) would be called for as something that reduces the risk of opportunism. The choice is between (relatively) incomplete contracts with partnering and (relatively) complete contracts where partnering is not needed.

PARTNERING AND COMPLETE CONTRACTS

Neither of the two cases described above was, however, found when studying partnering contracts in the Swedish construction industry with public clients. The Swedish National Road Administration (SRA) and the Swedish National Rail Administration (Banverket) have contracted out road and rail maintenance for a number of years. Experience of public tendering has been collected and developed into standardised tendering documents. Analysing these shows that partnering is tendered with roughly the same type of tendering documents as non-partnering projects, i.e., relatively complete contracts, or at least not more incomplete contracts than in non-partnering maintenance contracts.

This observation can be further strengthened with reference to the principle of transparency, which applies to all public clients due to EU directives. The motive for the principle is that fair and objective evaluations of the bids can be made (NOU, 2002). This does not exclude incomplete contracts, but it is easier for the client to justify why he chose contractor X over contractor Y based on price instead of more subjective parameters. Thus, choosing the lowest price reduces the client's risk of having the evaluation reviewed.

Studying the publicly procured partnering projects, it was found that these contracts were rather complete, but still included partnering. This is, given the reasoning above, contradictory since opportunism is lower with more complete contracts and there is no incentive for investing in a partnering arrangement.

The efficiency aspect of partnering with incomplete contracts, as explained above, is rather straightforward, but introducing partnering with a complete contract seems uncalled for. Why would anyone choose a complete contract with a costly partnering arrangement to neutralise opportunism when the risk is reduced to a minimum by a complete contract?

The rest of the paper focuses on finding an explanation for this phenomenon, partnering and complete contracts. Under what circumstances could this combination be an efficient solution? In order to go forward with this question three things need clarification.

New information – the complex construction industry

It has been said that complexity in the contracting situation adds to the justification of incompleteness (Segal, 1999). Complexity has been discussed in a number of articles and has been defined in somewhat different ways. Segal (1999) defines complexity as the number of potentially relevant future trade opportunities, which means that complexity rises with the number of possible trades in the future. Casadesus-Masanell and Al-Najjar (2001) have another way of defining complexity, not by focusing on the number of contingencies but the number of independent pieces of information within every contingency. The explanation for why complexity adds to the justification for incompleteness is that complexity makes the complete contract even more expensive because of the growing number of relevant contingencies to regulate (Segal, 1999) and/or because it requires more writing within each contingency (Casadesus-Masanell and Al-Najjar, 2001).

Adopting Segal's (1999) definition of complexity entails accepting that if a lot of new information arrives ex post then this makes the contracting situation more complex. This is relevant in construction projects, which have a long duration and where there are many unexpected circumstances in comparison to other contracts. Bajari et al. (2006) state that the ex ante design most often does not coincide with what is delivered ex post. The authors estimate the cost for renegotiation of the ex ante contract to be ten percent of the initial amount in the contract. Brousseau (1994) says that, due to the high level of uncertainty in the construction industry, more incomplete contracts are used frequently as a way to attain flexibility. The idea behind this type of flexibility is that filling in an incomplete contract as the project progresses is easier than renegotiating it. So when the number of potentially relevant future trade opportunities rise, it will be too expensive to foresee and regulate them ex ante.

Just adding new information to the scenario does not, however, offer explanations for the use of both partnering and complete contracts. Instead it would be an incentive to make the contract more incomplete.

The risk-averse client

In order to justify the combination of partnering and complete contracts it must be assumed that the client is risk-averse. A risk-loving client would never choose a complete contract with partnering, as this can be seen as a double protection against opportunism by using both completeness in the contract and partnering. They would prefer to handle new information by means of an incomplete contract, as that would reduce the initial cost.

Reciprocity

Reciprocity is a topic that has been much discussed in economic theory recently. In contradiction to the traditional homo economicus assumption, the concept of reciprocity means that human beings do not exclusively care about themselves.

There are two ways to explain reciprocity within economics: by (i) "social preferences" or (ii) intention-based reciprocity (Fehr and Schmidt, 2001; Dufwenberg and Kirchsteiger, 2004). The first type of theory focuses on changing the traditional utility functions, so that distributions over outcomes for both the person herself and others matter. Intention-based reciprocity, on the other hand, is usually handled in a game theory setting by assuming that people always play a lead–follow strategy based on intentions, i.e., they always repay a kind action with a kind action and the other way around concerning cruel actions.

The existence of reciprocity has been shown over and over again by experimental studies (see e.g. Davis and Holt, 1993). It is assumed here that introducing partnering into a contract will raise the probability of the parties acting in accordance with reciprocity. Reciprocity is, of course, not exclusive to partnering, but the probability of attaining such behaviour is assumed to improve with partnering. An explanation for this is the initial social gatherings and team building activities, which can be seen as a way to build up reciprocity between the firms and the people involved. Regular and recurrent structured meetings, focused on how to improve the project and solve problems together can also be seen as a way of strengthening reciprocity.

The role of partnering in the complete contract

Combining the assumptions of complexity, risk-aversion and reciprocity creates a setting where a risk-averse client encourages more reciprocal behaviour between the parties in order to handle new information by a more flexible way of renegotiating the contract. Partnering has been pictured as “a way of signalling an intention of techniques and approaches to improve relationships” (Alderman and Ivory, 2007, p.392). Entering into a partnering contract would, using economic terminology, be a way of signalling that the parties are prepared to renegotiate the complete contract. Mentioning partnering in the tendering documents for a complete contract could then be interpreted as a desire on the part of the client for more flexibility in order to lower the cost of renegotiations when there is a need to adapt to new circumstances. Easier renegotiations are possible because the client and the contractor have a good relationship based on trust, a reputation mechanism and/or reciprocity. The exact mixture of the last three components is not obvious, but the assumption is that partnering improves the possibility for more flexible and cheaper renegotiations.

Hence, partnering and complete contracts can be justified when the situation is such that new information can be expected to arrive during the project, when the client is risk-averse and when reciprocity can lower the transaction costs for renegotiations.

The following section will, in a game theory setting and with stylised examples from maintenance contracts in Sweden, show what kind of new information is needed to explain how partnering can be efficiency enhancing.

HOW PARTNERING AS PART OF A RELATIVELY COMPLETE CONTRACT CAN INCREASE EFFICIENCY: EXAMPLES FROM MAINTENANCE CONTRACTS

The underlying and realistic assumption in this section is that new information arises during the contract period since these projects are rather long, usually about five years, and concern complex contract situations.

New information is defined as information not available ex ante, i.e., it is not regulated in the contract and can be seen as an external factor that might influence the contract. The types of new information that will be exemplified in this paper are:

1. Technological improvements
2. Changed demands

3. Information about costs for the agreed measures and/or functions

The payoffs can be distributed as beneficial for both parties or just for one, where the following examples are of both kind.

Technological improvements

This section starts off with a simple example: assuming that a publicly owned research centre develops a new snowplough. The innovation is made available to every actor on the market, both clients and contractors. The new snowplough revolutionizes the industry, as it is both cheaper and delivers better quality. Assume further that the contract specifies what kind of snowplough the contractor should use (a prescriptive contract in contrast to a performance contract) so that renegotiation is needed before introducing the new snowplough. It would be in both parties' interest to adopt the new snowplough, given that transaction costs are not too high. Transaction costs can here be exemplified by the cost for renegotiations about ways to monitor the snowplough and perhaps how the payments should be adjusted, etc. There would be no incentive for any party to adopt the new snowplough if the costs of changing the contract exceed the surplus generated by the snowplough. Partnering can be seen as a way to reduce these transaction costs since it is not necessary to monitor each other strictly in a trusting environment – not every penny needs to be counted nor every proposal questioned. The parties know and trust each other, which make these renegotiations smoother, i.e., lowers transaction costs. The probability of reaching pareto-efficient solutions increases by introducing partnering as a way to reduce transaction costs for renegotiations.

However, just like the Coase theorem (Coase, 1960), this new allocation does not say anything about the distribution over the surplus. Even though renegotiations are pareto-sanctioned, they might be refused by some party due to an unfair distribution of surplus, e.g. if the contractor will gain a bigger surplus from the new snowplough than the client. Experimental evidence has shown that such renegotiations might not take place, even though they are pareto-sanctioned (Fehr and Schmidt, 2001). This problem grows with the existence of noisy observables, where parties are prevented from assessing each other's gain from the new snowplough. Both parties have incentives to signal a lower surplus in order for renegotiations to take place.

Partnering is often seen as a closer relationship between client and contractor entailing openness, which can smooth the issue of noisy observables. This will make both parties less suspicious of the other party's signal, which will facilitate renegotiation. An example of this is that the client gets access to the contractor's books, i.e., the "openness" component.

Changed demand and information about costs for the agreed measures and/or functions

Given the complete contract, there are often situations where the client wants to change what was initially ordered. Assume that there have been reports of fatal car accidents due to poor maintenance of crash barriers. This new information has led to public pressure to improve the barriers, which puts pressure on the client to act. The client would then like to renegotiate, within the budget restriction, a higher standard in a performance contract, or more checks on the barriers in a prescriptive contract. Such a change would lead to a surplus of e.g. (5) for the client but a negative outcome of (-2) for the contractor. The positive figure represents the client's, i.e., the public's, value for avoiding fatal accidents, which require more effort from the contractor, represented by the negative figure. Given these circumstances, the contractor would like to stick with the initial contract. However, there are pareto improvements to be found if allowing for redistribution of surplus and ending up in e.g. (1.5; 1.5).

Partnering can be seen as a way to smooth this progress towards finding the most efficient solution. As mentioned above, partnering facilitates solving the problem with "noise in the observables", i.e., asymmetric information, with a more open way of working. Both parties can together evaluate the surpluses and the client does not have to fear that the contractor is demanding excessive compensation for changing the contract. Theoretically, the parties can end up in (1.5; 1.5) by a monetary transfer.

A less costly solution than monetary transfers, interpreting partnering as a form of reciprocity, is that the contractor agrees to the (5; -2) proposition, i.e., the contractor agrees to better functional levels or more checks on the barriers without compensation. This could, in normal circumstances, with asymmetric information lead to the contractor slacking on some other assignments to compensate for his loss (see Holmstrom and Milgrom, 1991 on multitasking). However, seeing partnering as something that incorporates reciprocal thinking the contractor knows that it is very likely that he will be repaid later, given that new information will arise and where renegotiations will be to his advantage. Since the contractor "played nice" in this case he will be repaid with the same behaviour later.

An example of such information, where renegotiation can be to the advantage of the contractor, is when it is realized, for example, that clearing the ditches is more expensive than anticipated because of some unexpected characteristics of the ditches. This is an example of new information about costs for the initially agreed-upon measures for clearing the ditches. Assume that the initial contract specifies that this should be done every year. A reduction to doing this every second year would result in a quality reduction of (-1) for the client and a cost-saving benefit of (4) for the contractor. Given the prior arrangement concerning the crash barriers, and/or expectations about such situations in the future, the client would, according to reciprocity, agree to this renegotiation of the contract.

Following the same line of reasoning, partnering can also facilitate pareto-sanctioned renegotiations where they would otherwise be held back because of unfair distribution of gain (see the snowplough example above). Given that new information comes with an equal probability of both parties receiving a surplus, both parties are willing to renegotiate with partnering.

CONCLUSION

Two theoretical explanations have been provided for how partnering can enhance efficiency in the construction industry. Firstly, partnering can be seen as part of a relational contract with the aim of neutralising opportunism and thereby reduce the risk in an incomplete contract. The reduction in opportunism is then based on a mix of trust and repeated interaction. This is a standard result in applied economic theory and has been presented before by Cheung et al. (2006) although not as precise.

The second and more innovative interpretation of partnering is to focus on the use of partnering in combination with a (relatively) complete contract, which existence has been discovered in the Swedish construction industry. Partnering can then be justified as a way to facilitate renegotiations when new information arrives during the project and the client is risk-averse. Investing in a procedure to enhance trust and reciprocity can be efficiency enhancing because it will reduce the cost for and increase the probability of carrying out pareto sanctioned renegotiations.

REFERENCES

Alderman, N and Ivory, C (2007) Partnering in major contracts: Paradox and metaphor. International Journal of Project Management, 25(4), 386-393.

Bajari, P, Houghton, S and Tadelis, S (2006) Bidding for Incomplete Contracts: An Empirical Analysis. NBER Working Papers 12051, National Bureau of Economic Research, Inc.

By - og Boligministeriet (1998) Byggepolitisk Handlingsplan 98 - Initiativ 6.

Brousseau, E (1994) EDI and Inter-Firm Relationships: Toward a Standardization of Coordination Processes? Information, Economics and Policy, 6(3-4), 319-347.

Casadesus-Masanell, R and Al-Najjar, N (2001) Trust and Discretion in Agency Contracts. Harvard Business School Working Paper Series, No. 02-015.

Cheng, E and Li, H (2001) Development of a conceptual model of construction partnering. Engineering, Construction and Architectural Management, 8(4), 292-303.

Cheung, S O, Yiu, K T W, and Chim, P S (2006) How Relational are Construction Contracts? Journal of Professional Issues in Engineering Education and Practice, 132(1), 48-56.

Coase, R (1937) The Nature of the Firm. Economica, 4(16), 386-405.

Coase, R (1960) The Problem of Social Cost. Journal of Law and Economics, 3, 1-44.

Crowley, L and Karim, A (1995) Conceptual Model of Partnering. Journal of Management in Engineering, 11(5), 33-39.

Davis, D and Holt, C (1993) Experimental Economics. Princeton University Press, Princeton.

Dufwenberg, M and Kirchsteiger, G (2004) A theory of sequential reciprocity. Games and Economic Behavior, 47(2), 268-298.

Egan, J Sir (1998) Rethinking Construction. The report of the Construction Task Force. Department of Environment, Transport and the Regions. HMSO, London.

Fehr, E and Schmidt, K (2001) Theories of Fairness and Reciprocity - Evidence and Economic Applications. Institute for Empirical Research in Economics, University of Zürich, Working Paper No. 75.

Gransberg, D, Dillon, W D, Reynolds, L and Boyd, J (1999) Quantitative analysis of partnered project performance. Journal of Construction Engineering and Management, 125(3), 161-166.

Grossman, S and Hart, O (1986) The Costs and Benefits of Ownership: A Theory of Vertical and Lateral Integration. Journal of Political Economy, 94(4), 691–719.

Gibbons, R (2005) Four Formal(izable) Theories of the Firm? Journal of Economic Behavior & Organization, 58(2), 200-245.

Holmstrom, B and Milgrom, P (1991) Multi-task Principal-Agent Analysis: Incentive Contracts, Assets Ownership, and Job Design. Journal of Law, Economics, and Organization, 7, 24-52.

Kreps, D (1990) A Course in Microeconomic Theory. Princeton University Press, Princeton.

Latham, M Sir (1994) Constructing the Team. HMSO, London.

Macaulay, S (1963) Non-Contractual Relations in Business: A Preliminary Study. American Sociological Review, 25, 55-70.

Macneil, I. (1978) Contracts: Adjustment of Long-Term Economic Relations Under Classical, Neoclassical, and Relational Contract Law. Northwestern University Law Review, 72(6), 854-905.

Naoum, S (2003) An overview into the concept of partnering. International Journal of Project Management, 21, 71-76.

NOU, (2002) A brief description of LOU the Public Procurement Act in Sweden. NOU the National Board for Public Procurement. NOU, Stockholm.

Nyström, J (2005a) The public procurement phase with partnering and the actors' perception of the concept - results from a questionnaire. In Partnering: definition, theory and the procurement phase, Licentiate Thesis, Royal Institute of Technology, Stockholm.

Nyström, J (2005b) The definition of Partnering as a Wittgenstein Family-Resemblance concept. Construction Management and Economics, 23(5), 473-481.

Saussier, S (2000) Transaction costs and contractual incompleteness: the case of Électricité de France. Journal of Economic Behavior & Organization, 42(2), 189-206.

Segal, I (1999) Complexity and Renegotiation: A Foundation for Incomplete Contracts. Review of Economic Studies, 66(1), 57-82.

SOU 2000:44 Från byggsekt till byggsektor. Byggkostnadsdelegationen.

SOU 2002:115 Skärpning gubbar! Om konkurrensen, kvaliteten, kostnaderna och kompetensen i byggsektorn. Miljö- och samhällsbyggnadsdepartementet, Byggkommissionen.

Williamson, O (1975) Markets and hierarchies: analysis and antitrust implications: a study in the economics of internal organization. Free Press, New York.

ENERGY EFFICIENT BUILDINGS: MODELS, INNOVATION AND MARKET

Jean Carassus
Centre Scientifique et Technique du Bâtiment, Paris, France
jean.carassus@cstb.fr

At the beginning of the 21st century, the built environment cluster is facing a major challenge: that of energy- and environment-efficient buildings. From two international benchmarks, three energy- and environment-efficient building models are defined: the Low Consumption model (LC model), the Energy and Environmental model (EE model) and the Energy Saving and Production model (ESP model). A socio-eco-technical evolutionist approach to innovation allows analysing how those models can meet the market. The driver is political, at three levels: continental, national, and local. Local authorities and private local actor cooperation is an active engine for the dissemination of energy- and environment-efficient buildings.

KEYWORDS: innovation, green buildings, energy, market.

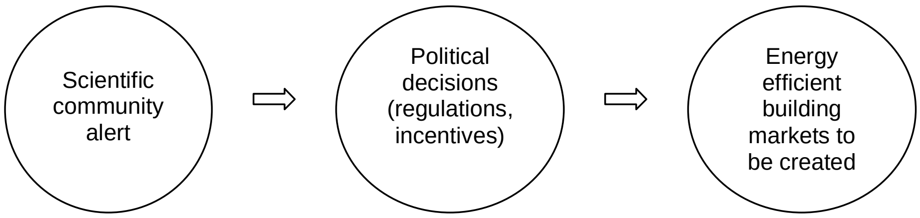
INTRODUCTION

At the beginning of the 21st century, the built environment cluster is facing a major challenge: that of energy- and environment-efficient buildings. The built environment cluster concept is wider than that of the building industry (Carassus, 2004). Based on the life cycle of buildings and infrastructures, the built environment cluster approach includes not only the site process non manufacturing industry (construction firms), but also service segments (developers, designers, material distributors, asset, property and facilities managers), manufacturing segments (construction material and equipment firms) and regulatory actors (public continental, national and local authorities, private industry and professional organisations) (Carassus et alii, 2006). The economic weight of the built environment cluster is twice the construction industry one (Sexton et alii, 2007).

Buildings represent roughly 40% of two major planetary challenges: that of climate change and energy supply. As the scientific community has demonstrated (IPCC, 2007, Stern, 2007), the main cause of climate change is human-origin CO_2 emissions. Buildings generate almost 40% of CO_2 emissions. Energy supply is a major strategic challenge. Buildings generate more than 40% of the final energy consumption, that is the total of industry and transportation energy consumptions.

An original three-step mechanism is currently in action: first, the scientific community alerts, second, political decisions (regulations, incentives) are made, not only to fight climate change but also to secure energy supply, third, energy buildings markets are to be created, with four main segments: those of new and refurbished residential buildings, and new and refurbished non residential buildings (see figure 1).

Figure 1 A three-step mechanism



Three energy- and environment-efficient building models will be identified through two international benchmarks. A socio-eco-technical approach of innovation will be defined through evolutionist analysis. The link between innovative models and market will be specified through the international benchmarks. The complexity of the innovative models meeting market will be summarized.

THREE ENERGY- AND ENVIRONMENT-EFFICIENT BUILDING MODELS

Several international benchmarks deal with the energy-efficient building topic. Two of them are used: the French government 2006-2007 Building and Energy International Benchmark (PREBAT, 2007) and the 2007-2009 World Business Council for Sustainable Development Energy Efficient Buildings Project (WBCSD, 2008).

The aim of the first one was to know the best practices to be transferred to the French context to meet the ambitious European objectives. Europe played an active role in the 1997 Kyoto agreement, which specifies a decrease of 8 % in greenhouse gas emissions between 1990 and 2010 in Europe. The March 2007 energy action plan, adopted by the State and government heads European council, defined three ambitious objectives for 2020, known as the “Three Twenty objectives”: a unilateral decrease of 20% in greenhouse gas emissions between 1990 and 2020, a decrease of 20% in energy consumption between 1990 and 2020 and a share of 20% of renewable energy in 2020.

The two main methodological aspects of the French international benchmark were a socio-eco-technical approach and a wide international partnership.

To analyse the foreign initiatives or innovations, the project used a socio-eco-technical methodology in 6 steps (1) national and local background, origin of the initiative or the innovation, (2) content of the initiative or innovation, type of building concerned, new construction, refurbishment, techniques used, (3) implementation, dynamics of the actors involved, funding, incentives, investment and operation costs, (4) evaluation, real performances, real costs, users’ view, impact of the initiative or innovation, (5) critical reflection, strengths, weaknesses, opportunities and threats, (6) transposition conditions in France.

The international partnership mobilised 55 engineers, economists and sociologists from 12 different countries (among them the Massachusetts Institute of Technology, the Building

Research Establishment, the Stuttgart Fraunhofer für Bau Physik, the University of Genève, the Danish University of Technology and the University of Technology of Catalunya).

Three fields were investigated: national and local initiatives, technological innovations, and R&D programmes. Best practices especially from Germany, Switzerland, Spain, Denmark, Austria, Finland, the Netherlands, the United States, Japan and Australia were analysed.

The aim of the World Business Council for Sustainable Development Energy Efficient Buildings Project is different. It is a business oriented project monitored by an American and a French firm (United Technologies Corporation and Lafarge) mobilizing several multinational private companies from Europe, the United States, Japan and India.

The aim is to promote new and refurbished zero net energy buildings in six main potential markets: North America, Europe, Japan, China, India and Brazil.

In 2007 the project team published its first report (Energy Efficiency in Buildings: Business Realities and Opportunities), which will be followed by the 2008 Scenarios Report and the 2009 Call for Action Report. The project includes lobbying action through international meetings, mobilizing public and private stakeholders, held in Beijing, Brussels, New Delhi, Paris, Washington DC, Sao Paulo and Tokyo.

The French benchmark highlighted three main energy- and environment-efficient building models (Carassus, 2007 a)[1]. The first one is the "Low Consumption" model (LC model). The emphasis is placed on low energy consumption in over-insulated buildings. The German version (*Passivhaus*) is more demanding than the Swiss version (*Minergie*®). The *Building America* Project is another example of this model, with less ambitious energy targets.

The second one is the "Energy and Environment" model (EE model). Energy is articulated to other environmental objectives (integration into the site, comfort, materials, waste, etc.). The American *LEED*™ label and, in a certain way, the British *BREEAM* label, the Japanese *CASBEE* label and the French *HQE*® label are examples of this model.

In the third model, the "Energy Saving and Production" one (ESP model), the buildings save energy and also produce energy, especially through solar photovoltaic panels. The American *Zero Energy Homes* are more insulated and less industrialized than the Japanese photovoltaic houses. The Spanish experience highlights the use of thermal solar energy for hot water.

The Low Consumption Model (LC model)

The emblematic example of the LC model is the *Passivhaus* label (Fraunhofer Institut für Bauphysik, 2006). The Germans (who are branching out into Austria, Switzerland, Belgium and France) know how to construct new buildings with practically no heating in the German climate, with an investment of 5 to 12% more than usual.

A house bearing the *Passivhaus* label must have a heat consumption of 15 KWh/m²/year of final energy, a total primary energy consumption of less than 120 KWh/m²/year, a maximum airtightness of 0.6 volume/hour.

The five most common characteristics of these houses are: over-insulation from the outside with triple-glazed windows, double-flow ventilation with heat recovery, passive solar gains,

[1] We were the head of the French Building and Energy International Benchmark project.

low-consumption household appliances and the use of renewable energies. Six thousand *Passivhaus* houses have been built.

The principles of the Swiss *Minergie*® label are the same with less demanding objectives (Haefeli et alii, 2006). More than 8000 buildings and houses are certified *Minergie*®. The French *Effinergie*© label is a version of the Swiss label adapted to the French context.

The LC model is well adapted to rigorous climates.

The Energy and Environment Model (EE model)

In 2000, the US Green Building Council (USGBC) launched its *Leadership in Energy and Environmental Design LEED*™ evaluation and rating program, with six action fields: Sustainable Site, Water Efficiency, Energy and Atmosphere, Materials and Resources, Indoor Environmental Quality, Innovation and Design Process (Norford, 2006).

The label specifies four performance levels: certified, silver, gold, platinum. *LEED*™ currently has four programs: New commercial constructions, Existing building operations, Commercial interiors projects, Core and Shell projects. Energy performance is 30% on average, compared to normal rules. Approximately 800 buildings are labelled, and 5500 applications are in progress.

The Building Research Establishment Environmental Assessment Model *(BREEAM)* was launched in the UK in 1990. It uses, for residential buildings, seven criteria: Energy, Water, Pollution, Materials, Transport, Ecology and Land Use, and Health and Well-Being. It is employed for seven types of buildings: dwellings (EcoHomes), industry, offices, retail, schools, courts and prisons.

It specifies four performance levels: “Pass” with 25 points, “Good” with 40 points, “Very Good” with 55 points, and “Excellent” with 70 points. More than 65,000 buildings have received *BREEAM* certification.

The *“Haute Qualité Environnementale” HQE*® method was created in France in 1997. It specifies fourteen criteria in four fields: Site (integration, materials, site process); Management (energy, water, waste, maintenance); Comfort (hydrometrics, vision, acoustics, olfactory); Health (quality of air, water, space).

“NF maisons individuelles démarche HQE®” certification for individual homes and *“NF bâtiments tertiaires démarche HQE®”* for non residential buildings were launched in 2005 and 2006. A seven-criteria version *“Habitat et Environment©”* is used for dwellings, condominiums and social housing units. Energy performance is only from 10 to 20% in comparison with normal rules.

The EE model is well adapted to investors, for whom energy is only one objective among others, in an environmental approach of the buildings.

The Energy Saving and Production model (ESP model)

An American *“Zero Energy Home”* is a wood-framed house with a thicker structural frame, a damp-proof membrane on the outside, well-insulated attic space, low-emission double-glazed windows, mechanical ventilation, a high-efficiency boiler and short networks, compact fluorescent lamps, thermal solar energy and a photovoltaic system (Norford, 2006).

A typical low-consumption Japanese house is a prefabricated house, in which everything is electric, with reinforced insulation, double-glazed windows, mechanical ventilation, heat pump, and local production through photovoltaic system integrated into the prefabricated house. 120,000 Japanese houses use photovoltaic.

In Spain, departing from an experience in Barcelona, according to municipal orders, thermal solar energy must cover 60% of the demand for domestic hot water in all important buildings, new or renovated.

The ESP model is well adapted for countries which plan to decrease peaks of electricity consumption. It also opens the perspective of Zero Energy or Positive Energy buildings, which will produce more energy than they will use.

A SOCIO-ECO-TECHNICAL APPROACH TO INNOVATION

How can those models meet the market? The evolutionist framework will be used. Founded by Joseph Schumpeter, for whom innovation was the engine of evolution (Schumpeter, 1959), this economics school for a long time highlighted essentially technological innovation.

In the two first editions of the "Oslo manual" defining guidelines for collecting and interpreting innovation data, from an experience based on the manufacturing industry, OECD uses in 1992, and still in 1997, a narrow definition of innovation, limiting it to technological product and technological process innovation.

Such innovation definition is not adapted to the complex building process produced by the built environment cluster, which includes not only the manufacturing industry (construction material and equipment firms), but mainly services firms (developers, designers, asset, property and facilities managers) and the site process non manufacturing industry (construction firms).

Several evolutionist economists insisted on the service characteristics of the products (Saviotti, 1996) and on the specificity of innovation in the service economy (Gallouj, 2002).

And for the first time in 2005, OECD and the European Commission pointed out a socio-eco-technical approach to innovation by specifying that "innovation is the implementation of a new or significantly improved product (good or service), or process, a new marketing method, or a new organisational method in business practices, workplace organisation or external relations" (OECD, Eurostat, 2005).

OECD and the European Commission specify that "innovation activities are all scientific, technological, organisational, financial and commercial steps which actually, or are intended to, lead to the implementation of innovation."

Four types of innovation are distinguished: product (good or service) innovations, (good or service) process innovations, marketing innovations and organisational innovations. Innovations can concern a novelty for the firm, for the market or for the world.

The two benchmarks dealing with energy-efficient buildings highlighted the importance of coordinated technical, service, organisational and marketing innovations, in a holistic view of building design, production and operation.

Formatted: Font: Arial, 10 pt

Highlighting only technical innovation is a failure factor, as was demonstrated by comparing the success of the Swiss *Minergie®* label and the failure of the French *5000 solar houses programme* (Carassus, 2007 b).

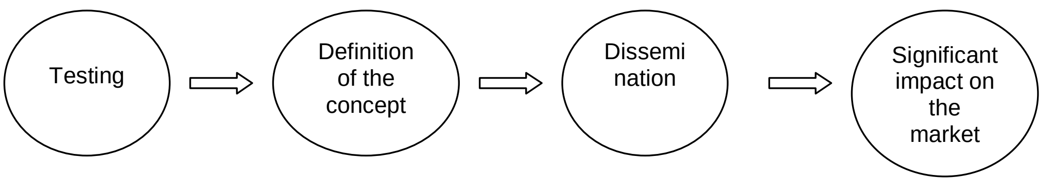
INNOVATION AND MARKET

The OECD and European Commission definition of a radical innovation is interesting to note: "A radical or disruptive innovation can be defined as an innovation with a significant impact on a market and the economic activity of firms in that market." The concept is focused on the impact of innovations as opposed to their novelty. The impact can, for example, "change the structure of the market, create new markets or render existing products obsolete."

This new approach of innovation meets our central question: how can energy-efficient building models meet the market?

The French benchmark specified four steps for the models' development: testing, definition of the concept, dissemination and significant impact on the market (see figure 2).

Figure 2. The four steps of energy-efficient building models development



The first step is testing. The first experiences allow testing a new design, new technologies, real performances, investment and operating costs, the users' view. When the learning from the first experiences is sufficient, the second step can be completed: the definition of the concept. Most of the time the concept takes the form of a label (*Passivhaus*, *Minergie®*, *LEED*™) specifying the performances of the building to be met.

This performance label form is crucial for the built environment cluster. Two characteristics of this cluster are: no actor is dominant, the production is very heterogeneous (houses, dwellings, offices, retail, schools, new construction, refurbishment…). The label can get the agreement of the different actors (developers, designers, construction firms…) and be used for many types of buildings.

When the concept is defined, it can be disseminated through several thousand buildings. This dissemination allows implementing the coordination of the different necessary innovations (technological, service, organisational, marketing), the new competencies of the actors, the legal conditions, the real performances of the model at large scale, the adaptation of the model to local conditions.

The fourth stage is the impact of the model on the market, when it has "a significant impact on a market and the economic activity of firms in that market" and can "change the structure of the market, create new markets or render existing products obsolete."

What are the present characteristics of the development of different labels implementing the three energy-efficient building models? (see table 1)

Table 1: Present impact of LC, EE, ESP models on the market in three countries

Model	Label	Testing	Concept	Dissemination	Significant impact on the market
LC model	Swiss Minergie® new				In 2005, 17% of new Swiss residential buildings are labelled Minergie®
	Swiss Minergie® refurbishment				
	German Passivhaus new				
	German Passivhaus refurbishment				
EE model	American LEED™ new				
	American LEED™ refurbishment				
ESP model	American Zero Energy Homes new				

Source: PREBAT, 2007

According to our analysis, only one label (from the LC model) has a significant impact on the market in its country today, the Swiss *Minergie*® for new construction. The other ones are widely disseminated through several thousand buildings, but their impact on the market is for the moment marginal.

5. MEETING THE MARKET: A COMPLEX PHENOMENON

The two benchmarks showed that the driver for energy-efficient buildings development is not the market. The driver is political and three political levels have to be distinguished.

The first political level is the intercontinental and continental one. This political level specifies the quantitative objectives to be met (1997 Kyoto objectives, 2007 European objectives, post-Kyoto agreement expected objectives). The national level is the second political level. It defines the framework: regulations, taxes, incentives, funding. The regional/local level is the third one. It is the practical one, where energy-efficient buildings are made through active cooperation between regional/local authorities and private actors.

The regional/local level is the strategic one. The international benchmarks highlighted its importance. In Switzerland, the canton level; in Spain, the regional and municipality levels; in Scandinavian countries the municipal level; in Austria and Germany, the land level; in the

United States, the state and municipality levels are the more important for the dissemination of energy- and environment-efficient buildings.

The main reason for such a characteristic is that the essential part of the built environment cluster actors is regional and local.

The building market is highly segmented. Roughly, nine segments can be distinguished: new residential buildings, new non-residential buildings, existing individual houses owned by households, existing condominiums owned by households, existing residential buildings owned by social housing and private companies, existing public non-residential buildings, existing private non-residential buildings.

To meet ambitious CO_2 2020 objectives, action must be concentrated on the existing stock. New construction will generate a negative impact by 2020: the main part of new construction will enlarge the stock, and a minor part will replace obsolete existing buildings.

For each segment, a demand/supply analysis has to be completed. On the demand side, public decisions (regulations, incentives, funding) will be the main engine of the market mechanisms. Market obsolescence will be a specific market instrument, especially for some segments like private non-residential buildings, energy and environmental efficiency "rendering existing products obsolete."

The main challenge concerns the supply side. The two international benchmarks highlighted that simply adding an energy and environmental dimension to usual practices is a failure factor. Energy and environmental efficiency creates a new paradigm for the built environment cluster actors. Every actor of the value chain is concerned. New ways to finance energy- and environment-efficient buildings, using life cycle cost analysis, have to be invented. Performance briefing has to be the new norm. Holistic design has to replace sequential design: climate, shell and equipment have to be analysed and defined by architects and engineers, working together at the very beginning of the design.

The site process has to be renewed, especially to obtain very good air tightness. Quality process has to ensure a high level of commissioning, guaranteeing the continuity of energy and environmental performance from the production to the operation of the building. Eventually, the users have to adopt a new behaviour to meet the ambitious energy, water and waste consumption objectives.

New actors will appear, such as house energy renovators. The initial and continuous training of all the actors has to integrate this new view of the building process. It is one of the more difficult parts of the challenge.

CONCLUSION

The energy and environment efficiency of new and existing buildings is a major challenge for the built environment cluster. Three main energy- and environment-efficient building models can be identified: the Low Consumption model (LC model), the Energy and Environmental model (EE model) and the Energy Saving and Production model (ESP model). The driver is political. The objectives are specified at the intercontinental and continental level. The national level defines the regulations, taxes, incentives and funding framework. The strategic level is the regional/local one, where an active cooperation between regional/local authorities and local built environment cluster actors is a key factor of the dissemination of energy- and environment-efficient buildings. An in-depth analysis of each market segment is necessary to know in detail the specific barriers and drivers of the models' dissemination.

REFERENCES

Carassus, J. (ed) (2004) Construction sector system: an international comparison. CIB W55-W65 Construction industry comparative analysis Project Group report, Rotterdam: CIB Publication 293, available at: http://www.irbdirekt.de/daten/iconda/CIB1204.pdf

Carassus, J., Andersson, N., Kaklauskas, A., Lopes J., Manseau, A., Ruddock, L., De Valence G. (2006) Moving from production to services: a built environment cluster framework. International Journal of Strategic Property Management, 10 (3) 169-184, available at: http://www.ijspm.vgtu.lt/upload/property_zurn/ijspm_2006_vol_10_no_3_p_169-184.pdf.

Carassus, J. (2007 a) Trois modèles de maîtrise de l'énergie dans le bâtiment. Une comparaison internationale. Annales de la Recherche Urbaine, La ville dans la transition énergétique, 103, 87-94, available at : http://desh.cstb.fr/file/fc3_fiches395.pdf

Carassus, J. (2007 b) Innovation in Buildings: a Socio-Eco-Technical Approach. Cape Town, CIB Congress Proceedings, available at: http://desh.cstb.fr/file/rub49_doc50_3.pdf

Fraunhofer Institut für Bauphysik, (2006), Analysis of low energy programmes in Germany. Report for the PREBAT Comparaison internationale Bâtiment et énergie project. Stuttgart: Fraunhofer Institut für Bauphysik.

Gallouj, F. (2002) Innovation in the Service Economy: the new wealth of nations. London: Edward Elgar Publishers.

Haefeli, P., Lachal, B., Weber, W., Garbely, M. (2006) Le programme Minergie® (Suisse). Report for the PREBAT Comparaison internationale Bâtiment et énergie Project (Genève : Université de Genève).

IPCC, (2007) Intergovernmental Panel on Climate Change - Climate Change 2007 Reports, available at: http://www.ipcc.ch/

Norford L. K. (2006) US Energy efficient buildings : Building America, Zero Energy Homes, Leadership in Energy and Environmental Design. Report for the PREBAT Comparaison internationale Bâtiment et énergie Project. Cambridge: Massachusetts Institute of Technology.

OECD, Eurostat (2005) Guidelines for collecting and interpreting innovation data. Brussels: OECD and European Commission.

PREBAT (2007) Programme de Recherche et d'expérimentation sur l'Energie dans le Bâtiment. Comparaison internationale Bâtiment et énergie, available at : http://www.prebat.net

Saviotti, P.P. (1996) Technological Evolution, Variety and the Economy. London: Edwar Elgar Publishers.

Formatted: Font: Arial, 10 pt

Schumpeter, J. (1959) The Theory of Economic Development. Cambridge: Harvard University Press

Sexton, M., Abbott C., Barrett, P. and Ruddock, L. (2007) Hidden Innovation in Construction, International Conference World of Construction Project Management 2007, de Ridder H., Wamelink J. (eds.) (The Netherlands: Delft), available at: www.wcpm2007.nl/.../file/Conference%20papers/WCPM2007%20paper%5B40%5D%20**Sexton-**Abbott-Barrett-Ruddock.pdf

Stern, N. (ed) (2007) The Stern Review: the Economics of Climate Change, avalaible at: www.hm-treasury.gov.uk/independent_reviews/stern_review_economics_climate_change/sternreview_index.cfm

WBCSD (2008) Energy Efficiency in Buildings: Business Realities and Opportunities Report, available at: http://www.wbcsd.org/templates/TemplateWBCSD5/layout.asp?type=p&MenuId=MTA5NA&doOpen=1&ClickMenu=LeftMenu

AN AHP FRAMEWORK TO ASSESS DESIGN FREEDOM IN AUSTRALIAN PPP PROJECTS

Peter Raisbeck
Faculty of Architecture, Building and Planning, The University of Melbourne
raisbeck@unimelb.edu.au

It is claimed that the PPP procurement provides incentives that drive innovative outcomes. One element to this concept is the idea that PPPs allow designers to respond more freely to PPP performance specifications. Developing a framework which can be used to understand how design freedom is either constrained or supported in PPP projects is important. Once design knowledge is created, how is it then “managed” and “constrained” in order to mitigate the risks or create construction innovation arising from this knowledge? Moreover, what are the organisational factors which come into play once a design is created? In order to answer these questions this study uses an Analytic Hierarchy Process to model an ideal framework for managing design innovation in PPP projects. It allows a complex problem or situation to be articulated through the use of a hierarchical structure. This method has been employed because it allows qualitative data to be transformed and compared in a quantitative fashion. This framework then allows pairwise comparisons to be made between the diverse factors and objectives which underpin the design process in PPP projects.

KEYWORDS: Public-Private Partnerships, Architecture, Design Management, Design Innovation.

INTRODUCTION

In the Australian PPP context “the commercial pressure to deliver a project quickly places enormous pressure on designers to create innovative solutions and to do so within a specified budget ” (Duffield and Clifton, 2007). Despite this Australia designers or architects of PPP projects are regarded as “subcontractors to others and may be treated simply as a provider of services rather than a generator of innovative solutions.” (Duffield and Clifton, 2007 p.3). It is often argued that given the right incentives the private sector is able to produce a higher level of innovation in the PPP model than via other methods of procurement. This is because in PPP procurement PPPs allow the private sector to achieve a higher degree of design freedom because of the looser flexible performance specifications or contracts which are a part of the PPP process. However, once an architect or designer creates a design how is it then “managed” and “constrained” in order to mitigate the risks arising from it? What are the organisational factors which come into play once a design is created?

Accounting for design in PPPs projects requires a framework that begins to define the activities undertaken by designers and the organisational systems and infrastructure which underpin those activities. The Analytic Hierarchy framework developed here suggest a way to examine the design process and its relation to PPP project networks. The AHP model is used because it is a model which can rank qualitative data in quantitative terms. The hierarchy described here presumes design is an activity that produces innovative outcomes. Design is conceived of here as a unique, and often one off activity or process which does not end once the initial architectural design has been created. As has been suggested in more recent research findings architectural practices can be characterised as knowledge intensive professional firms in which architects "have a pivotal role of the knowledge worker in leading the co-production of innovation with clients" (Lu and Sexton 2006). Architectural design is an activity which creates knowledge which in turn creates innovation at a project or product level.

The Role of Design in PPP procurement

Given that the design of a project has a bearing on the management and commercial viability of a PPP project in the concession stage then it is important to understand how design knowledge is created and managed throughout the PPP lifecycle. However, the importance of architectural design as an integrative process in PPP projects is often understated. Yet it is underscored by the history of PPP projects themselves. Strictly defined the PPP model is a procurement system which integrates both construction and design. As Masterman defines it, this model "incorporates all of those methods of managing the design and construction of a project where these two basic elements are integrated and become the responsibility of one organisation, usually a contractor" (Masterman, 2002 p.66).As he suggests PPPs are related to turnkey methods of procurement and appear to have evolved out of past models of procurement which we are all familiar with: "BOO (Build, own, operate) BOT (Build operate transfer), BOOT (Build, own, operate, transfer) and DBFO (Design, Build, Finance and Operate)" (Masterman, 2002, p. 84). These integrated procurement methods include, as Gann argues, "the solutions concept" and "build-operate-transfer (BOT)" solutions which can now be seen as the precursors of today's current crop of PPP projects (2005, p. 572).

As Gray and Hughes contend "design has now become an integral part of a complex industrial process" (Gray and Hughes, 2001, p. 2). Indeed, in the literature on Design Management architectural design is often seen as a process "which involves a great deal of originality" (Gray and Hughes, 2001, p. 26). As has been argued "a good design provided by the architect not only leads to pleasing structures and facilities but also determines the social, cultural and economic quality of the built environment now and in the future (Cheung et. al 2002). As Gann emphasises the architect ahs an important role to play and at the design stage the architect is the prime "systems integrator" in building projects. (2005, p. 573). He states that "Systems integrators perform a range of activities such as technology development, design, project management, construction, assembly or integration of components, maintaining relationships with customers and managing internal or external suppliers of specialized components or expertise." (2005, p. 573). As Lu and Sexton argue, architects are "knowledge-intensive" professionals who operate in project based situations of complexity and ambiguity (Lu and Sexton, 2006).

However, a key problem in this research field is the split between design and construction fields in construction innovation research. As Winch notes "The systems integrator role is shared between the principal architect/engineer and the principal contractor. Thus construction typically has two separate systems integrators—one at design stage and one at construction stage (Winch 2008). This may explain why a more integrated approach to considering the relationship between design and construction does not exist to date. Yet in theories of procurement design and construction are seen as integrated. As Masterman explains this model "incorporates all of those methods of managing the design and construction of a project where these two basic elements are integrated and become the responsibility of one organisation, usually a contractor" (Masterman, 2002 p.66).

Design and PPP research

To date evaluations of design in a PPP context have been scant even though this procurement model integrates both design and construction. Those studies that do exist have highlighted the importance in PPPs of developing, at the organisational level, "creative problem solving" and "mechanisms for developing new ideas" alongside the "encouragement of risk taking and risk management. (Eaton et. al, 2006, 70). Yet few studies of focused on the role that design has to play in PPPs. Construction management research is often framed in terms of a contracting perspective rather than from the perspective of design innovation. The role of architectural design and its relationship to different procurement models and risk management tends to be downplayed and the emphasis is on the constructor as a project's prime systems integrator. For example, in their study on construction innovation Manley and McFallen (2006) define innovation in terms of technical expertise, associated with the introduction of new technologies and technical capabilities. Another approach would be to examine how the activity of designing or system integration brings together organisational expertise, technologies and technical capability.

In international PPP research itself the role of design as a critical success factor has also been downplayed. For example, Akintoye and Hardcastle et al. argue that a key hindrance to best value in PPPs is the "pricing of FM services" possibly due to "the very fluid design" (2003). However, in their study of best value in PPPs the architect's role is downplayed and is seen as being a part of the facilities management team (2003, p.468). Surprisingly, their subsequent research into critical success factors in PPPs does not identify the role of design as an element of success in PPPs (Akintoye and Bing et al. 2005). This may be because their summary of critical success factors in PPP research since 1992 identifies 19 factors which are unrelated to architectural design. (Table 1, 2005).

In Australian research a number of pioneering studies have been undertaken by Australian researchers into procurement decision making (Skitmore and Marsden 1998; Love, Skitmore and Earl 1998). There have also been studies of procurement models as they have gained initial acceptance (Hampson, et. al. 2001). Yet, more recent Australian procurement research has tended to focus on issues of concern to contractors within the procurement lifecycle such as tendering and bidding costs. (McGeorge et. al, 2007). Indeed, in Australia's PPP market, the role of architectural design and design innovation in a PPP policy and research has often been minimised (MacGeorge et al., 2007; Hodge, 2005; Commonwealth of Australia, 2000; New South Wales Treasury 2001, 2006.) This is compounded by the fact that Value for Money tools such as Public Sector Comparators and audit processes have tended to focus on financial risks. Auditors have rarely investigated or examined issues which compare the initial performance specification to a winning design and the design outcomes of the completed project. Another problematic issue is the influence of the initial design on the long term maintenance and facilities contracts that operated during a PPPs concession period. But, as Gann argues, "a direct relationship exists between performance in design and construction and efficient and effective operation" of new facilities (Gann, 200 ,12)

One reason why design may not be accounted for in PPP research is because a number of the studies draw their data from economic infrastructure rather than social infrastructure which requires a higher level of functional design and user consultation (Zhang, 2004). In some research the distinction between these different types of infrastructure is ignored in order to look at PPPs and their associated risks from a more strategic or common perspective (Ng, Loosemore, 2006). In this approach the risks inherent in complex social infrastructure projects such as hospitals, schools and housing are equated with transport infrastructure such as road and rail. In these studies risk is normally segmented into different categories such as public risk, asset risk, operating risk, sponsor risk, financial risk and default risk. (Ng, Loosemore, 2006). Simulations developed to model PPP concession periods have also tended to focus on transport infrastructure rather than more complex arrangements that may occur in social infrastructure. Modelling traffic flow and linking it to a revenue stream is not the same as modelling the revenue streams generated by an operating hospital or commercial office building. (Ng, Xie, Cheung Jeffries, 2007).

The point at which design and construction processes intersect in PPPs is through the use of performance based specifications and contracts. In theory these types of specifications and contracts allow designers more freedom because it is thought that Performance Based Contracting (PBC) allows “designers more freedom to propose alternative solutions” (Gruneberg *et.al* 2007). This freedom is said to “provide real incentives and create a business environment that encourages innovation and improved practices in the construction phase.” (Leiringer, 2006). Countering this is the argument that this design freedom must be constrained because under performance based conditions designers may actually be more likely to “include tried and tested products” and that contractors may not necessarily be equipped to bear the development costs of prototyping new innovations (Gruneberg *et.al* 2007). This may be why project managers regard creativity and innovation only taking place in the “very early conceptual phases” of a PPP project (Leiringer, 2006). In this view, once created, the conceptual design is then tempered or weakened, depending on your view, by regulatory norms and practices. This is tantamount to assuming that design is not integrated with construction and that design innovation only takes place at the beginning of construction process and not throughout the entire PPP lifecycle. In this view once a unique or exotic design is created and then tempered or diminished in order to fit more “realistic” and “pragmatic” requirements misunderstands the design and innovation processes.

Whilst it has been argued that PPP success is dependent on “creativity and innovation.” (Eaton et. al, 2006, 63) the degrees of design freedom and issues surrounding design innovation in PPPs is complex. This is because design itself is a complex problem solving activity that “focuses on identifying the several possible solutions or hypotheses.” (Gray and Hughes, 2001, p. 27). Once the correct design solution has been reached the risks arising out of it are then separately managed. As Emmitt notes “Value management and risk management are complementary activities that inform the design team” (Emmitt 2007, p. 38). As Gray and Hughes contend, the role of managing design is often separately taken up by project managers who “can take decisions in the commercial framework of the project to maintain continuity of production ” (2001, p.51). These views suggest that architects are responsible for design alone and it is left to project managers to undertake “ experimentation with different forms of procurement” in the hope of making “the design and construction process more interactive ” (Gray and Hughes, 2001, p. 52). These approaches suggest that design activities are isolated from a project’s construction and organisational context. The purpose of the framework and hierarchy developed here is to understand which factors are more or less important in the management of design in a PPP project.

An AHP framework for assessing design freedom

Saaty’s Analytical Hierarchy Process is suitable for developing a framework which can begin to assess how design innovation and design activities play themselves out in PPP projects. (Saaty, 1980) This method is useful because it enables both quantitative and qualitative factors to be combined and analysed within the one model. This is because AHP uses pairwise comparisons between both qualitative and quantitative criteria in order to assess the relative importance of each criteria. In this context it is preferred over factor analysis or multivariate regression because it provides a set of mathematical methods tools than can identify alternatives from a set of complex objectives. As Roger's notes the AHP hierarchy allows "the decision problem to be broken down into individual elements whose relationships with each other can then be analysed'. (Rogers, 2001 p.240).

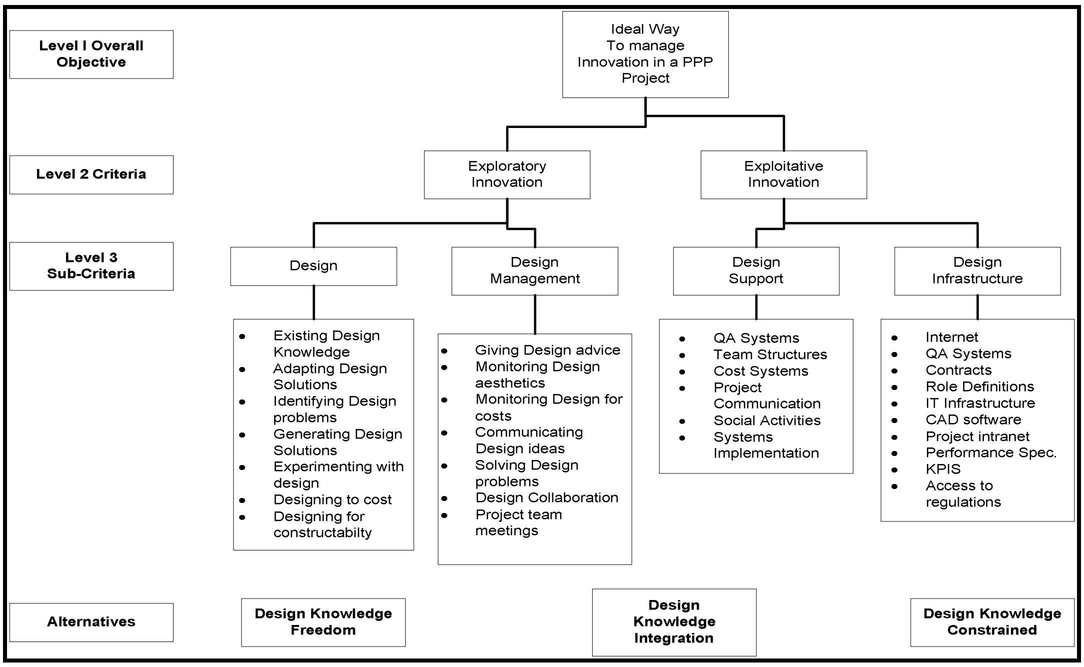
In construction management AHP has often been proposed as a useful decision tool. It has been proposed as a way to set priorities in maintenance management, contractor selection, procurement selection and for the selection of architectural consultants. As has been pointed out the use of AHP represents one aspect of the use in construction management of the application of Artificial Intelligence techniques to construction optimisation problems (Hua, 2008). The use of AHP as developed in this paper is different to those applications because it does not relate to a decision making problem where a single outcome or selection is required. Instead the purpose of the framework developed here is to ascertain which criteria are more or less important in a given PPP project. For example in any given PPP project is design as an activity more important than providing the systems and infrastructure which support it. In other words how do different projects produced via PPP procurement balance out exploitative and exploratory notions of design. If exploratory or radical innovation is created in one PPP project how is it then managed. For this reason the first level of our hierarchy had the overall objective of "the ideal way to manage design in a PPP project."

The level 2 criteria used to develop the model is based on a consideration of the types of innovations developed by the architects interested in this project. As Tushman and Brenner point out innovations can be distinguished between incremental or exploitative innovations and more radical innovations. They claim: 'incremental innovation, characterized by small changes in a technological trajectory, builds on the firms current technical capabilities, while radical innovation fundamentally changes the technological trajectory and associated organizational competencies.'(p. 238) As they explain: 'Incremental technological innovations and innovations designed to meet the needs of existing customers are exploitative and build upon existing organisational knowledge. In contrast radical innovations or those for emergent customers or markets are exploratory since they require new knowledge or departures from existing skills.'(Benner and Tushman, 2003). Distinguishing between these two types of innovation is important if we are to investigate the idea of design freedom in a PPP project context. This is because the creating a design or design knowledge which results in radical innovation is evidence that a PPP project has fostered design freedom. This is because this type of innovation requires a departure from existing skills or technologies and implies that a greater degree of freedom and project customisation has been allowed. In contrast exploitative innovations appear to rely more on existing knowledge. This existing organisational knowledge and technical expertise often already pre-exists within an PPP project organisation and may not require a degree of design freedom for it to be fostered.

In a recent study of an architectural firm explorative innovation has been distinguished as being "client facing, project-specific problem solving." It was seen that explorative innovation relied on architects at an operational level to "solve client problems to generate "short term" and "project specific" competitive advantage. An example of this activity might be the development and use of new materials, or the design of new environmental systems alongside complex geometries. These innovations can be been seen as being individually driven either by the architects or by the clients. In contrast exploitative innovation is about "organizational effectiveness" and "systems or structures" which are "embedded in the structure capital, in other words the "organizational systems, processes, tools rules and routines of the firm" It is argued that getting an appropriate balance between these two types of innovation is important in the knowledge based firm that purses innovation (Lu and Sexton, 2006). Level 3 of the sub-criteria highlights these issues. These sub-criteria describe the design activities other components related to the management of design knowledge once it is created as well as the "routines of the firm". In other words, the organisational systems and infrastructure which support it. In this level of the hierarchy Design, Design Management is related to exploratory innovation. Design support systems and design infrastructure were related to exploitative innovation.

The further articulation and segmentation of the Level 3 hierarchy developed and presented here extends studies and builds upon research into the design and construction of one of Australia's largest PPP projects (Raisbeck 2006). In this research the activities of the architect were defined and broadened to clarify what it was the architects did in each phase of the project. In it architectural design was defined as a research and development activity rather than as a problem solving activity. Hence, it is viewed as a process of research in order to develop new forms and ideas about buildings; it is this research which is a key driver of design innovation. This approach extends from recent studies in architectural theory which argues that design, especially architectural design, is a research activity in its own right. For this reason we defined the design activities of the architects as including the creation of design knowledge which comprised several components: researching design ideas, initiating new design approaches and solving problems through design. Also included was the activity of design monitoring which comprised: providing advice on design issues, ensuring the design meets aesthetic, architectural and spatial requirements as well as ensuring the design meets established cost and planning levels. The final component was design liaising and management which included communicating and negotiating design ideas to the client group, communicating with the project team, planning and coordinating with the project team and engaging in activities to build relationships within the team.

Figure 1: AHP Hierarchy: Ideal way to Manage Innovation in a PPP Project



Conclusion

The developed AHP hierarchy enables further research to take place which will test the extent to which design innovation is driven by the project context or by the organisations and teams involved in a particular project. The hierarchy will be used to develop a questionnaire based on the level four sub-criteria. Respondents will be asked to rank each of these using a Likert scale. As well as measuring the different factors that influence the management of a design in a PPP project the hierarchy will indicate the degree to which design freedom takes place. This approach is important because it will test to what degree architects pursue exploratory innovation in their early sketches and diagrams and then follow this through using their existing organisational competencies via processes of exploitative innovation. As has been noted elsewhere, achieving the appropriate balance between these two types of innovation is important in knowledge based firms that pursue innovation (Lu and Sexton, 2006). In the PPP context it is necessary to understand this process in order to understand if the PPP procurement model allows a greater degree of design freedom or not.

REFERENCES

Akintola, A., Beck, M.,. and Hardcastle, C. eds. (2003) Public-private partnerships : managing risks and opportunities, : Blackwell Science, Malden MA.

Akintoye, A., and Hardcastle, C. et al. (2003) Achieving best value in private finance initiative project procurement. Construction Management and Economics, 21, 461-470.

Akintoye A, Bing Li, Edwards P. J. and Hardcastle C. (2005) Critical success factors for PPP/PFI projects in the UK construction industry. Construction Management and Economics, 23, 459–471.

Benner, M.J. and Tushman, M.L. (2003) Exploitation, Exploration, and Process Management: The Productive Dilemma Revisited. Academy of Management Review, 28, 238-256.

Cheng Eddie W. L.; Li Heng, Contractor selection using the analytic network process. Construction Management and Economics, Volume 22, Issue 10, 2004, Pages 1021 – 1032

Cheung, Franco K. T .; Judy Leung Fung Kuen; Martin Skitmore Multi-criteria evaluation model for the selection of architectural consultants. Construction Management and Economics, Volume 20, Issue 7, 2002, Pages 569 – 580

Duffield, C. F. and Clifton C. J. (2007) Combining finance and design innovation to develop winning proposals. Unpublished paper Melbourne University.

Eaton, D, Akbiyikli, R and Dickinson, M (2006) An evaluation of the stimulants and impediments to innovation within PFI/PPP projects Construction Innovation, 6, 63–77

Emmitt, S. (2007) Design management for architects, Oxford, Blackwell.

English, Linda, (2005), "Using public-private partnerships to deliver social infrastructure: the Australian experience", pp.290-304 in Graeme Hodge and Carsten Greve (Eds.) The Challenge of Public-Private Partnerships: Learning from International Experience, Edward Elgar, Cheltenham, UK, and Northampton, MA, USA.

Gray, C. and Hughes, W. (2001) Building Design Management Butterworth-Heinemann, Boston.

Gruneberg, S., Hughes W., and Ancell D. (2007) Risk under performance-based contracting in the UK construction sector. Construction Management and Economics 25, 691–699

Gann, D. and Salter, A., (2000) Innovation in project-based, service enhanced firms; the construction of complex products and systems. Research Policy 29 pp. 955-972.

Gann, D, Brady T, Davies A, (2005) Can integrated solutions business models work in construction. Building Research and Information, 33/6, pp. 571-579.

Hampson, K.D., Peters, R.J., Walker, D.H.T., Tucker, S.N., Ambrose, M., and Mohamed, S. (2001). Case Study of the Action Peninsula Development. Department of Industry, Science and Resources, Commonwealth of Australia.

Hodge, Graeme, (2005), “Public-private partnerships: the Australasian experience with physical infrastructure”, pp.305-331 in Graeme Hodge and Carsten Greve (Eds.) The Challenge of Public-Private Partnerships: Learning from International Experience, Edward Elgar, Cheltenham, UK, and Northampton, MA, USA.

Leiringer, R. (2006) Technological Innovation in PPPs: incentives, opportunities and actions. Construction Management and Economics 24, 301-308.

McGeorge, D., Marcus J., Cadman K., and Chen S., E. (2007), Implications for Design and Build contractors bidding in Public-Private-Partnership Consortiums: an Australian perspective, Working Paper, School of Architecture and Built Environment, Faculty of Engineering and Built Environment, The University of Newcastle.

Masterman, J. W. E. (2002) Introduction to building procurement systems. Spon Press, London ; New York 2nd.ed.

Raisbeck, P. (2006), PPP financing, architectural design, and risk mitigation in Melbourne’s Southern Cross Station project. Joint International Symposium of CIB Working Commissions W55/W65/W86 Construction in the XXI century: Local and global challenges, Rome 18-20 October 2006.

Saaty, T.L. (1980). The Analytical Hierarchy Process, McGraw-Hill, New York. 1980.

Shu-Ling, L and Sexton, M., (2006) Innovation in small construction knowledge-intensive professional service firms: a case study of an architectural practice. Construction Management and Economics.24 1269-1282.

Sexton, M., and Barrett, P., (2003) A literature synthesis of innovation in small construction firms: insights, ambiguities and questions. Construction Management and Economics. 21 613-622.

Skitmore, R.M., and Marsden, D.E. (1998). Which procurement system? Towards a universal procurement selection technique. Construction Management and Economics, 6, pp.71-89.

Zhang, X (2005) Criteria for Selecting the Private-sector Partner in Public-Private Partnerships Journal of Construction Engineering and Management, 631.

CROSS-INDUSTRIAL COLLABORATION FOR INNOVATION IN CONSTRUCTION?

Innovative performance in the steel structure conservation production chain

Emilia van Egmond *
e.v.egmond@tue.nl

Andreas Heutink **
andreas.heutink@rws.nl;

Stache Bancken*
e.l.j.bancken@wolmail.nl

Albert Barneveld **
albert.barneveld@rws.nl

*Eindhoven University of Technology, Eindhoven, The Netherlands
**Ministry of Public Works, Transport and Water Management, Department Innovation & Development, Utrecht, Netherlands

Drawing on the innovation system theories, which are rooted in the broad field of evolutionary and institutional economics and sociology of technology, we have applied the concepts of innovation and innovation system as a tool to analyse innovation processes and the innovative performance in production chains. This paper describes the analyses of the innovation system and innovative performance in the production chain of steel structure conservation (SSC). Findings of this case study give insight in (1) the major source of innovations; (2) the innovative performance in the SSC production chain; (3) features of the technological regime and cross industrial collaboration between actors (4) the relation between innovation, sustainable construction and competitiveness of firms; (5) opportunities to increase the innovation performance by a transition towards long term cross-industrial collaboration in the construction industry (CI) production chains. The latter, however, requires change management in the rather tradition bound CI.

KEYWORDS: Construction Industry, Innovation system, Production Chain, Technological Regime

INTRODUCTION

Innovation contributes to the competitive success of firms in many different ways (Bessant and Tidd 2007). Yet, at a longer term, innovation by single firms or organizations offers insufficient opportunities for sustainable competitiveness. Due to the increasingly shorter and freaky lifecycle of products or services, firms are urged to innovate at a faster pace. This is not any longer feasible in the traditional organisation of production. In many firms, conditions are simply not present to stimulate more entrepreneurship and creativity (Chesborough, 2003). Also due to an increased complexity of the demand in the market, firms and organisations are more and more forced to innovate in networks and beyond the boundaries of their own sector. Innovating in new combinations of firms and organizations in networks offers new chances of new markets; a direct link with the market thanks to improved access to information; a better utilization of the available knowledge within the organization but also beyond (knowledge leverage and knowledge spillovers); increased efficiency through direct collaboration with clients; and shorter lead time from idea to market. In fact, for firms it all comes down at the need for searching, selecting and applying complementary knowledge to innovate by collaborating with others (Bessant and Tidd, 2007; Chesborough, 2003).

Also construction firms are faced with the need to innovate in order to struggle out of the grasp of intensified competition and to respond to the increased societal pressure to meet the demand for sustainable and cleaner industrial production, higher quality of output against lower cost and higher value added. The construction industry (CI); however, despite its many cross –industrial relations; is a tradition-bound sector and lags behind in innovativeness compared to the manufacturing industries. Production chain relations in construction are ad-hoc and project based and firms are facing uncertainties and a vulnerability to risks which leads to information and knowledge hiding. This forms a barrier to learning and exchange of knowledge about project experiences and is detrimental to innovation. (Franco et al, 2004) By knowing the innovative performance as well as the source and mechanism of innovation in construction, strategies can be determined to increase the competitive position, sustainability of production, the quality of output and cost-efficiency of construction firms, for example by a transition towards long term cross-industrial collaboration in the CI production chains comparable with those in manufacturing.

These views are applied in a case study, in the steel structure conservation sector (SSCS) -a sub-sector of the CI- engaged in the conservation of steel structures such as bridges, platforms, etc. The study has been part of a larger program to transform the Dutch construction industry to achieve a structural and irreversible quality improvement (PSIBouw) The following paragraphs describe first the methodological approach on innovation in the SSCS, followed by the research results, conclusions and a discussion of opportunities to improve the innovative performance in the sector.

THEORETIC BACKGROUND

Various scholars have attempted to explain innovation processes over the past decades by using innovation system theories, which are rooted in the broad field of evolutionary and institutional economics and sociology of technology (Metcalfe, 1995; Edquist, 1997, Nelson and Winter, 1984). Innovation in this perspective is seen as an on-going cyclic *process* that encompasses the *creation, diffusion, selection, adoption and application* of new ideas, knowledge and technological skills by individuals, firms and organizations. An important insight of the innovation theories is that innovation thrives on knowledge. Tidd, Bessant and Pavitt (2005) argue that innovations emerged in the course of time thanks to the increasing levels of knowledge and technological skills, enhanced by continuous learning: *accumulation, integration and mobilization* of knowledge and technological skills. This enables individuals, firms and organizations to create new possibilities through combining different knowledge sets which include knowledge about products, processes, markets, competitors, etc.(Tidd, Bessant and Pavitt 2005). Innovation implies change, which can take many forms. There are different classifications such as: product-, process-, position- (of organizations in the socio-economic context) and paradigm- innovation. (Bessant and Tidd 2007) A position innovation implies a structural change in the positions and relations of firms and organizations operating in a certain socio-economic context. This highlights that innovation processes do not take place in isolation but in a social and economic context around the innovation (Von Hippel, 1988). The processes take place under high uncertain conditions in an innovation system.

An innovation system is seen as a set of distinct interconnected institutions which jointly and individually contribute to the development, creation, diffusion and implementation of knowledge, skills and artefacts; which define new technologies and which provides the framework within which governments formulate and implement policies to intervene in the innovation processes (Metcalfe, 1995). Harkema and Baets (2001) advocate that innovation processes should be defined in terms of actors in an innovation system and the interactions between them, which result in different levels of learning (i.e. knowledge accumulation and integration) and continuous adaptation of cognitive schemata and underlying structures. The interaction is defined as the exchange of ideas and knowledge that takes place in the setting of an actor network, in an innovation system.

Marsili and Verspagen (2001) indicate that the prevailing technological regime sets the boundaries and form a constraint to what can be achieved in innovative activities -associated with a given set of production activities- and the directions (natural trajectories) along which solutions are likely to be found. Technological regimes are seen as social constructs: a pattern of knowledge, rules, regulations conventions, consensual expectations, assumptions, or thinking shared by the actors in the innovation system. A t*echnological regime* (comparable with paradigm) characterizes the professional practice of the network actors and guides the design and further the development of innovations (Dosi 1982, Nelson & Winter 1982). Besides the macro level framework where socio-economic, cultural, natural and physical aspects rule the game have always been important as a driver for technological and economic development (Lundvall, 1992; Edquist, 1997). Consequently, it can be concluded that a variety of contextual factors at different levels has an impact on the development trajectory of an innovation. At *macro-level*, the socio-economic context is reflected in policies, laws and regulations. At *meso-level, it concerns the technological regime in the innovation system, i.e.* the social norms, interests, rules and belief systems that underlie the strategies of companies, organizations and institutions and policies of political institutions. At *micro-level*, individual actors have an impact on sets of knowledge, technological skills, innovation and local practices (Kemp et al1998). In this perspective, it can be stated that an innovative effort will be successful, when fitting the prevailing innovation system: i.e. the actor network, the technological regime at industry level and the institutional infrastructure at national level (Nelson & Winter 1982; Douthwaite 2002). Concluding: an innovation system encompasses basically three building blocks (see figure 1)

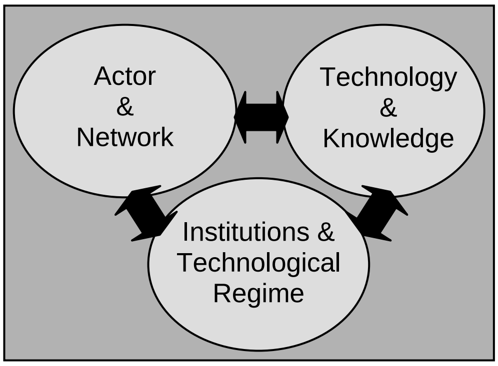


Fig 1.Innovation system building blocks according to Malherba (2002)

The building blocks of an innovation system include: (1).a network of agents interacting in a specific economic/industrial area; (2).a set of knowledge and technological skills that define competitive products, processes and services that fulfil a specific need in markets; (3).a particular technological regime and institutional infrastructure (Carlsson and Stankiewicz, 1991; Breschi and Malerba, 1997). Meanwhile, innovation systems have been categorized into different levels of aggregation: national -, regional -, and sectoral innovation systems. There is no consensus yet on the exact definition and boundaries of an innovation system and its components, and the concept is still emerging.

RESEARCH METHODOLOGY

Drawing on the innovation theories, we used the concepts of innovation and innovation system to explore the building blocks of the innovation system of steel structure conservation; the innovative performance of the system as well as the source and mechanism of innovation – i.e. the processes of creation, diffusion and implementation of new knowledge embodied in products and production processes, by the production chain actors of the steel structure conservation sector (SSCS). Given the foregoing theoretic considerations we defined the innovation system boundaries by including the agents in the actor network which are (1) directly involved in a production chain, which is in our case the steel structure conservation (SSC) production chain; (2) branch organizations; (3) knowledge institutions and organizations; (4) policy makers and regulating actors. Thus, the actor network is the organizational structure in which innovation takes place by the network actors who combine different sets of knowledge and technological skills, and which is ruled by the technological regime at meso-level and institutional infrastructure at macro level.

This approach leads the attention to multi component analyses of the SSC innovation system which are mutually supportive and necessary and may help to get insight in the innovative performance of firms and organizations as well as the factors that have an impact on innovation processes in the innovation system. They include an analysis of: (1). The composition and structure of the actor network (i.e. the functional relations between actors); (2). The institutional infrastructure, i.e. the macro level contextual factors codified in laws and regulations; (3). The current knowledge and technologies sets in the innovation system; (4). The innovative performance of the SSC production chain actors; (5). The technological regime of the firms and organizations directly involved in the production chain of SSC.

The results of the first three analyses provide insight in the macro- and meso-level setting in which innovation at firm level takes place. A problem and disadvantage of analysing the innovation system at these levels is the broad range of knowledge and technologies that exist in the system, which makes it impossible to analyse them in a detailed manner (Carlson 2002). We decided to focus at the current knowledge and technology domains in the SSCS. Data are collected by means of literature studies and expert interviews.

The analyses at macro and meso-level formed the basis for further exploration of the innovative performance of the firms and organizations involved in the SSC production chain and the features of the technological regime that have an impact on the innovation trajectory. These analyses take place at firm and organisation level. Innovative performance is defined in this research as the extend, to which a firm or organisation, has been able to bring about competitiveness and sustainability in their professional practices by means of innovation.

We used a questionnaire in this part of the research. The key questions addressed to the respondents refer to the features of the technological regime (professional practices) during three phases of the innovation process: creation, diffusion and implementation of new knowledge and technology. The questions relate to the firms' and organizations' expectations, awareness, strategies and commitment to innovation (budget + staffing); the mechanism used by the firms and organizations in the process of creation, diffusion and implementation of new knowledge and technologies in the production chain, such as dedicated R&D, collaboration with other actors, project evaluation, literature and document reviews, conferences, meetings, publications, training; and the resulting proactive innovation relations of the organizations and firms in the innovation system. The questionnaire was sent to a representative sample of firms and organizations operating in the production chain of steel structure conservation in the Netherlands, classified in suppliers, contractors and (public and private) clients. The questionnaire has been validated by comparison with similar ones used for innovation studies at firm level (SMILE 2001; Gras and Wijffels, 2006). The questionnaire has been tested and adapted to the comments from representatives of the branch organizations of firms involved in the SSCS. A total number of 56 respondents equally divided amongst the 3 classes of actors have participated in the research.

RESULTS

The Dutch SSC actor network

The set of distinct institutions which jointly and individually contribute to innovation in the Dutch SSC innovation system encompasses the following. (See figure 2)

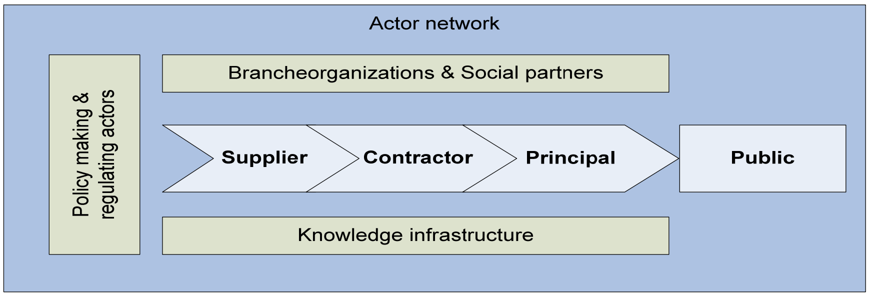


Fig 2 Actor network

The three major players in the production chains of the SSC who are involved in the primary processes and who collaborate (often ad hoc) in projects based on contractual agreements that define the quality and sustainability of an envisaged steel structure: (1) suppliers (paint manufacturers and suppliers of basic chemicals and additives) responsible for (new developments regarding) the conservation product quality (2) contractors (steels structure builders and metal conservation firms) responsible for the conservation process and steel structure quality and who have to rely on the steel- and conservation materials producing companies; (3) public and private clients, having an important say in defining the quality requirements in the contractual agreements. Production chains are composed by integrated tendering (Engineering & Construct and Design & Build) on the basis of functional demand specifications by clients and selected upon a best price-quality ratio. Specialist knowledge institutions such as consultancy engineering firms, R&D institutes and universities may support the production chain actors.

Branch organisations promote the economic interests of the individual firms and organizations in the SSC production chain at national and European Union level via lobby

networks, thereby acting as a connecting link between the individual firms and policy making institutions (PSIBouw, 2005).
Policy making and regulating institutions (various ministries, governmental agencies, EU institutions) formulate and implement policies to intervene in the innovation processes.

The Dutch SSC institutional infrastructure

Environmental and sustainability aspects of production processes are considered of pivotal importance in Dutch policy making The innovation system of the Dutch SSCS is subject to policy ambitions, institutional and social pressure, particularly reflected in the laws and regulations regarding tender procedures, occupational health and safety and environmental protection, transport, sustainable entrepreneurship and international norms. The construction industry’s response on these matters is based on three cornerstones: innovation, transparency and price/quality. (Regieraad Bouw 2005)

Current Dutch SSC technology and knowledge sets

The following knowledge and technology domains are mentioned to be important and relevant to achieve sustainable steel structure conservation: knowledge and technology on (a) project specification and commissioning; (b) steel structure design and engineering; (c) conservation products; (d) conservation processes; (e) environmental conditions in which the production is taking place (PSIB 2007)
Knowledge bottlenecks in the SSC innovation system relate to (1) corrosion conscious design, (2) maintenance monitoring system, (3) knowledge supplying institutions and organisations who do not meet the knowledge needs in the production chain; (4) too late involvement of consultants in new projects; (5) poor formulation of inspection assignments during maintenance phase of the structure.; (6) the fact that required knowledge for sustainable and competitive SSC is not exchangeable, fragmented available and still partly needs to be developed. (NCC 1996, COT 1998) Important developments in the SSCS, which requires additional and different knowledge are (1) increased project execution and delivery based on functional specifications; (2) improved knowledge base amongst line executives; (3) increase of outsourcing and (3) extension of the range of duties of inspectors and supervisors.

The innovative performance of the Dutch SSC production chain actors

The innovative performance during the three phases of the innovation process (creation, diffusion and implementation) of the SSC production chain actors is measured on a scale 1-4, based on the responses to the questionnaire sent to them through internet. The respondents represent practically all firms and organizations operating in the heavy steel structure conservation sector.
The innovative performance in the total production chain of SSC is rather moderate. (See Table 1).

Table 1 Innovative performance in the SSC production chain

	Supplier	Contractor Conservation	Contractor Steel structure	Private client	Public client	Total
Creation	3,2	2,4	2,2	2,5	3,1	2,8
Diffusion	3,2	2,0	2,0	2,0	2,6	2,5
Implementation	3,0	2,4	2,1	2,4	2,6	2,6
Innovative performance	3,2	2,3	2,1	2,4	2,8	2,6

The production chain scores best for the creation of new knowledge whilst the diffusion of knowledge in the production chain is undersized. The innovative performance differs between the various actors in the production chain The findings indicate suppliers as the major source of innovations. The innovative performance of the public clients scores relatively high. The level of diffusion among contractors and private clients is low. Also implementation stays behind among contractors and private clients.

The Dutch SSC technological regime

Table 2 gives an overview of the major regime features that have an impact on the innovative performance of the suppliers, contractors and clients in the SSC production.

Table 2 Major influencing technological regime features on innovative performance

	Creation	Diffusion	Implementation
Promoting features	▪ Awareness of technological and social developments ▪ Orientation at innovation collaboration ▪ Insight in own competences ▪ Budget for innovation	▪ Management commitment to facilitate diffusion ▪ Participation in meetings for innovation ▪ Evaluation of innovation failures	▪ Awareness of a positive impact of innovation SSC sustainability ▪ Orientation at other application opportunities of novelties ▪ Evaluation of impact of novelties ▪ Positive expectations regarding new type of contracts (Functional specification) ▪ Awareness of the pressure of current laws and regulations
Constraining features	▪ Limited consideration for sustainability requirements ▪ Limited relations with knowledge institutions	▪ Limited combination of knowledge sets, e.g. marketing- engineering ▪ Limited knowledge exchange among production chain actors on innovation failures ▪ Lack of journal publications	▪ Limited opportunities to test novelties in real practice ▪ Rigid specifications in traditional contracts ▪ Limited involvement of clients in the implementation of novelties

The following remarks can be made additionally. *A promoting regime feature* for the innovative performance in the production chain is the importance attached to novelties by the actors in relation to their competitive position. Suppliers (100% of the respondents) and contractors (83% of the respondents) who have indicated to attach importance to the relevance of novelties for their competitive position appear to have a higher innovative performance score. The same higher innovative performance score is found under suppliers and public clients who have indicated that the sustainability of the SSC (improved safety and health conditions, less negative environmental impact) has increased due to their innovation efforts. In contrast the overall innovative performance level of steel structure contractors is low whilst they also mentioned a low sustainability increase, which actually is not surprising since they generally are the risk bearing main contractors working with low profit margins in traditional project contractual agreements.

The *experience level* of the leading persons of the firms and organizations in the SSC production chain is rather high. (a majority of 69% with more than 15 years experience). At one hand this may favor the innovativeness in the SSC production chain, at the other however it may imply that –particularly the contractors- keep sticking to the familiar way of working, The *percentage of the annual turnover* dedicated to innovation is for 18% of the respondents more than 3% of the annual turnover and for the rest it is between 0-2% of the annual turnover. 10% of the steel structure contractors and 16% of the private clients indicate that the percentage to be spent on innovation will decrease, 33% expects that it stays the same, whilst 40% expects an increase. 70% of the suppliers, 50% of the conservation contractors and 36% of the public clients expect an increase.

CONCLUSIONS

Due to the increased social pressure as well as due to an intensified competition, the SSC innovation system needs to innovate to achieve a higher quality and sustainability of output against lower cost and a higher value added. The social pursuit to achieve a higher quality and sustainability of output is imposed by institutional infrastructure developments. This is reflected in stronger requirements -particularly in the area of environmental protection and occupational health and safety- formulated in laws, regulations and norms for products and production processes as well as in the requirement for an integral lifespan approach and quality specifications in construction project contracts.

The results of our research indicate opportunities to increase the innovation performance in the SSCS provided that a transition takes place towards longer term cross-industrial collaboration in the construction industry (CI). This however calls for adequate management to bring about change in the mutually related building blocks of the innovation system: the actor network, the technological regime and institutional infrastructure and the technology and knowledge set. In the end this may entail a total system innovation.

This conclusion is underpinned by the features of the present situation in the SSCS, which indicated that the functional relations in the actor network are still more or less ad-hoc and not strong. Production chains are project based and composed by means of integrated tendering on the basis of functional demand specifications and a selection upon best price-quality ratio. A central direction and promotion of the common interests of the actors in the SSC innovation system is lacking, which is detrimental to stimulate innovation. Knowledge and technology sets needed for sustainable and competitive production in the SSC innovation system are fragmented available among the actors, not exchangeable and still partly needs to be developed. Suppliers in the production chains of SSC appear to be most innovative followed by the public clients. The improvement of competitiveness and sustainability appeared to be an important driving force to innovate. An important problem that occurs relates to the diffusion of innovative knowledge particularly amongst contractors and private clients. The major bottlenecks in the technological regime in the SSC innovation system detrimental to the innovative performance – particularly with respect to the diffusion of knowledge in the actor network- include (a) Limited focus at sustainability requirements; (b) Limited communication, knowledge exchange and combination of different knowledge sets -e.g. marketing & engineering- in firms and organizations, through cross-industrial collaboration, with knowledge institutions and clients; (c) Lack of journal publications; (d) Limited opportunities to test novelties in real practice; and (e) Rigid specifications in traditional contracts. Moreover it is evident that there is a need for uniform sustainability norms for products, processes and services in the SSC innovation system. However there appears to be no uniformity in the sustainability measures for the steel structure which should serve as criteria for the quality of production output.

Given the case study findings and relying on evidence in manufacturing, it can be stated that sustainability and continuity by means of different forms of cross industrial collaboration and contractual agreements between the actors based on transparent performance measurement and improvement targets will benefit clients and entrepreneurs in the SSCS. Sustainability of operations and economies of scale are important aspects to be taken into consideration in the transition from project towards a portfolio approach. Entrepreneurs will be stimulated to invest in product innovation, output quality improvement and process organizational innovation in case quality and innovation are highlighted in more projects at the same time. Learning effects and the resulting improved operational performance will then actually be favourable to both clients and contractors in the whole CI. Besides, in the end the whole society will benefit such as in the case of the transport sector, which will benefit from an improved quality of the steel constructions in road and rail networks.

To conclude can be stated that the used methodological approach has showed to be useful, by means of which we could explore the innovative performance in the SSCS and its technological regime that has an impact on the development trajectory of innovations. Yet changing the innovation system building blocks of the whole industry calls for additional research to support change management in the rather tradition bound construction industry.

REFERENCES

Bessant,J and Tidd, J (2007) Innovation and entrepreneurship, Chichester, John Wiley and Sons

Breschi S. Malerba F. (1997), Sectoral systems of innovation: technological regimes,Schumpeterian dynamics and spatial boundaries in Edquist C. (ed), Systems of innovation, F Pinter, London

Carlsson, B., en Stankiewicz, R., 1991, On the nature, function and composition of technological systems; Journal of Evolutionary Economics; Vol. 1; pag. 93 – 118.

Chesbrough, H.W., 2003, Open innovation, The new imperative for creating and profiting from technology, Harvard Business School Press

COT, 1998, Rapportage IOP VERF, Inventarisatie van de kennisbehoefte in de verfkolom, september 1998, rapportnummer LB98-255.RAP

Dosi, Giovanni, (1982) Technological Paradigms and Technological Trajectories, Research Policy, 11, pp. 147-162.

Douthwaite, B. (2002). Enabling Innovation: A practical guide to understanding and fostering technological innovation. Zed Books:London, UK.

Edquist, C. (ed.) (1997) Systems of Innovation: Technologies, Institutions and Organizations, London: Pinter/Cassell

Franco L. A., Cushman M, and Rosenhead J., (2004), “Project review and learning in construction industry: Embedding a problem structuring method within a partnership context”, *European Journal of Operational Research*, **152**, 586-601

Gras, B., Wijffels, D., 2006, InnovatieScan voor onderzoeksinstituten, Beschrijving van de scan en resultaten van toepassing bij KIWA Water Research, InnoQ.

Harkema S J.M. and Baets, W (2001)“Customerized” innovation through the emergence of a mutually adaptive and learning environment in European Journal of Economic and Social Systems 15 N° 1 (2001) 111-129 EDP Sciences 2001

Hippel, E. von, (1988) The Sources of innovation, Oxford university press, NY, Oxford.

Lundvall, B-Å. (1992) (ed.). National Systems of Innovation: Towards a Theory of Innovation and Interactive learning, London: Pinter.

Malerba, F., 2002, Sectoral systems of innovation and production; Elsevier; Research Policy; Vol. 31; Pag. 247-264.

Marsili, O & Verspagen, B (2001) “Technological regimes and Innovation: Looking for Regularities in Dutch manufacturing” Druid summer conference 2001 Denmark.

Metcalfe, S. (1995), Technology systems and technology policy in an evolutionary framework, Cambridge Journal of Economics, 1995, 17, pp. 25-46

NCC, 1996, Resultaten onderzoek naar kennistekorten op het gebied van corrosie en corrosiemanagement, april 1996.

Nelson, R.R.& Winter, S.G., (1982). An Evolutionary Theory of Economic Change. Bellknap, Cambridge, MA.

PSIBouw O210, 2005, Projectplan Professionalisering Staalconservering, documentnummer SCON-2005-068-TCE, versie definitief,

PSIBouw, 2007, Resultaten Dialoog Professionalisering Staalconservering, SCON-2007-417-TCE 17 april 2007.

Kemp, R, Schot J and Hoogma,R(1998), ‘Regime Shifts to Sustainability through Processes of Niche Formation. The Approach of Strategic Niche Management', Technology Analysis and Strategic Management, 10(2): 175-195

Regieraad Bouw, 2005, Vernieuwingsoffensief bouw *2005-2008.*

SMILE-team (2001). Small and Medium-sized Innovatively Leading Enterprises; De SMILE-innovatie audit; standaardvariant versie 2. Technische Universiteit Eindhoven.

Tidd, J. Bessant, J., and Pavitt, K. (2005) Managing innovation, Willey & Sons Ltd

NIGERIAN CONSTRUCTION AND FOREIGN DIRECT AND PORTFOLIO INVESTMENTS

Saka, N.
Department of Quantity Surveying,
Federal University of Technology, Akure, Ondo State
saka_najimu@yahoo.com

The low gross domestic savings of most Less Developed Countries (LDCs), which Nigeria belongs, is a major limitation to infrastructure development, a fundamental requirement for rapid socio-economic transformation. LDCs must therefore mobilize capital from high income countries to bridge their savings investment gap. This study assessed the response of the Nigerian construction sector to Foreign Direct Investment (FDI) and Foreign Portfolio Investment (FPI). Annualized time series data for this study were extracted from Central Bank of Nigeria (CBN) and National Bureau of Statistics (NBS) statistical bulletins covering the year 1981 through 2006. Econometric techniques including unit root test, co-integration test as well as Granger causality test were adopted for the analyses. The result indicated the data were non-stationary at level but became stationary at first difference of their natural logarithm. Johansen co-integration test also shows that FDI and FPI significantly co-integrated with the construction, Granger causality test at several lags indicated that the FDI granger caused construction significantly at several lags while the FPI only marginally affected construction. The study concluded that though FDI and FPI impacted significantly on Nigerian construction sector, the impact could be further enhanced by increased net FDI and FPI inflow into the Nigerian economy.

KEYWORDS: Foreign Direct Investment, Foreign Portfolio Investment, Construction Sector, econometric techniques

INTRODUCTION

Foreign capital has long been accepted as inevitable input in the development process; given the fact that no country is an "island" with in all resources needed to stimulate economic growth and development. Foreign Investment has been hailed as a vehicle for accelerating economic development and ameliorating the commercial bank debt problems of Less Developed Countries (LDCs). The need for external capital inflow arises when desired investments exceed actual savings in a country. Such countries rely heavily on foreign aid and investment to alleviate poverty and foster sustainable growth. The argument for increased Foreign Investment to developing countries is timely and compelling because at best foreign investment brings capital technology and international market and management skills to countries where these resources are in short supply. Furthermore, private foreign investment harmonises nicely with efforts to promote private sector initiatives and resonate sympathetically with the call for privatization of state owned enterprises. Foreign investment help facilitate the reallocation of LDCs abundant natural and human resources away from inefficient uses that drains domestic savings and foreign exchange earnings , and toward industries that will absorb surplus, transfer technology and management skills and open up new export markets (Dickie & Layman, 1988; Vries, 1990 and World Bank, 1995).

Foreign investment happens to be the beneficial and efficient source of external finance to LDCs of the private international capital movement. While foreign investment is seen as synonymous with the development especially in Low Income Countries (LICs), it is universally acknowledged that foreign investment is increasingly becoming the most potent source of capital formation across the globe. Therefore LICs needs investment in order to maximize their economic potentials to a level where they can aim to compete in the global economy and by so doing improve the quality of life of there citizens (Aremu, 2003; Wakil, 2004). Foreign investment through debt equity swap but more importantly through increased traditional investment vehicle is attractive because it can provide new capital , improve exports earning and convert fixed foreign exchange obligations (debt service) to external payments (Ellis, 1990).

Few will disagree that for Africa to successfully reduce poverty and increase standards of living, substantial external financing is required. The debate with regard to the efficacy of foreign investment as the source of this financing however remains a contentious issue. It would seem difficult for even the most cynical of economists to completely disregard the potential benefits of foreign investment in Africa. foreign investment that involve the acquisition of a direct and controlling stake in local firms will no doubt have both a greater and longer lasting impact on economic growth (Van der Walt, 1997). However, it would be unwise to pin too much hope on foreign investment flows to bridge either the foreign exchange or domestic saving gaps (Hussein, 1993). Foreign investment are broadly divided into two categories i.e. Foreign Direct Investment (FDI) (Kenen, 1968) and Foreign Portfolio Investment(FPI) (Babalola, 2004).

Many policy makers and stakeholder in Africa have skeptical views of benefits that can accrue to national economies through FDI. The conventional view has always been that Multinational Companies (MNCs) investment in Africa is primarily to exploit the natural resources / wealth of African countries in order to maximize monopoly of rents. Evidence from other LDCs suggests that these fears are not well founded. The two major obstacles to higher growth in this region are low investments and shortage of foreign exchange. FDI could address both problems; it brings in foreign exchange to supplement domestic savings and raise investments. FDI could also increase the efficiency of the domestic economy. The experience of Asian economies shows that FDI can accelerate the rate of growth and diversification of exports not only by providing finance but also by giving access to technology and markets (Hussein, 1993).

FDI has recently been marked by a significant expansion in net and gross capital and a substantial increase in the participation of foreign investors and foreign financial institutions in the financial markets of developing countries (World Bank, 1997).While Asian and Latin American countries, including China, India, and Brazil continue to attract foreign international capital from all over the World, the same cannot be said of African countries (Taylor & Sarno, 1997). African countries particularly Sub Saharan African countries have had a disappointing performance in attracting FDI, even the political economic and social reforms that started since the late 1980s are yet to significantly affect Sub Saharan Africa (SSA) performance in attracting international capital flows (Orji, 2004).

FPI flow into Nigeria is either directly through the Nigerian Stock Exchange Market or through some dollar-dominated mutual funds managed by a few fund managers such as Securities Transactions and Trust Co. Plc and Denham Management Limited (World Bank, 2007). FPI have witnessed a winding growth pattern, with the promulgation of the Nigeria Investment and Promotion Commission Act No.16 and the Foreign Exchange (monitoring and Miscellaneous Provisions) Act No.17 both of 1995, there is a gradual increase of FPI flow into Nigeria (Papionnu and Duke, 1993).

The dismal performance of Nigeria in attracting significant FDI and FPI has a far reaching implications on the growth and development of Constructed Investment(CNV) and the Construction Sector (CNS) which is largest components of Gross Fixed Capital Formation(GFCF) of developing economies (Hillebrandt, 2000) and an important contributor to the national economies of African countries. The infrastructural base of the Nigerian economy has remained weak in the past decades and further characterized by uneven distribution and decay arising from several years of neglect. Power supply in the country for instance has been grossly inadequate as only 30 percent of the population had access to electricity (Wakil, 2004). The country currently needs 16 million houses costing in excess of N8 trillion naira to build (World Bank, 2007).The aim of the study is to assess the effect of FDI and FPI on the Nigerian construction sector performance.

METHODOLOGY

The study used Econometric methodology which involves the use of several econometric techniques including unit root test, Johannes co-integration test and granger causality tests to determine stationarity and causality among the series data. The statistical software EViews 4.1, was used to analyze the data.

Unit root analysis: Time series models are based on the notion that the series to be forecasted has been generated by a stochastic (or random) process, with a structure that can be characterized and described. In other words, a time series model provides a description of the random nature of the (stochastic) process that generated the sample of observations under study. The description is given not in terms of a cause-and-effect relationship (as would be the case in a regression model) but in terms of how that randomness is embodied in the process. If the time series to be forecasted has been generated by a stochastic process, it is assumed that each value y_1, y_2, ..., y_t in the series is drawn randomly from a probability distribution. A model of this process attempts to describe the characteristics of its randomness. Of course, the usefulness of such a model depends on how closely it captures the true probability distribution and thus the true random behavior of the series (Pindyck and Rubinfeld, 1991). A simple example of a stochastic time series is the random walk process. Each successive change in y_t is drawn independently from a probability distribution with 0 means. Thus y_t is determined by

$$y_t = y_{t-1} + \varepsilon_t \qquad (1)$$

With E (ε_t) = 0 and E ($\varepsilon_t\varepsilon_s$) =0 for $t \neq s$

A simple extension of the random walk process is the random walk with drift. This process accounts for a trend (upward or downward) in the series y_t and thereby allows to embody that trend in the forecast. In this series, y_t is determined by

$$y_t = y_{t-1} + d + \varepsilon_t \qquad (2)$$

so that on the average the process will tend to move upward (for d > 0)

If the underlying stochastic process that generated the series can be assumed to be invariant with respect to time, the process or series is non-stationary. If the stochastic process is fixed in time, the process or series is stationary. Stationary series can be modeled via an equation with fixed coefficients that can be estimated from past data. The random walk with drift is one example of a non-stationary process. Many of the time series encountered in business and economics are not generated by stationary processes (Nelson and Plosser, 1982; Pindyck and Rubinfeld, 1991). The number of times that the original series must be differenced before a stationary series results is called the order of homogeneity. Thus, if y_t is first-order homogeneous non-stationary, the series

$$w_t = y_t - y_{t-1} = \Delta y_t \qquad (3)$$

is stationary. If y_t happened to be second-order homogenous, the series

$$w_t = \Delta^2 y_t = \Delta y_t - \Delta y_{t-1} \qquad (4)$$

would be stationary.

The formal method to test the stationarity of a series is the unit root test (Leitner, & Fischer, 1998). Dickey fuller (DF) and augmented dickey fuller (ADF) test (Dickey and Fuller, 1979) are applied to test the two time series data for unit root. Both tests control for higher-order serial correlation in the series. The ADF approach controls for higher-order correlation by adding lagged difference terms of the dependent variable y to the right-hand side of the regression (Quantitative Micro Software, 1998b):

$$\Delta y_t = \mu + \gamma y_{t-1} + \delta_1 \Delta y_{t-1} + \delta_1 \Delta y_{t-2} + \ldots + \delta_{p-1} \Delta y_{t-p+1} + \varepsilon_t \qquad (5)$$

Co-integration analysis: Two time series are said to be co-integrated, when both are non-stationary, but a linear combination of those time series is stationary (Engle and Granger, 1987; 1991). For example, it may be that the variables x_t and y_t are non-stationary time series, but the variable $z_t = x_t - ßy_t$ is stationary. If this is the case, x_t and y_t are said to be co-integrated, and ß is called the co-integrating parameter. The stationary linear combination is called the co-integrating equation and may be interpreted as a long-run equilibrium relationship between the variables (Leitner, & Fischer, 1998). Co-integration literature goes back to Yule (1926), who suggested that regressions based on trending time series data can be spurious. This problem of spurious regression was further pursued by Granger and Newbold (1974) and this also led to the concept of co-integration. The literature on co-integration has finally exploded after the pathbreaking paper by Granger (1981). The earliest co-integration test was the one suggested in Engle and Granger (1987) which consists of estimating the co-integrating regression by OLS, obtaining the (estimated) residuals u_t and applying unit root tests for u_t. Several extensions of this test have been proposed and since they are all based on u_t, they are called residual-based tests. The co-integration analysis is performed with a vector autoregression (VAR)-based co-integration test, using the methodology developed by Johansen (1995). The Johansen's method is to test the restrictions imposed by co-integration on the unrestricted VAR involving the series (Quantitative Micro Software, 1998b).

Test for Granger Causality: The procedure for testing statistical causality between FDI, FPI, CNV and CNS is the direct granger causality test proposed by Granger (1969). Granger causality may have more to do with precedence or prediction than with causation in the real sense. It suggests that while the past can cause/predict the future, the future cannot cause /predict the past (Comincioli, 1996). The causality test aims to verify whether historical variations of the construction data follow or precede those of FDI and FPI. The Granger Causality test performs pairwise causality tests between (all possible) pairs of the listed series or a group of series. If cointegration exists between the two variables, i.e. they exhibit a long run equilibrium relationship, if they share a common trend; causality (in the Granger sense, not in the structural sense) must exist in at least one direction, either unidirectional or bi-directional (Granger & Newbold, 1986). The establishment of cointegration, ruled out the possibility of a spurious relationship between the variables, and also it suggested that a causal relationship must exist in at least one direction. It is always better to lag to a high number to achieve a good result. The hypotheses are normally rejected at 10%, 5% and 1% levels.

Data

Data for this study were extracted from Central Bank of Nigeria (CBN) statistical bulletin vol.16 2005, and National Bureau of Statistics (NBS) abstract of statistics, the data cover four variables including Foreign Direct Investment (FDI) Foreign Portfolio Investment (FPI) Construction Investment (CNV) and Construction GDP Sector (CNS). Data used for the study were annualized, covering a 26 year time period between 1981 through 2006.

Operationalisation of Variables

1. **Foreign Direct Investment (FDI);** this is the annual monetary investment made to acquire lasting interest in enterprises operating outside of the economy of the investor when the foreign ownership is sufficiently extensive to give the foreign company a measure of control. Most international finance statisticians have chosen the level of at least 10% ownership of a company ordinary shares or voting power to constitute control. An original as well as incremental investment where a minimum of 10% ownership is involved is also part of FDI.

2. **Foreign Portfolio Investment (FPI);** this is the monetary value of all investment in local securities (stocks, bonds and other financial assets) by foreign residents or companies within a given quarter or year. FPI however represents passive holdings of such securities since the foreign investor has no control over the local companies.

3. **Construction Investment (CNV);** this is total monetary value of all the expenditure/investment in the construction of new constructed facilities or the maintenance of old ones within a country during the year.

4. **Construction Sector (CNS**); this is the total monetary value of all activities in the construction sector within a given year.

RESULT

Table 1 shows the descriptive statistics of the series including mean, median, standard deviation and Jarque-Bera. The p-values of the Jarque-Bera indicated that all the series are normally distributed p-values <0.01.

Table 1: Descriptive statistics

	CNV	*CNS*	*FDI*	*FPI*
Mean	64546.7128571	46554.292381	115283.911905	31323.5357143
Median	29274.11	16042.2	80750.4	1015.7
Maximum	271530	271530	573835.05	373573.9
Minimum	3692	1920	735.8	-12056.6
Std. Dev.	74523.5866983	75245.015237	140944.418111	83466.5806852
Skewness	1.37733620131	2.06603744055	1.80708332993	3.54628519942
Kurtosis	4.10700833392	5.92352488395	6.30811915407	14.9187692282
Jarque-Bera	7.71197655995	22.4184104988	21.0051213599	168.31641293
Probability	0.0212	0.0000	0.0000	0
Sum	1355480.97	977640.14	2420962.15	657794.25
Sum Sq. Dev.	111075299488	113236246360	397306579935	139333401826
Observations	21	21	21	21

Result of Unit Root Test :Table 2 shows the results of the DF and ADF unit root tests for the FDI, FPI, CNV and CNS. For each time series, both the DF and ADF tests were run two different times: first, no trend was included in the test regression (this assumes that the series fluctuates around a zero mean); second, a trend was included (this assumes that the series contains a trend). The majority of the time series tested are statistically significant non-stationary with one unit root. Result of unit root test is presented in table 2; it revealed that all the data in the series are non stationary at level and at first difference, since the null hypothesis cannot be rejected at 5% significance level (Harris, 1995). Regressing one non-stationary time series against another can lead to spurious results, in that significant tests will tend to indicate a relationship between the variables when in fact none exists (Gujarati, 2003). If a test fails to reject the hypothesis of non-stationarity, one can difference the series in question before using it in a regression. While this is acceptable, differencing may result in a loss of information about the long-run relationship between two variables (Pindyck & Rubinfeld, 1991). The series were transformed to their natural logarithm and the transformed data were used to rerun the unit root test. The latest unit root test is presented in table 4, the result now reject the null hypothesis of unit root in all the series except for FPI which result is unavailable, because of the insufficiency of data as most of the FPI data have negative sign and hence can not have natural logarithm.

Table 1 : Test for stationarity

	DF test at levels		*ADF test in first difference*	
Series	No trend	With trend	No trend	With trend
CNS	0.98	-1.13	1.577	0.695
CNV	1.35	3.71	0.866	-2.230
FDI	1.18	-0.48	0.901	-2.246
FPI	-3.16***	-4.09***	6.500	NA

Note: *, ** and *** denote the rejection of the null hypothesis of unit roots at 10%, 5% and 1% significance levels respectively.

Table 2 : Test critical values

	DF test at levels		*ADF test in first difference*	
Critical value	Constant	With trend	Constant	With trend
1%	-2.680	-3.77	-3.788	-4.468
5%	-1.958	-3.19	-3.012	-3.645
10%	-1.608	-2.89	-2.646	-3.262

Table 3 : unit root test (natural logarithm)

	DF test at levels		*ADF test in first difference*	
Series	No trend	With trend	No trend	With trend
LCNS	-0.453	-1.683	-3.672**	-4.632***
LCNV	0.196	-1.789	-3.990***	-4.346**
LFDI	-0.013	-2.718	-7.826***	-3.606*
LFPI	NA	NA	NA	NA

Note: *, ** and *** denote the rejection of the null hypothesis of unit roots at 10%, 5% and 1% significance levels respectively.

Table 4 : test critical values

	DF test at levels		*ADF test at first difference*	
Critical value	Constant	With trend	Constant	With trend
1%	-2.674	-3.770	-3.738	-4.394

5%	-1.957	-3.190	-2.992	-3.612
10%	-1.608	-2.890	-2.636	-3.243

Result of Johansen Cointegration Test : A linear combination of two or more non stationary series may be stationary. Two time series are said to be co-integrated, when both are non-stationary, but a linear combination of those time series is stationary. Cointegration test was carried out to see if there was a long run equilibrium relationships relationship between the series (Johansen, 1988, 1991; Johansen and Juselius, 1990). The result of the cointegration test including Eigenvalue, the associated likelihood ratio statistics (trace statistics) and the hypothesized number of cointegrating equations of cointegration tests is presented in table 6, it is evident that all the hypothesized cointegration equations rejected the hypotheses that there is no cointegration relationship between LFDI v LCNV, LFPI v LCNV, LFDI v LCNS and LFPI v LCNS at least 5% level. With the establishment of cointegration, these rules out the possibility of spurious relationships between the variables, and also suggested that a causal relationship must exist in at least one direction.

Table 5: Johansen cointegration test

Variables	Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	5 Percent Critical Value	1 Percent Critical Value
LFDI and LCNV	None **	0.338152	17.09495	12.53	16.31
	At most 1 **	0.258863	7.189679	3.84	6.51
LFPI and LCNV	None *	0.776610	13.86295	12.53	16.31
	At most 1	0.382196	3.371086	3.84	6.51
LFDI and LCNS	None **	0.408685	18.86576	12.53	16.31
	At most 1 *	0.229463	6.256017	3.84	6.51
LFPI and LCNS	None **	0.939267	27.72539	12.53	16.31
	At most 1 **	0.686358	8.116511	3.84	6.51

*(**) Denotes rejection of the hypothesis at the 5 %(1%) level respectively

Result of Granger causality test : The granger causality test is used in the present study fitted with annualized data. The number of lags in the causality model is set at 1 through 7. Table 7 presents the probability values of the granger causality test for the logarithm of the series. From table 7, it is evident that the causal effect running from LFDI to LCNV and LCNS shows that at lags of 1 through 4 LFDI significantly granger causes the LCNV, while LFDI causes LCNS only at lag 1. The test of causality running from LFPI to LCNV and LCNS shows that LFPI significantly causes the LCNV at lag 2 and no effect on LCNS at all possible lags tested. LCNV does not significantly caused LFDI even though it significantly caused the LFPI at lag 1. LCNS granger caused the LFPI at lags 1 and 2 but had no significant effect on LFDI.

Table 6: Granger causality test (p values)

Direction of causality	1 Lag	2 lags	3lags	4lags	5lags	6lags	7lags
LFDI→LCNV	0.014**	0.016**	0.010***	0.087*	0.107	0.219	0.154
LCNV→LFDI	0.796	0.837	0.953	0.862	0.891	0.888	0.964
LFPI→LCNV	0.978	0.036**	NA	NA	NA	NA	NA
LCNV→LFPI	0.018**	0.549	NA	NA	NA	NA	NA

LFDI→LCNS	0.069*	0.232	0.335	0.290	0.314	0.443	0.378
LCNS→LFDI	0.584	0.809	0.907	0.638	0.562	0.403	0.450
LFPI→LCNS	0.829	0.542	NA	NA	NA	NA	NA
LCNS→LFPI	0.001***	0.012**	NA	NA	NA	NA	NA

Figures marked with *,** and *** denotes rejection of the hypothesis at the 10%, 5% and 1% level, respectively.

Discussion of Results

The result showed that FDI affected significantly on the both the CNV and the CNS, This assertion is supported by both the cointegration and granger causality tests results discussed previously. This suggests that FDI inflow over the years may have been a major contributor or driver of the performance of the Nigerian construction sector. The impact of FDI on CNV is far reaching as it is spread over four year (year 1 through 4) this means that for any FDI inflow into Nigeria will continue to affect construction investment for the period of four years. The effect of LFPI on LCNV is relatively weaker as it takes two years for any FPI inflow to affect construction investment significantly this may not be unconnected with the fact that FPI inflow into Nigeria has not been as significant as FDI, besides FPI does not involve the acquisition of physical assets and for many years during the period under review net FPI inflow was negative i.e. there was net outflow of FPI from Nigeria. The effect of FPI on CNV is also delayed for one-year period this may be due to the difficulty existing in the capital market. The impact of FDI and FPI could be further enhanced by increased net FDI and FPI inflow and fast tracking the impact by removing bureaucratic bottlenecks so that significant effect on construction can manifest and improve the fortunes of the construction sector faster.

CONCLUSION

The study was able to confirm that FDI significantly impacted on the construction (i.e. CNV and CNS) at different lags. The effect of FPI on construction is not significant except for its effect on CNV where the effect was at lags two only. There is need for government to provide enabling environment for increase foreign investment to benefit the construction sector in particular and the economy in general. Policy makers should examine the existing laws, with view to removing the bottlenecks and look for new ways of increasing foreign investment flow especially in the area of Construction Facility Investment (CFI), this may be in form of Public Private Partnership in infrastructures development. Furthermore, investment promotion by institutions like the Nigeria Investment Promotion Council (NIPC) should evolve strategies aimed at assessing the progress made if any, in adopting measures to create investment-friendly environment; in addition to other measures including regulatory changes in institution building, mainly in areas of investor protection and investment facilitation.

REFERENCES

Aremu, J. A**.** (2003). An Overview Of Foreign Investment In Nigeria In Nnanna, O.I, Okafor, M.C And Odoko, F.O. (Eds) Foreign Private Investment In Nigeria*,* Proceedings of The Twelve Annual Conference Of The Regional Research Unit Of CBN At Hamdala Hotel Kaduna 1st – 5th September, 2003.

Babalola, O.M. (2004, October 4). How to induce foreign investments into Nigeria's economy. Paper presented at the forum organized by the Institute of Corporate Treasurers and Accountants in Lagos.

Comincioli, B. (1996). The Stock Market as a Leading Indicator: An Application of Granger Causality. The University Undergraduate Journal of Economics, Illinois Wesleyan Sample Issue.

Dickey, D. A. and Fuller, W. A. (1979). Distribution of the estimators for autoregressive time series with a unit root. Journal of the American Statistical Association, Vol. 74, 427-431

Dickie, R.B. and Layman, T.A. (1988). Foreign Investment and Government Policy in Third Foreign Common Investor in Indonesia and Beyond. London: Macmillan press

Ellis, C. N. (1990). Foreign Direct Investment and International Capital Flows To Third World Nations; United State Policy Consideration in Wallace, C.O. (Ed) Foreign Direct Investment in 1990s: A New Climate in the Third World. London: Martinus Mijhoff Publisher

Engle, R. F. and Granger, C. W. J. (1987). Co-integration and error correction: representation, estimation, and testing. Econometrica, Vol. 55, 251-276.

Engle, R. F. and Granger, C. W. J. (1991). Long run Economic Relationships. Oxford: Oxford University Press.

Granger, C. W. J. (1969).investigating causal relations by econometric methods and cross spectral methods , Econometrica*,* 34, 541-51.

Granger, C. W. J. (1981). Some properties of time series data and their use in econometric model specification. Journal of Econometrics, Vol. 16, 121-130.

Granger, C. W. J. and Newbold, P. (1974). Spurious regression in econometrics. *Journal of Econometrics*, Vol. 2, 111-120.

Granger, C.W.J. and Newbold, P. (1986). Forecasting economic time series (2nd Ed.). New York: Academic press

Gujarati, D. N. (2003). Basic Econometrics (4th Ed) .New York: McGraw Hill Inc.

Harris, R. (1995). Using cointegration analysis in econometric modeling (3rd Ed.). Englewood Cliffs: Prentice-Hall

Hillebrandt, P. (2000). Economic Theory and the Construction Industry. London; Macmillan.

Hussein, I**.** (1993). Trade, Aid And Investment In Sub-Solution African, In Rimmer, D. (Ed.) Action In African The Experience of People Involved In Government, Business and Aid. Portsmouth. Heinemann Royal African Country In Association With James Curry London.

Johansen, S. (1988). Statistical Analysis of Cointegration Vectors, Journal of Economic Dynamics and Control, 12, 231-54.

Johansen, S. (1991). Estimation and Hypothesis Testing of Cointegration Vectors in Gaussian Vector Autoregressive Models, Econometrica, 59, 1551-80.

Johansen, S. (1995). Likelihood-based inference in co-integrated vector autoregressive models. Oxford University Press.

Johansen, S. and Juselius, K. (1990). The Full Information Maximum Likelihood Procedure For Inference On Cointegration With Application , Oxford Bulletin Of Economic And Statistics , 52, 169-210.

Kenen, P.B. (1968). Private International Capital Movement. In International Encyclopedia of Social Sciences (1st Edn.) London: Collier-Macmillan Publisher

Leitner, M. & Fischer, M.M (2000). Investigating the spatial and temporal relationship between income and unemployment in Austria and its nine states from 1967-1997. Retrieved February 20, 2008, from http://wigeoweb.wu-wien.ac.at

Nelson, C. R. and Plosser, C. I. (1982). Trends and random walks in macroeconomic time series: some evidence and implications. Journal of Monetary Economics, Vol. 10, 139-162.

Orji, O.H. (2004). Foreign direct and portfolio investment in Nigeria and selected African countries from 1980 to 2004. Paper presented at the senior executive course No.26 of The National Institute for Policy and Strategic Studies, Kuru, Jos.

Papionnu, M.G. and Duke, K.L (1993). The internalization of emerging equity markets, finance and development. Journal of World Bank Economic Review, Vol.11 No.33, p.8 - 10.

Pindyck, R. S. and Rubinfeld, D. L. (1991). Econometric models and economic forecasts. (3rd ed.). New York: McGraw-Hill, Inc.

Quantitative Micro Software (1998b) EViews 3 User's Guide. Irvine, CA.

Taylor, M.B. and Sarno, L. (1997). Capital flows to developing countries; long and short term Determinants. The World Bank Economic Review 3(33)

Van der Walt (1997). A neoclassical model of foreign direct investment. Unpublished Thesis, University of Pretoria.

Vries, R. (1990).Foreign Direct Investment In Heavy Indebted Developing Countries; A View From The Financial Community In Wallace, C.D. (Ed.) Foreign Direct Investment In 1990, A New Climate In Third World. London: Martinus Mijhoff Publisher .

Wakil, G.H. (2004). The role of foreign direct investment in sustainable economic growth: Challenges for Nigeria. Journal of Investment Facilitator, Vol.1 No.1 pp19- 21.

World Bank, (1995). *Private Sector Development in Low Income Countries.* Washington, DC: author

World Bank, (1997). The Road to Financial Integration: Private Capital Flows to Developing Countries (1st Ed.). Washington. D.C.: Author.

World Bank. (2007). World Bank history. Retrieved February 19th, from http://www.worldbank.org/website/external/history.

Yule, G. U. (1926). Why do we sometimes get nonsense correlations between time series? A study in sampling and the nature of time series. Journal of Royal Statistical Society, Vol. 89, 1-64.

Realizing Sustainability through Stakeholder Management

Ali M. Al-Yami and A. D. F. Price
Department of Civil and Building Engineering, Loughborough University, Leicestershire, LE11 3TU, UK.
E-mails: Ali_alyami@yahoo.com and A.D.F.Price@lboro.ac.uk

A main driver in the creation of sustainable value is the need to satisfy stakeholders in the process of the delivery of the functional unit through the project or service. Clients may well be satisfied when the project is delivered but if users, occupants and suppliers are poorly consulted new ideas and improvements will not be produced and the project may fail to meet local needs. Each construction project has its own stakeholders who have often different and conflicting interests associated with the project objectives. Moreover, insufficient stakeholder consultation and management frequently leads to conflicts and controversies about the implementation of construction projects and the achievement of best value in that projects. Thus, the management of vested interests of stakeholders is very paramount for the successful of the project. This paper provides a methodology for stakeholder analysis during strategic briefing to help implement sustainable construction. It integrates value management and sustainability in one study and utilises tools and techniques of value management to realise the principles of sustainability in a projects.

***Keywords**: construction projects, stakeholder analysis, strategic briefing*

1. Introduction

A main driver in the creation of sustainable developments is the need to satisfy stakeholders in the process of the project delivery. Clients may well be satisfied when the project is delivered but if users, occupants and suppliers are poorly consulted new ideas and improvements will not be produced and the project may fail to meet local needs. It is therefore essential to consider the impact of any development on key (local) stakeholders' quality of life (Charter 1998). To achieve this, the project manager (or facilitator) should need to ensure that: the concerns of all stakeholders are taken into account; and conflicting interests are aligned through negotiation (Olander, Landin 2005).

Each construction project has its own stakeholders who often have different and conflicting interests associated with the project objectives (PMI 2004). To manage these stakeholders, it is fundament to ensure that their alignment with the project's objectives and how much power and influence they have (Dallas 2006). Insufficient consultation and management of stakeholders' interests frequently leads to conflicts and controversies about the project implementation. This paper provides a methodology for stakeholder analysis during strategic briefing to help implement sustainable construction. It integrates value management and sustainability in one study and utilises tools and techniques of value management to realise the principles of sustainability in a projects.

2. Methodology

This research adopted a qualitative approach to deeply investigate the subject of the study. Qualitative research is a systematic, empirical strategy for eliciting responses from people in a special social context (Locke, Spirduso et al. 2000). It is often referred to as 'idealistic' and is concerned with information about things that are less easily understood by numerical analysis. It seeks to understand how people see and interact with ‘the world’ (Fellows, Liu 2003). This study intends to: explore; explain; and describe stakeholders in terms of sustainable construction implementation; and develop a robust methodology for stakeholder analysis at strategic level during the implementation of sustainable construction principles in construction projects.

The data used in this paper were obtained through a review of related literature, reinforced with information distilled from interviews conducted with twelve experts possessing significant experience in value management and/or sustainable construction practice. These semi-structured expert interviews were conducted as part of an in-depth investigation of the impact of stakeholder on the implementation of sustainable construction. Their experience in sustainability was on average 13 years. The qualifications of interviewees were: three of them held a PhD; seven held an MSc; and five held a BSc. The interviewees were Fellow of the Institution of Civil Engineers (FICE), Member of the Royal Institution of Chartered Surveyors (MRICS), Member of the Chartered Institute of Building (MCIOB), Member of Chartered Institution of Building Services Engineers (MCIBSE), Member of Royal Incorporation of Architects in Scotland (MRIAS), Member of the Royal Institution of Chartered Surveyors (MRICS), Member of Association of Project Management (MAPM), Professional in Value Management (PVM) and Certified Value Specialist (CVS). The interviewees are highly qualified practitioners and occupying high positions in their organisations. They have also performed many studies and delivered training on sustainability.

An interview protocol for asking questions and recording information during the qualitative interviews was designed. This protocol comprised a heading, instructions to the interviewer, key research questions, probes to support key questions, space for recording the interviewer’s comments, and space for the researcher records reflective notes. The interviews were audio tapped and the collected data were analysed to identify and describe perceptions on stakeholder management in addition to the value and impact on health and well-being resulting from sustainability implementation. The data were transcribed, prepared for analysis, organised categorically and chronologically, reviewed repeatedly and continually coded. The transcribed data were then sorted and categorised into a number of themes under several headings (Miles and Huberman 1994). The process yielded data with a high degree of reliability and viability.

3. Value Management and Sustainable Construction

The application of Value Management and Sustainable Construction aims to achieve high value for money resulting from a development or construction project. Sustainable Construction is associated with delivering better long-term value for clients, users and other stakeholders. It means balancing value, risk and waste within project parameters, taking into account factors such as land use, materials selection, construction methods, regeneration and community needs. Sustainable development was defined as ‘development that meets the needs of the present generations without compromising the ability of the future generations to meet their own needs’ (WCED 1987), whereas Sustainable Construction was defined as ‘a holistic process aiming to restore and maintain harmony between the natural and built environments, and create settlements that affirm human dignity and encourage economic equity’ (Du Plessis 2002)

The construction industry concentrates on the three aspects of sustainability: environmental, social and economic. Environmental issues cover the use of natural resources, waste minimisation, and energy and water efficiency to avoid a harmful effect on the environment. Social factors encompass taking the stakeholders into account which include employees, suppliers and the community, and economic factors include the construction industry's contribution to economic growth and employment (Adetunji and Price et al. 2003).

Value Management is a powerful tool that has the potential to promote and support sustainable construction through: multidisciplinary teamwork; forums for all stakeholders to exchange ideas and thoughts; systematic process to monitor sustainability schema, its tools and techniques which facilitate decisions taking and identify and solve problems, its strategic timing application during the early stages of a project and its aptitude to eliminate unnecessary costs, thus, implementing sustainability via VM is viable and advisable (Abidin and Pasquire 2003). Value Management was defined as 'a style of management which aims to reconcile multiple stakeholders' differing needs and enable an organisation to achieve the greatest progress towards its stated goals with the minimum use of resources' (BS-EN 12973:2000)

4. Defining Stakeholders

Stakeholders were defined by Cleland (1998) as 'people or groups that have, or believe they have, legitimate claims against the substantive aspects of the project. A stake is an interest or share or claim in a project; it can range from informal interest in the undertaking, at one extreme, to a legal claim of ownership at the other extreme'.

The European Value Management Standard states that 'Stakeholders, internal and external customers may all hold differing views of what represents value. The aim of Value Management is to reconcile these differences and enable an organisation to progress towards its stated goals with the use of minimum resources' (BS EN 12973 2000).

Grimble (1998) stated that the greatest distinction between stakeholders is likely to be between those who affect or take a decision or action, and those who are influenced positively or negatively by the work or its outcomes. Stakeholder analysis also differentiates between conflicts and trade-offs. Conflicts concern the state of competition and prospective disagreement between two or more stakeholder groups in terms of execution and completion of the project. A trade-off is the procedure of balancing conflicting objectives within a single stakeholder group.

5. Timing of Stakeholder Analysis

The timing of stakeholder consultation and analysis timing is an influential factor within the project life cycle. Doing this at the strategic briefing phase enables the facilitator and team members to understand stakeholders' requirements, expectation, and objections against the project at an early stage. It will also ensure the identification of project objectives and draw the attention of affected stakeholders to consideration of Sustainable Construction and Value Management implementation in the project. This paper suggests that Stakeholder Analysis should be conducted at the planning stage. In early stages of developing strategic briefing, Stakeholder Analysis can help measure the possible acceptance of innovative ideas integrated with Sustainable Construction and Value Management themes so as to achieve value for money in the project.

The Value Management and Sustainable Construction study will significantly help the facilitator and design team satisfy the project objectives and identify issues that need to be included in the workshop to develop a strategic brief. The use of Stakeholder Analysis at the right time, in conjunction with other techniques such as Value Management and Sustainable

Construction assessments, can increase the success of the project and achieve best value in addition to overcoming opposition, building coalitions, and changing information and resources to promote and sustain the proposed strategic briefing.

6. Reasons behind Stakeholder Management

It is important to know beforehand the objectives for early stakeholder engagement. In addition to knowing the key stakeholders who have great interest in and power to affect or be affected by the works and/or outcomes of the project, the following points associated with stakeholder analysis were elicited from the study findings to help the facilitator and study team in analysing stakeholders.

- Knowing and agreeing the objectives of the stakeholder analysis.
- Identifying and understanding needs and expectations of the key stakeholders.
- Understanding how the stakeholders might affect or be affected by the implementation of Sustainable Construction and works and its outcomes.
- Understanding and managing the relationships between stakeholders including any potential conflicts of interest in relation to considering Sustainable Construction in the project or any other issues.
- Obtaining better understanding of who and how the various stakeholders can be involved in the project and contribute directly or indirectly to support achieving best value, including considering Sustainable Construction at early stages of the project.
- Raising awareness of the key stakeholders about benefits and drivers of considering Sustainable Construction and Value Management into the project.
- Exerting influence on stakeholders who are not supportive of considering Sustainable Construction in the project.
- Identifying sustainable value criteria in addition to CSFs and KPIs for selecting sustainable options and innovative ideas as well as monitoring and measuring progress in the project.
- Establishing opportunities to reconcile the stated needs of each of the stakeholders and explore trade-offs to optimise the outcome for all.
- Building shared understanding between stakeholders, illustrating the project objectives and targeting the sponsoring client body (possibly comprising several organisations).
- Identifying potential supporters of and opponents to the consideration of Sustainable Construction and Value Management implementation.

7. Stakeholders' methodology

This section illustrates steps of stakeholders' analysis which is illustrated in Figure 1. It defines each step and its importance in terms of objectives of the project.

Figure 1: Stakeholder Methodology

7.1 Step 1: Identify project stakeholders

The identification of the key stakeholders and their needs are the most important steps to: ensure the process is effective and well targeted; reduce conflict and discrepancies (PMI 2004); and boost decision support and implementation throughout the participative group process of Value Management (Thiry 2004). The implementation of Sustainable Construction and Value Management principles, and achieving value for money thus depend on obtaining the support of key stakeholders at early stages of the project.

The interviews with five of the key project members (see Table 1) at the planning stage and before starting conducting the Value Management and Sustainable Construction workshops, can help to precisely identify stakeholders. All possible stakeholders need to be identified to ensure that all needs and requirements are covered in the project. Moreover, similar projects and literature could help to identify key stakeholders. It was concluded from the study that the key stakeholders for building projects could be owner, sponsor or financer, users or occupants, facilitator, study team including multi-disciplines, facility manager, developer, project manager, financier and design team, contractor, subcontractors, local authorities, knowledgeable people with public amenities, the water board, electricity supply, the regulator and planner and other related authorities.

There are many stakeholder analysis tools which help to determine the key stakeholders associated with the project. This methodology could help to discover potential opponents who may have misconceptions about the project which may arise as problems later on in the project but need to be considered during Sustainable Construction implementation. Potential opponents if dealt with appropriately can be used to challenge and improve the project. The opposition to the project can be reduced effective communication of: the drivers and benefits of the project; the sustainability characteristics of the project; and the benefits of changing thinking from cost to value, short-term to long-term, shareholder to stakeholder. Table 1 illustrates the range of stakeholders that might be involved in any construction project. This table will help in the identification and listing of the key stakeholders when it is necessary to engage them as part of the project planning process.

Table 1: A number of project stakeholders (Adapted from Winch 2004)

Internal Stakeholders		External Stakeholders	
Demand Side	**Supply Side**	**Private**	**Public**
Client	Consulting engineers	Local residents	Regulatory agencies
Sponsor	Principal contractors	Local landowners	Local government
Financiers	Trade contractors	Environmentalists	National government
Client's employees	Materials suppliers	Conservationists	
Client's customers	Employees of the above	Archaeologists	
Client's tenants			
Client's suppliers			

7.2 Step 2: Identify needs and expectations

Having identified stakeholders, it is important to define their needs and expectations within the project. Quality Function Deployment (QFD) can be used as a sequence of matrices to collect, understand and deploy the requirements of the client or users throughout a project. It ensures obtained requirements and expectation are reflected throughout the project design developments, materials production, installation, service and demolition of a project. The most common arrangement of these matrices is known as the House of Quality (LeBlanc 2004). The following questions were elicited from interviews to help identifying the requirements and expectation of stakeholders.

- What are stakeholders' expectations and needs from the project?
- What stakeholder benefits would be gained by considering Sustainable Construction and Value Management in the project?
- What resources will be used or avoided by each stakeholder in the project?
- What are the reasonable and realistic roles and requirements of the stakeholders assumed to implement the principle of sustainable construction into the project?
- What negative or positive responses are likely to occur for the stakeholder as a result of considering Sustainable Construction and Value Management in the project?
- What are the power relationships and how weak players can have an influence?

7.3 Step 3: Prioritise stakeholders

This step aims to prioritise the stakeholders identified in previous stages in order to classify them to four groups, namely, key players, potentially influential, affected and marginal(Thiry 2004) according to Figure 2. The prioritisation depends on the influence and importance of each stakeholder in addition to the objectives of the project.

Influence is the power of stakeholders to instruct change to the project, control decision-making, exert influence which negatively or positively affects or is affected by the work and outcomes in addition to the consideration of Sustainable Construction and Value Management or any other techniques in the project. The suitable definition of influence is the extent to which people, groups or organisations are able to persuade others to make decisions, and follow certain courses of action associated with Sustainable Construction implementation in the project.

Influence can derive from the nature of stakeholders in terms of their organisations, or positions in relation to other stakeholders or organizations. It is also necessary to consider stakeholders whose influence will increase due to resources used by the project (Overseas Development Administration 1995). Importance indicates the priority given to satisfying stakeholders' needs, interests and requirements through the project. It usually becomes noticeable when stakeholder's interests in a project align directly with the project objectives. There are often stakeholders who have only a weak capacity to participate in the project, and limited power to influence decision making (Overseas Development Administration 1995).

The stakeholder power/interest matrix illustrated in Figure 1 can help to evaluate stakeholders' relative power and influence, importance to the project, and possible contributions to the success of the project.

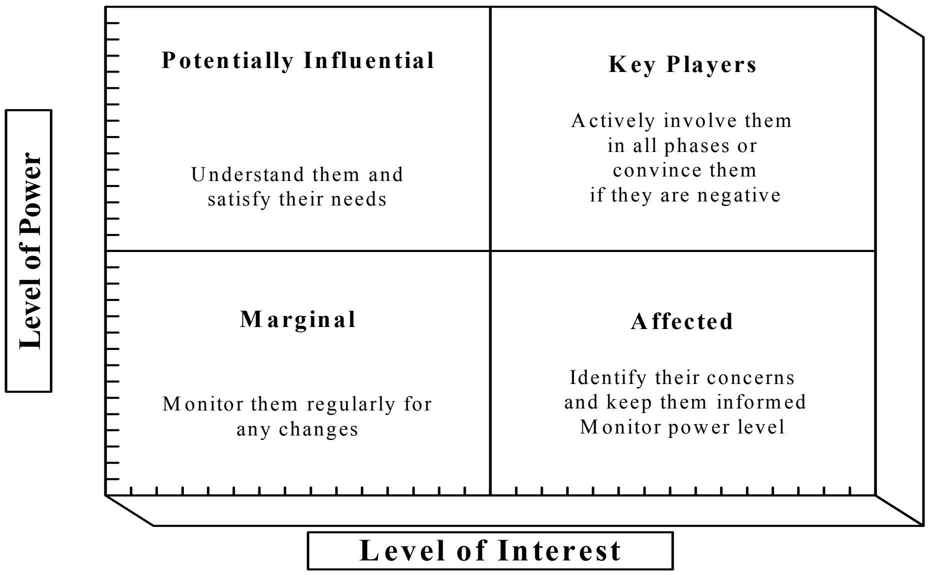


Figure 2: Stakeholder mapping, the power/interest matrix (adapted from Thiry 2004)

7.4 Step 4: Involve stakeholders

The engagement of the key stakeholders in one place will enhance the overall strategic briefing and consequently the project design. All stakeholders will interact during the Value Management and Sustainable Construction study, which should help to develop strong working relationships, effective communication, understanding and mutual consensus between the various stakeholders. The findings should be used to develop: a working plan concerning the implementation of Sustainable Construction and Value Management; the objectives and intended outputs; the relevant decision-makers and key stakeholders; how to achieve best value in the project; and how outputs will be measured. These will form the basis for developing a good strategic briefing.

The identification and selection of stakeholders to participate in the Briefing Stage from the integrated approach should be at the Planning Stage. Further stages and information obtained from the study may reveal previously unrecognised stakeholders, or show how significant each stakeholder is. It is strongly recommended that verification and possible update of the list of stakeholders identified should be kept in mind throughout the study of the integrated approach to value management and sustainable construction during briefing stage. These findings from a stakeholder analysis need to be included in the project brief depending on the nature of the stakeholders' positions regarding implementation of Sustainable Construction within strategic briefing to next stages of the integrated approach to value management and sustainable construction.

The purpose of participation of each stakeholder should be clearly defined and could be either for direct engagement during the project process developments or for learning if the stakeholder has a lack of awareness of Value Management and Sustainable Construction and/or their drivers and benefits achieved.

The purpose of their participation is to introduce the benefits and drivers and added value that could be achieved from the consideration of Sustainable Construction and then convert opposition to considering Value Management and Sustainable Construction into support through negotiation, raising awareness, information and/or coalition building, including offering trade-offs. By the end, it is very important to ensure commitment of the key stakeholders in the project. This step also provides an opportunity for stakeholders to understand the needs of other stakeholders and the constraints the project is under. It also helps to create a feeling of ownership of the project if stakeholders are appropriately engaged and consulted early on in the project.

7.5 Step 5: Synthesise information

The success of developing robust strategic briefing depends on obtaining sufficient information from the project's stakeholders. The collection of information is crucial for the design team and the key stakeholders in order to understand the project objectives. This information could include budgets, project inclusions, starting and finishing times for the construction of new facilities, demographics, policies, location and regulations, needs, requirements and expectations. The proper way to compile this information is to interview the people previously indentified, in addition to examining related documents. Suitable methods needed to collect this information are: conducting interviews face-to-face, telephone conversation, responses to questionnaires exchange of emails, historical data and similar projects.

The facilitator should also gather any relevant information with regards to similar projects, Sustainable Construction and Value Management guidance and the obligations of all participants. The information collected during stakeholder analysis, should be sorted and organised before being circulated to the participants in the study prior to the workshop stage with enough time to give all participants a quick brief about the project and what is required from them in the study. This method should enhance the effectiveness and efficiency of the Value Management and Sustainable Construction study performance to develop vigorous strategic briefing.

8. Conclusions

A main driver in the creation of sustainable value is the need to satisfy stakeholders in the process of the delivery of the functional unit through the project or service. Clients may well be satisfied when the project is delivered but if users, occupants and suppliers are poorly consulted new ideas and improvements will not be produced and the project may fail to meet local needs or its objectives. Moreover, each construction project is unique and has its own stakeholders who have often different and conflict interests associated with the project objectives. Furthermore, the consideration of sustainable construction often faces resistance by a number of stakeholders whose views is not long-term value or whole life value. Thus, this paper provides a systematic methodology for stakeholders' consultation and management at early stages of a project to help the achievement of sustainable construction principles in construction projects to satisfy stakeholders of that project. It integrates both value management and sustainability in one study and utilises tools and techniques of value management to realise the principles of sustainability. It provides suitable place to bring stakeholders in then educate them and identify their needs and expectations. The proposed methodology comprises on five steps, namely, the identification of stakeholders, finding out their requirements and expectations, prioritising them, involving them and finally synthesising the required information to develop the client strategic briefing.

13. References

ABIDIN, N.Z. and PASQUIRE, C.L., 2003. Moving towards sustainability through value management, *The Joint International Symposium of CIB Working Commissions W55, W65 and W107,* 22-24 October 2003, pp258-268.

ADETUNJI, I., PRICE, A.D., FLEMING, P. and KEMP, P., 2003. Sustainability and the UK construction industry - a review. *Engineering Sustainability,* **156** (ES4), pp. 185-199.

BS EN 12973, 2000. *Value management.* UK: British Standards Institution.

CHARTER, M., 1998. Sustainable Value. *The Journal of Sustainable Product Design,* (6), pp. 57-59.

CLELAND, D.I., 1998. Stakeholder management. In: J. PINTO, *Project management handbook.* San Francison: Jossey-Bass, pp. 55.

Du Plessis, C., 2007. A strategic framework for sustainable construction in developing countries. *Construction Management and Economics*, **25**(1), pp. 67-76.

DALLAS, M.F., 2006. Value & Risk Management: A guide to best practice. Oxford, UK: Blackwell Publishing Ltd.

FELLOWS, R. and LIU, A., 2003. Research methods for construction. 2nd ed. edn. Oxford: Blackwell Science.

GRIMBLE, R., 1998. *Stakeholder methodologies in natural resource management.* BPG2. Chatham, UK: Natural Resources Institute.

LEBLANC, A., 2004. Integrating value methodologies into product development and project management processes, *SAVE International conference,* SAVE International 2004, SAVE International pp1-10.

LOCKE, F.L., SPIRDUSO, W.W. and SILVERMAN, S.J., 2000. Proposals that work: A guide for planning dissertations and grant proposals. 4edn. London: Sage Publications, Inc.

BS EN 12973, 2000. Value management. UK: British Standards Institution.

Miles, M. B. and Huberman, A. M., 1994. *Qualitative Data Analysis*, Sage Publications, Inc., Thlusand Oaks, California.

OLANDER, S. and LANDIN, A., 2005. Evaluation of stakeholder influence in the implementation of construction projects. *International Journal of Project Management,* **23**(5), pp. 321-328.

OVERSEAS DEVELOPMENT ADMINISTRATION (ODA), 1995. *Guidance Note on How to do stakeholders Analysis of Aid Projects and Programmes.* London: Social Development Department.

PMI, 2004. A guide to the project management body of knowledge. Third edn. Pennsylvania, USA: Project Management Institute.

THIRY, M., 2004. A group decision-making process to achieve stakeholders' needs and expectations in the most resource-effective ways. In: MORRIS, P. W. G. and J.K. PINTO, eds, *The Wiley guide to managing projects.* 1 edn. Hoboken, New Jersy: John Wiley & Sons, INC, pp. 876-902.

World Commission on Environment and Development (WCED) (1987) Our Common Future. Oxford University Press, Oxford.

WINCH, G.M., 2004. Managing project stakeholders. In: MORRIS, P. W. G. and J.K. PINTO, eds, *The Willey guide to managing projects.* 1 edn. Hoboken, New Jersey, United Sate of America: John & Sons, Inc, pp. 321-339.

AN ENVIRONMENTAL AND ECONOMIC TOTAL LIFE CYCLE COSTING METHODOLOGY AND DESIGN SUPPORT TOOL FOR BUILDINGS

Sami Haddad
Concordia University, Montreal, Canada
samihaddad@canada.com

Sabah Alkass
Concordia University, Montreal, Canada
alkass@cbs-engr.concordia.ca

Fariborz Haghighat
Concordia University, Montreal, Canada
haghi@bcee.concordia.ca

This research utilized life cycle costing, life cycle assessment and the Kyoto protocol principles in developing a methodology to evaluate the economic and environmental life cycle costing of buildings and building materials. The methodology aims at a number of building professionals: 1) designers, 2) material specification writers and quantity surveyor, 3) building permit officials, 4) research groups, 5) developers, and 6) manufacturers. Based on the developed methodology, the economic LCC of building materials is calculated according to the ASTM's standard methodology. However, their environmental impact is first quantified in tonnes of carbon dioxide equivalent (CO_2e), based on Global Warming Potential (GWP), then translated into monetary value to be used in the environmental impact LCC evaluation. The monetary value of quantified CO_2e emissions is taken from CO_2 stock markets. The methodology is supported with a web-based design tool named the "EconoEnviroTLCC Tool" to enhance its applicability. The tool enables its users evaluate economic LCC, environmental LCC and total life cycle costing (TLCC) of partial and/or complete building envelope elements. The tool's results are presented in tabular and graphic formats.

KEYWORDS: environmental impact, life cycle costing, building materials, sustainable building.

INTRODUCTION

Understandably, increasing international attention has focussed on global warming, believed to be caused mainly by the greenhouse gases effect (Statistics Canada 2006). The increase in greenhouse gases (GHG) has led to a global temperature increase, quality change and disorder of precipitation, an increase of storms in magnitude and frequency, and a rise in sea level (IPCC 2007). Therefore, national and international efforts are currently aimed at controlling environmental impacts in general and reducing GHGs in particular (UNFCCC 1998).

The process that building materials go through (extraction, production, transportation, construction and end-of-life scenarios) has a great impact on the environment. Since the building industry is responsible for a large percentage of the global resource use and energy consumption (i.e. buildings account for 40% of the stone, 25% of the timber, and 16% of the water consumed annually worldwide (World Resource Institute 1998)); it could be though responsible for a significant minimization of their environmental impacts if suitable measures are considered.

The building process starts at building designers' tables (or computer platforms). Building designers are major key players in the building design process in general, and in sustainable building design in particular. To select the most preferable building component from a sustainable-design point of view (materials, products and/or systems), it is important for building designers to weigh their environmental impacts and calculate their environmental performances. However, it has been difficult to quantitatively evaluate the overall environmental impact of building materials. In other words, there is no uniform basis for weighing their various and diverse environmental impacts along one homogenous scale (Levin 1997). This supports and strengthens the current need for a design support tool that evaluates sustainable buildings on quantitative basis.

The main objective of this research is to *develop a methodology to evaluate the economic impacts of building materials on the environment based on the Kyoto protocol and life cycle costing principles*. However, the research has a number of sub-objectives, as listed below:

- To develop a methodology to assign a monetary value for environmental impact of building materials, where it could be incorporated into a life cycle costing evaluation.
- To establish a direct link between the building industry and the Kyoto protocol.
- To develop a design support tool to incorporate the proposed methodology in a web-based tool for building designers and professionals.

METHODOLOGIES AND TOOLS FOR SUSTAINABLE BUILDINGS

Over the last few years, many national and international organizations have focused on the sustainable built environment and many of its related issues. Several methodologies and tools, at different scales and localities, have been developed. Table 1 lists a sample of the most well-known tools, language of each tool and the country where it was developed and is used. A complete list of the tools and more details on them could be found at (Haddad 2008). Evaluation and critique of the well known tools have been conducted (Haddad et al. 2003) from a sustainable design point of view.

The available tools vary in their methodologies, target users and scopes of application. In the building industry sector and from a designer's point of view, some of these tools are strictly for assessment and auditing (i.e. BEPAC, Eco-Points, and LEED), others are simplified design-aid tools (i.e. Eco-Quantum-domestic and the Green Guide), and the remainder are more advanced design-aid tools (i.e. Athena, BEES, BREAM and Eco-Quantum-Research). Despite these differences, there are major similarities between these tools such that all of them: 1) aim to evaluate the environmental impact of materials and processes, 2) use environmental datasets and inventories, and 3) apply life cycle assessment (LCA) principles. It should be noted that life cycle costing (LCC) use in the available tools is very limited.

Table 1: A sample of life cycle assessment tools

Tool	Language	Geographic coverage
Athena	English	Canada
BEES 3.0	English	USA
BREEAM	English	UK
Eco-Design-Tool	-	The Netherlands
Eco-Quantum	-	The Netherlands
GaBi	English, German, Japanese	Global
Green Building Challenge (GBC)	English	Global
LEED	English	USA
PEBAC	English	Canada
SimaPro	English, Japanese	Global
TRACI	English	USA
Umbetro	English, German, Japanese	Europe

LIFE CYCLE COSTING OF ECONOMIC AND ENVIRONMENTAL IMPACTS

The concept of the developed methodology is to evaluate the economic and environmental impacts of buildings and building materials using life cycle costing and the Kyoto protocol principles. The economic evaluation of building materials using life cycle costing procedures that are established by the American Society for Testing and Materials Standards (ASTM 2003) is already established and used in the building industry by building designers and professionals. However, their environmental impact needs to be transformed into a monetary format to be integrated into standard life cycle costing evaluation. Figure 1 illustrates the methodology's concept and shows its major components as highlighted below:

1. The economic impact LCC evaluation of each building material studied is carried out by applying the ASTM's procedure of life cycle costing evaluation and calculation using collected economic data. The evaluation is then divided into:

    a. Data collection of materials intended to be evaluated.

    b. Applying ASTM's procedures and equations to estimate their life cycle cost.

2. The environmental impact LCC evaluation is carried out in four steps:

    a. Data collection of subject building materials.

    b. Emission quantification (using the LCA tool: SimaPro), in tonnes of carbon dioxide equivalent (CO_2e), that are associated with each subject material along its life span.

    c. Establishing a monetary value for the quantified emissions by utilizing Kyoto protocol's principle of emission trading.

d. Performing the environmental impact life cycle costing.

3. The total life cycle costing is then the integration of the above established economic and environmental evaluations. The above evaluation is applied to each material, independently.

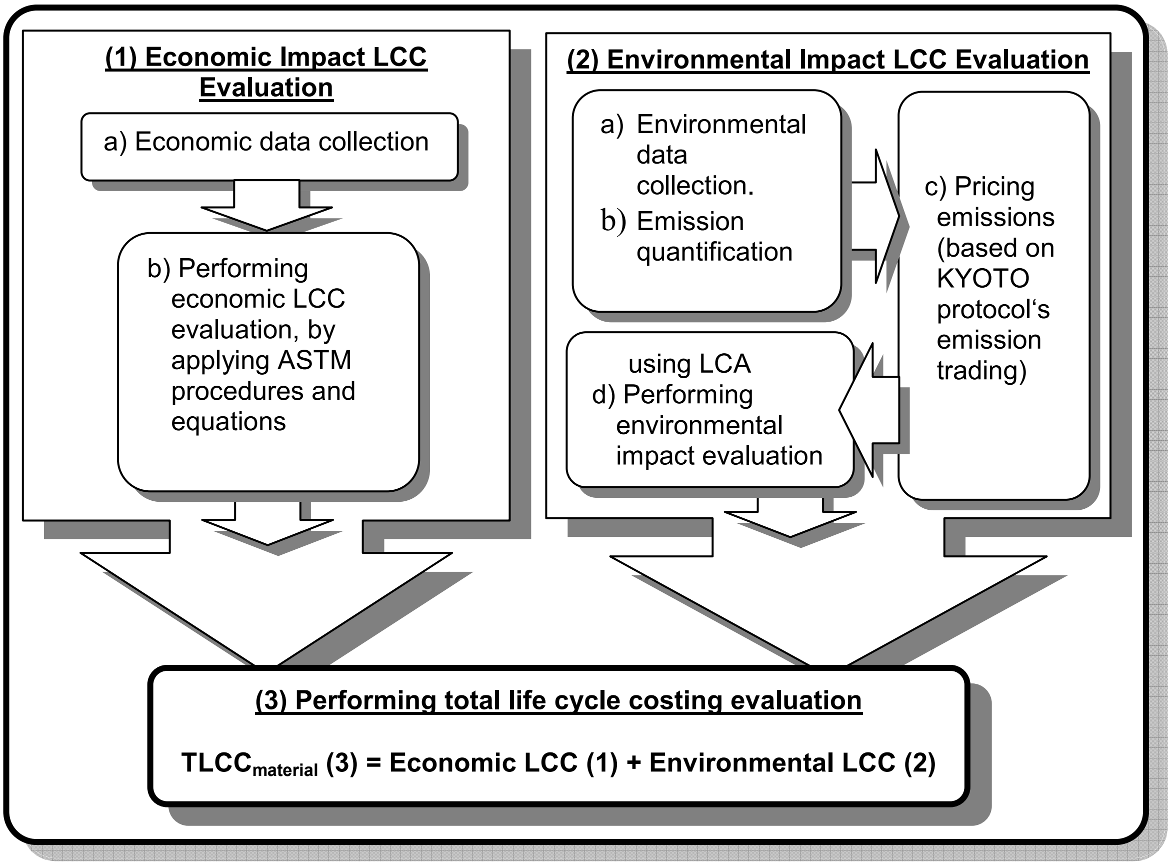


Figure 1: Concept of LCC evaluation of economic and environmental impacts of building materials

Each of the above methodological LCC evaluation procedure (economic, environmental and total) is developed in a detailed calculation procedure. A web-based design support tool has been developed to enhance the methodology's applicability, to widen its use and to ease the evaluation process for the methodology's target users: building designers and professionals.

Calculation procedures

(1) Economic Impact LCC Evaluation

(A) Calculation of LCC in equivalent annual value terms (AV) of each material is done by applying the following equation.

$$LCC(AV) = AIC + AM + AR - AS \qquad (1)$$

Where:

LCC (AV)	= LCC in annual value terms
AIC	= initial cost in annual value terms
AM	= annual maintenance cost
AR	= replacement cost in annual value terms
AS	= salvage value in annual terms

1) Calculation of initial cost in equivalent annual value (AIC) is done using the following equation:

$$\text{AIC} = P\left(\frac{i(1+i)^n}{(1+i)^n - 1}\right) \qquad (2)$$

Where:

P	= present initial cost of each material
i	= bank discount rate
n	= number of discount periods or years

2) Annual maintenance cost (AM) is to be assumed by building designers as an annual value that should be used directly in equation 1.

3) Calculation of replacement cost in annual value terms (AR) should be done using the following equation:

$$\text{AR} = R\left(\frac{i}{(1+i)^n - 1}\right) \qquad (3)$$

Where:

R	= replacement cost of each material
i	= bank discount rate

n = number of discount periods or years

4) Calculation of salvage value in annual terms (AS) should be done using the following equation:

$$AS = SV\left(\frac{i}{(1+i)^n - 1}\right) \quad (4)$$

Where:

SV = salvage value of each material

i = bank discount rate

n = number of discount periods or years

(B) The LCC of a complete building (or part of a building) is then the sum of the equivalent annual value (AV) of all used materials.

(2) Environmental Impact LCC Evaluation

(A) Life cycle costing of the environmental impact of each material is calculated as follows:

$$LCC(EI) = CO_2e\ (\text{tonnes})\ \text{X}\ CO_2e\ (\text{price}) \quad (5)$$

Where:

LCC (EI) = life cycle costing of the environmental impact of a single building material

CO_2e = Carbon dioxide equivalent emissions of the subject material

(B) The environmental impact's life cycle costing of a building is the sum of the environmental impacts of all used materials.

(3) Total LCC Evaluation

The Total Life Cycle Costing (TLCC) that accounts for economic impact LCC and the environmental impact LCC is calculated as per the procedure:

a. Calculate economic life cycle costing in annual value terms LCC(V) as shown in step 1 above and illustrated in Figure 1 above.

b. Calculate environmental impact life cycle costing LCC(EI) as shown in step 2 above and illustrated in Figure 1 above.

c. The sum of both LCC(AV) and LCC(EI) is the anticipated total life cycle costing (TLCC), as represented in the equation below.

$$TLCC = PVLCC + EILCC \tag{6}$$

THE EonoEnviroTLCC TOOL

Beyond the developed methodology, as shown above, a design support tool, named the "EconoEnviroTLCC Tool" has been designed aiming at building designers and professionals to expand the methodology and put it forward for practice. The evaluation of the available sustainable tools showed that designers are still in-need for a total life cycle costing tool that integrates between economic and environmental costs buildings and building materials resulting in a total life cycle costing evaluation (Haddad et al. 2003). The EconoEnviroTLCC consists of several input and output modules:

- Introductory module,
- Project module,
- Material module (economic and environmental data),
- Economic LCC module,
- Environmental LCC module,
- Graphics module,
- Administrator's module, and
- Help module.

Using the EconoEnviroTLCC Tool could be summarised in the following step:

- Start with creating a new project where he/she can define project's location, year, discount rate, CO_2 market price (per tone) and currency of the evaluation (figure 2).

- Select building envelope elements (i.e. roofs, walls, doors, . . . etc.) and define their quantities (i.e. m3 or m2).

- Select materials for each envelope element where for each selected material, a user can use default values or override them with his/her own values. These values include economic and environmental values such as: material unit price, life span, annual maintenance cost, salvage value, distance material to be brought to construction site, method of transportation and end of life scenario. All above mentioned elements affect the economic and environmental life cycle calculation; therefore, users are advised to be careful about values they use (figure3).

- Economic life cycle costing in annual value terms (LCC(AV)) of selected materials could be seen separately (for each building envelope element) or combined for the project as a whole (figure 4).
- Environmental impact life cycle costing (LCC(EI)) of selected materials could be seen separately (for each building envelope element) or combined for the project as a whole (figure 5).
- Total life cycle costing (TLCC) of the whole project could be seen in a separate screen showing both economic and environmental totals (figure 6).
- Bar graphic presentation of a single project that compares between its economic and environmental LCC could be presented, printed or saved to an electronic file.
- Bar graphic comparison could be selected to compare between several projects comparing between their TLCC, economic LCC(AV) and environmental LCC(EI) in three separate graphs (figure7).
- Help menu could be accessed at any time to assist users on how to use the tool.

Figure 2: Creating a new project

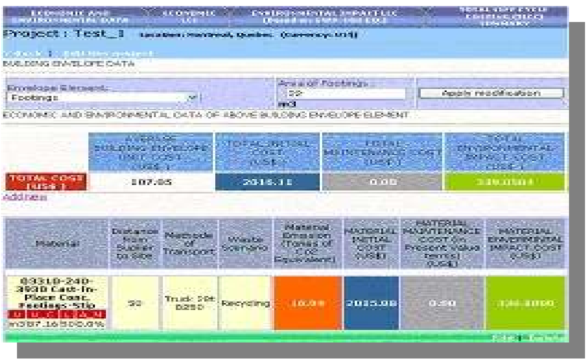


Figure 3: Selecting building envelope elements and building materials

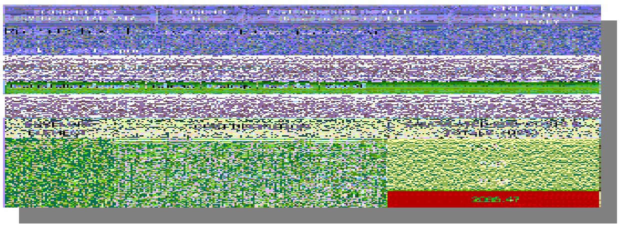


Figure 4: Economic LCC results

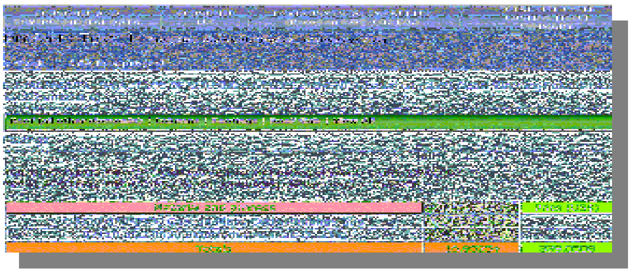


Figure 5: Environmental LCC results

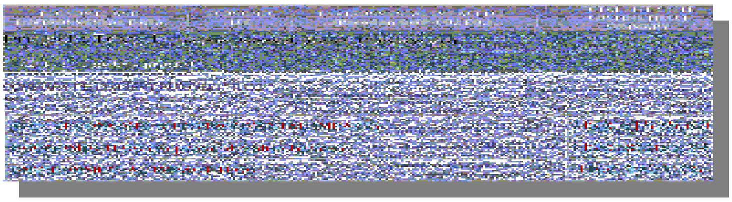


Figure 6: Total life cycle costing (TLCC) results

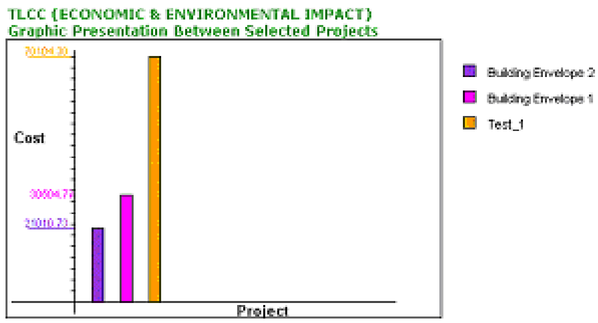


Figure 7: Project-to-project comparison in graphic presentation

CONCLUSION

The building industry, has great impacts on the environment such as resource depletion, energy consumption, green house gases and their consequences such as the global warming. Governmental, private and public organisations worked through out the last few years for the cause of saving the environments. Their efforts resulted in developing strategies, treaties, methodologies and environmental tools. All role players in the building industry (i.e. owners, designers, manufacturers and authorities) carry a share of the responsibility in this regard. Building designers, where the starting point of building realization takes place, could be the most important players in the process. The developed methodology in this research equips building designers as well as other building professionals with the proper tool (the EconoEnviroTLCC Tool) to achieve sustainable buildings.

The developed methodology where environmental impact of buildings and building materials are evaluated in monetary terms based on LCC standards opens the way to its acceptance internationally. This research is among the early steps in the direction of evaluating the quantitative evaluation of environmental impacts.

REFERENCES

Haddad, S., Alkass, S. and Haghighat, F. (2003), “Sustainable Building Design and Assessment Tools, Current Evaluation and Future Expectations”; Proceedings of the *31st Annual Conference of the Canadian Society for Civil Engineering*, pp. END-250, June 4-7 June, Moncton, New Brunswick, Canada.

Haddad, S. (2008), *Economic Impacts of Building Materials on the Environment*, Ph.D. Thesis, Department of Building, Civil and Environmental Engineering, Concordia University (Supervisor, Dr. S. Alkass).

IPCC (2004), “Intergovernmental Panel on Climate Change.” IPCC, <http://www.ipcc.ch/> (May 16, 2005).

Levin H. (1997), “Systematic Assessment of Building Environmental Performance.” Proceedings of the *Second International Conference on Building and the Environment*, Paris, V. 2, pp. 3-10.

Statistics Canada (2006), “Human Activity and the Environment”, <http://www.statcan.ca/english/kits/hae2000/green1.htm> (May 10, 2007).

UNFCCC (1998), “Kyoto Protocol to the United Nations Framework Convention on Climate Change.” UNFCCC <http://unfccc.int/resource/docs/convkp/kpeng.html> (Apr. 10, 2006).

World Resource Institute (1998), *Power Surge: Energy use and emissions continue to rise*, A joint publication by the World Resources Institute, the United Nations Environment Programme, the United Nations Development Programme and The World Bank, Washington, DC, USA

MATERIALS WASTAGE: CAUSES AND THEIR CONTRIBUTIONS' LEVEL.

Oladiran, Olatunji Joseph.
University of Lagos, Akoka Yaba, Lagos, Nigeria.
tungybox2000@yahoo.com

ABSTRACT.

This study investigates the existence of certain predetermined causes of materials wastage and their degree of contributions to materials waste generation (MWG) in building projects. The population of the study consists of construction professionals in building projects in Lagos state, Nigeria. The survey involves the usage of a designed questionnaire to elicit information from the targeted population via convenience sampling method. The data were analysed using frequency, mean score and t-test. The research confirms the existence of all the predetermined causes of materials wastage in Nigerian building projects. It also reveals that these causes contribute significantly to MWG but at different level on Nigerian building projects. Poor supervision contributes most to materials waste generation while bulk purchases is least among all the causes. The study therefore recommends that practitioners should be cognizant of these causes of materials waste and introduces measures to curb them to minimize MWG.

KEYWORDS: MWG, causes, contributions, Nigeria.

INTRODUCTION.

Chadwick (1982) views materials as one of the scarce resources usually required for in the erection or construction of physical infrastructure. He adds that the cost profile of materials forms about 51% by cost of construction. Oladiran (2008b) defines construction wastes generally as excess resources used (which includes materials) than required for construction production. In this regard, Ekanayake and Ofori (2000) views materials waste as any materials, apart from earth materials, which needs to be transported elsewhere from the construction site or used within the construction site itself for the purpose of land filling, incineration, recycling, reusing or composting, other than the intended specific purpose of the project due to materials damage, excess, non-use, or non-compliance with the specifications or being a by-product of the construction process.

The quality of materials used and the management of material waste in building projects are of paramount importance. Obviously, the control of quality of materials used leads to savings from materials wastage. It is generally an accepted phenomenon that not all the materials requested and delivered to construction sites are used for the purpose for which they are ordered. Also, contractors often use sub-standard materials after billing their clients with standard material's cost. Due to lack of control, these materials are either lost or the quality is not met. Chandrakanthi *et. al* (2002) report that growth in construction activities increases the amount of construction waste generated. Also, Andy *et al* (2002) discover that over 70 million tonnes of waste is generated in the construction industry yearly, which amounts to 24kg per week for every person in the UK, about four times the rate of household waste production. Waste costs money at any level of the construction and should be the concern of all the parties in the construction team as it gives rise to loss of resources. In respect to this, this study is focused at investigating the causes of materials wastage and their contribution to materials wastage on building projects.

RESEARCH HYPOTHESIS.

A null hypothesis was postulated for the study, which is: *causes of materials waste have no significant contributions to materials waste generation on building projects.*

LITERATURE REVIEW.

Construction Waste Management.

Chandrakanthi *et al* (2002) reports that a high proportion of municipality waste is construction related, so its reduction becomes important. According to them, construction companies benefit in reducing waste generation by reducing transportation and landfill deposition costs, and the purchasing costs of virgin materials. They add that waste production at a construction site may result from a lack of attention being paid to the size of the product used, lack of interest of contractors, and lack of knowledge about construction during design activities. In this vain, Bossink and Brouwers (1996) discover that about 1-10% by weight of the purchased construction materials depending on the type of material leaves the site as waste. According to them, about 50 to 80% of the construction waste can be reused or recycled. They state further that in terms of sustainability, construction waste management and reduction can be considered an issue that focuses on the danger of depletion of materials used in the construction industry such as timber, sand and gravel. It is also a common practice to transport construction waste to landfills. Construction and demolition waste as a percentage of all solid waste that enters landfills in various countries as reported by them are outlined in Table 1. The importance of the construction waste management is illustrated by the data in Table 1.

Similarly, identification of the composition of waste is also relevant for an efficient waste management process due to the amount of waste that is reusable. Hence, Hettiaratchi *et. al* (1997) examine construction waste composition in countries from Europe and United States which yield data summarized in Table 2.

Table 1: Construction and Demolition Waste as percentages of all Solid Waste entering Landfills.

Country	Construction and Demolition Waste (by weight) in percentage (%)
United States	26
Australia	20-30
The Netherlands	20-29
Germany	19
Finland	13-15

Source: Bossink and Brouwers (1996)

Table 2: Composition of Construction and Demolition Waste.

Construction & demolition Waste Category	Composition (by weight) in %			
	Spencer (1991)	Bossink & Brouwers (1996)	AEP (1995)	CH2M Hill (1992)
Asphalt	46			
Concrete	14	13		70
Metal	5		7	6
Wood	26		35	13
Clay stone Tablets		29		
Concrete and Wood piles		17		
Clay Bricks		14		6
Clay roof tiles		10		
Cement Mortar		8		
Paper / cardboard packing material		7	8	
Rubble, Aggregate, Ceramics & Concrete			24	
Building materials like Gypsum Board			17	2
Glass			3	
Plastics			2	
Other mixed C & D Waste	9	2	4	3
Total	100	100	100	100

Source: Hettiaratchi *et al* (1997)

Waste Minimization Strategies.

Andy *et al* (2002) define waste minimization as any technique that avoids, eliminates or reduces waste at its source. Designing out waste at the earliest stage of the construction process offers the greatest opportunities for waste minimization. They state further that best management approach to waste, particularly hazardous waste, is to manage the process so that there is no waste to manage. The process of waste generation through design is complex when a single product, a building system for example can have a large number of materials and processes to realize the product. The issue is made more complex when further creators of waste are added during sub-contract and construction phases. Many variables and restraints affect the design that in turn affects the wastes arising and the resultant opportunities for designing out waste. Such variables include materials, choice, and component complexity, building complexity, co-ordination, fast tracking and communication (Andy *et al*., 2002). According to them, one must identify the route of the waste, whether its origins are in concept, scheme or detail design and what disciplines are involved. It is then necessary to adopt a waste reduction approach to address the cause of this issue. This approach includes: Use of prefabrication and off-site prefabrication, standard component, realistic component size, capacity and specification, minimizing temporary works, optimizing design lives, designing for recycling and ease of disassembly, identification of materials which create waste and poor communication. Also, the process of designing out waste must be integrated within the project process to ensure its success.

In this regard, Akindoyeni (1989) states that in order to reduce waste, the designers' decisions need to be carefully described in the specification documents. This document communicates to the supplier the quantity of materials and to the operative the care that must be taken in fixing the materials. On the other hand, Chadrakanthi *et al* (2002) categorize waste on construction sites as metal, wood, drywall, concrete and other wastes, which can be reduced using a Special Purpose Simulation (SPS) model that was developed by Hajjar and Abourizk (2000).

RESEARCH METHODOLGY.

A questionnaire was design to elicit the required data to achieve the objectives of the study. The population of the study consists of construction professionals in building firms in Lagos state, Nigeria. A sample size of 40 respondents, selected through convenience-sampling method was used for the research. Table 3 reveals the type of organizations while Table 4 sheds light on the construction experience of the respondents for the study.

Table 3: Types of Organizations.

Organizations.	Frequency
Contracting	19
Consulting	13
Teaching/Research	7
Total	39

Table 4: Respondents' Construction Experience

Years of work experience	Frequency
Below 5 years	5
6-10 years	13
11-15 years	10
16-20 years	7
Above 20 years	5
Total	40

As many as 29.7% of the respondents are Civil Engineers, 37.9% are Builders, 21.6% are Architects and 10.8% are Quantity Surveyors. This shows a trend that Builders dominate the building firms. Similarly, 21 respondents are HND/BSc holder, 16 are M.Sc holders, 2 are NCE/OND holders and just 1 is a Ph.D holder.

In addition, 30.6% of the respondents are corporate members of Nigerian Institute of Building (NIOB), 27.8% each are of Nigerian Society of Engineers (NSE) and Nigerian Institute of Architects (NIA) while 13.9% are of Nigerian Institute of Quantity Surveyors (NIQS). Thus, the respondents are capable both academically and professionally to provide the required information for the study.

The questionnaire also sought the opinions of the respondents on a list of predetermined causes of MWG, derived from the opinions of the researchers and other professional practitioners in building production. The respondents' opinions on the existence of these causes in building projects were sought and their contribution to MWG were measured on a likert scale. In the scale, 1 implies very low, 2 implies low, 3 implies average, 4 implies high, and 5 implies very high. Mean scores and ranking were used to determine the causes' level of contributions to MWG.Similarly, one-sample t-test was used to examine the significance of all the causes in generating materials waste.

FINDINGS.

Causes of Materials Wastage and their level of contributions to Materials Waste Generation.

Table 5 shows the various causes of material wastage on building projects and their different contributions to materials waste generation as signified by the respondents. The Table reveals 13 causes with their varying contributions to materials waste generation. It can be inferred from the Table 5 that Poor supervision contributes most to material waste generation on building projects. This is followed by design error and all the respondents opined that bulk purchase that results in excess is the least. This result is partly similar to the causes of MWG highlighted in Illigurth (2000). Poor supervision is perhaps the chief cause because Nigerian construction projects are rife with the presence of quacks. Professional Builders that are specifically trained for building production are not involved in some projects and are not adequate where they are involved.

Similarly some of the projects are not even designed by Architects and other requisite professionals but by quacks and hence specification errors, design errors and changes which induce materials wastes. In addition, Nigerian construction industry is currently faced with the problem of lack of adequate skilled operatives, which perhaps is responsible for the use of unskilled labours. One of the respondents noted that the usage of defective and wrong quality materials is largely as a result of tendering at lower cost because in most cases the lowest bidder gets the job. Nigerian clients are more concerned about cost than any other thing at the tendering stage.

It can also be observed from Table 6 that all the causes have significant contributions to materials waste generation on building projects. This is because the t_{cals} for all the causes are greater than the t_{tab} at 95% confidence interval. Hence the research hypothesis, which states that *causes of materials waste have no significant contributions to materials waste generation on building projects,* is rejected. Therefore all the causes contribute significantly to materials waste generations. This is perhaps so of all the causes due to the reasons mentioned earlier.

Table 5: Causes of Materials Wastage and their level of contributions to MWG.

Causes of materials wastage	N	Level Of Contributions					MIS	Rank
		1	2	3	4	5		
Poor supervision	40	-	1	4	16	19	4.33	1
Design error	40	1	1	3	18	17	4.22	2
Defective materials	40	-	2	4	22	12	4.10	3
Unskilled labour	40	1	1	6	20	12	4.03	4
Wrong quality materials	40	1	1	7	19	12	4.00	5.5
Changes in design	40	2	2	5	16	15	4.00	5.5
Specification errors	40	1	1	7	22	9	3.93	7
Poor storage facilities	40	1	4	4	21	9	3.85	8
Poor handling process	40	1	6	8	18	7	3.60	9
Poor material scheduling	40	1	3	12	21	4	3.58	10
Poor product information	40	1	4	16	14	5	3.45	11
Wrong suppliers advice	40	1	8	11	13	7	3.43	12
Bulk purchase which leads to excess	40	-	9	15	12	4	3.28	13

N = Number of respondents 1 = Very low 2 = Low 3 = Average 4 = High 5 = Very high

Table 6: One-Sample t-test for causes of MWG.

Causes	N	Mean	df	t_{cal}
Poor supervision	40	4.33	39	35.795
Design error	40	4.22	39	29.984
Defective materials	40	4.10	39	33.334
Unskilled labour	40	4.03	39	28.564
Wrong quality materials	40	4.00	39	27.928
Changes in design	40	4.00	39	23.294
Specification errors	40	3.93	39	28.900
Poor storage facilities	40	3.85	38	24.316
Poor handling process	40	3.60	39	22.045
Poor material scheduling	40	3.58	39	25.877
Poor product information	40	3.45	39	23.404
Wrong suppliers advice	40	3.43	39	19.994
Bulk purchase which leads to excess	40	3.28	39	22.192

Note that Test is at 95% confidence interval and t_{tab} is 1.684

CONCLUSION AND RECOMMENDATIOS.

The study reveals from Table 5 that the followings causes of materials wastage exist on Nigerian building projects:

- Wrong quality materials.
- Bulk purchase, which leads to excess.
- Wrong suppliers' advice.
- Unskilled labour.
- Changes in design.
- Specification errors.
- Design errors.
- Poor supervision.
- Poor product information.
- Poor handling process.
- Poor storage facilities.
- Defective materials.
- Poor material scheduling.

It also reveals from Tables 5 and 6 that these causes have varying and significant contributions to materials waste generations on building projects in Nigeria.

Due to these findings, in order to minimize materials waste generation on building projects, it is recommended that:

- Practitioners should be cognizant of these causes of materials waste and introduce measures to curb them.
- Design changes, specification and design errors should be avoided or minimized.
- Adequate supervision by requisite building professionals should be promoted and skilful operatives are used.

- Good building materials with proper storage facilities and handling processes are used.
- Products' information and advices are sought directly from manufacturers and experienced suppliers.
- Practitioners should endeavour to use proper materials scheduling and avoid excess bulk materials' purchase.

SHORTCOMINGS.

- The first limitation is that only 40 respondents on building sites are used which appear to be small considering the large number of building sites in Nigeria. There are 36 States and Federal Capital in Nigeria and all the respondents are just from one State (i.e. Lagos State-the research area). There is therefore the likelihood that these sites are not truly representative of the population. Hence, generalizing the findings to the Nigerian building sites must be done cautiously.
- The second limitation is the possible biases that might be introduced when respondents answer some of the questions. For example, the levels of materials waste contributions of the predetermined causes were measured on a Likert scale. These subjective responses may not have been rated unbiasedly.
- Thirdly, the respondents may not have been able to supply all the information on the causes of materials waste because their opinions was only sought on predetermined causes. This will limit the amount of information on the causes of materials waste received from them for the research.

FURTHER STUDIES.

The weaknesses of this research noted above are not expected to nullify the results but rather point our attention to, *inter alia* the undermentioned areas of future research:

1. A repeat study in Nigeria of wider research area, with a larger sample size and possibly with a probabilistic sampling method for proper representativeness.
2. Objective measurements of the level of contributions to materials waste generation by various causes.
3. Empirical surveys involving the usage of open-ended questions to identify the sources and causes of materials waste with their level of contributions. This will reflect in detail the actual sources and causes of materials waste in Nigerian building projects.
4. The actual materials waste generation's level in Nigerian projects should be examined and determined quantitavely. This will properly reveal the problem of materials waste in Nigeria and proffers leads toward minimizing it and sustainability.

REFERENCES.

Akindoyeni, A. (1989). Quality control in construction and maintenance. Proceedings: 20th Annual Conference of the Nigerian Institute Of Building.

Andy, K., Andrew, B., & Simon, A. (2002). Designing to encourage waste minimization in the construction industry. Journal of the Department of Civil and Building Engineering, Loughborough University, Leicestershire, UK.

Bossink, B. A., & Brouwers, H.J. (1996). Construction waste quantification and source Evaluation. International Journal of Construction Engineering and Management, 1(221).

Chadwick, L. (1982). Material management profitability and the construction industry. Journal of Building Technology and Management, 2(8).

Chandrakanthi, M., Hettiaratchi, P., Prado, B., & Ruwanpura, J. (2002). Optimization of waste management for construction projects using simulation. The proceeding of the 2002 winter simulation conference, 1771-1774.

Ekanayake, L.L., & Ofori, G. (2000). Construction materials waste source evaluation. Proceedings: Strategies for a sustainable built environment, Pretoria, 23-25 August.

Hajjar, D., & Abourizk, S. (2000). Application framework for development of simulation tools. Journal of Computing in Civil Engineering, 14(3).

Hettiaratchi, J. P., Ajward, M. H., Joshi, R.C., & To, M. (1997). Construction and demolition of waste. Proceeding of the International Conference on Engineering Materials, CSCE, Ottawa.

Illigurth, J.R. (2000). Waste in the construction process.2nd Edition. EF&N Spon: London

Oladiran, O. J. (2008b). Lean -In- Nigerian Construction: State, Barriers, Strategies And “Go-To-Gemba” Approach. Proceedings of the IGLC –16, Manchester, UK..

CRITICAL SUCCESS FACTORS FOR PUBLIC–PRIVATE PARTNERSHIP PROJECTS IN NIGERIA: A PERCEPTUAL SURVEY

Martin. O. Dada
Department of Building, University of Lagos, Akoka, Yaba, Lagos, Nigeria.
tobdad@yahoo.com

Michael G. Oladokun
Department of Building, University of Lagos, Akoka, Yaba, Lagos, Nigeria
michael.oladokun@gmail.com

There has been a movement towards involvement of the private sector in the provision of public infrastructure and services through the use of Public Private Partnerships (PPPs). This paper sought to identify a number of factors judged critical to the success or failure of PPP projects in order to determine the criticality of those factors. A questionnaire survey was conducted based on the experience of the respondents on PPP related projects. Five main success factors (SFs) and some success sub factors (SSFs) were identified. Of the main SFs, economic viability was ranked most critical to the success of PPP projects followed by appropriate risk allocation via reliable contractual arrangements, sound financial package, favourable investment environment, and reliable concessionaire with strong technical strength respectively. The study findings further suggest that there is agreement in the perceptions of both the public and private sectors on the criticality of SFs and significance of SSFs. It is recommended that relevant stakeholders can be appropriately guided in policy formulation for PPP projects in Nigeria.

KEYWORDS: **Success factors, public-private partnerships.**

INTRODUCTION

Innovative procurement approaches have emerged in infrastructure development through PPPs while limited–time privatization based on the concept of concession or build – operate – transfer (BOT) or other variants is popular in many countries (Zhang, 2004) because PPP approach can have a strong positive effect on the economic life of any country (Montanheiro, 2008). Government is no longer considered the sole provider of public works and services. PPPs through the private finance initiative (PFI) have been recognised as important approaches to solving problems for governments in providing infrastructure systems (Ho, 2006). Consequently, there has been a strong movement toward involvement of the private sector in the provision of public infrastructure and services across a wide range of industries and sectors, including power, transportation, water supply and disposal, telecommunications, oil and gas, mining, schools, hospitals, and military training facilities in order to alleviate the spending on governments' budgets (Algarni, Arditi & Polat, 2007; Zhang, 2005a). Some of the forces driving this movement have been a scarcity of public resources, a political trend toward the deregulation of infrastructure, and an expansion of global markets (Ababutain, 2002). With this movement, the private sector is playing an increasingly crucial role in the finance and provision of services that were traditionally the domain of the public sector (Chege and Rwelamila, 2001).

Nigeria is not left out in this movement as the Federal Government of Nigeria is moving increasingly into a private sector driven economy with the use of PPP procurement system in different sectors of the economy. Governments at various levels (i.e. federal, state and local) are increasingly utilising this methodology. For instance, in Lagos state, the PPP methodology has been adopted in the generation of power; management of waste disposal; highway maintenance, and street cleaning; provision of infrastructures, among others. This research thus intends to identify and assess the critical success factors for the successful implementation of PPP construction projects in Nigeria. The study has the capability of contributing to the PPP body of knowledge. This knowledge would help in the establishment of relevant laws, regulations, and guidelines and in the development of efficient procurement framework for best PPP practices in Nigeria.

CRITICAL SUCCESS FACTORS FOR PPP PROJECTS

Rockmart and the Sloan School of Management developed the concept of 'Critical Success Factors' (CSFs) accoding to Jefferies, Gameson and Rowlinson (2002). Morledge and Owen (1999) developed the concept of CSFs further to identify certain weaknesses associated with the practical application of Rockart's method. These include: subjectivity; bias, human inability to process complex information, change in relation to surrounding environments; imprecise definitions and generalisations, and qualitative performance measures. This method of CSFs has been applied as a management measure in a number of sectors. Thus, there have been attempts to apply this same concept to construction management.

A number of authors have identified CSFs for PPP projects. Tiong (1996) identified six CSFs for private contractors in competitive tendering and negotiation in BOT contracts as: entrepreneurship and leadership; right project identification; strength of the consortium; technical solution advantage; financial package differentiation; and differentiation in guarantees. Qiao, Wang, Tiong, and Chan (2001) established eight CSFs in BOT projects in China as: appropriate project identification; stable political and economic situation; attractive financial package; acceptable toll/tariff levels; reasonable risk allocation; selection of suitable subcontractors; management control; and technology transfer. Jefferies et al. (2002) explored CSFs for BOOT procurement system specific to Stadium Australia. Hardcastle, Edwards, Kintyre and Li (2005) used factor analysis approach to identify CSFs in

PPP/PFI projects in the United Kingdom construction industry: effective procurement; project implement ability; government guarantee; favourable economic conditions; and available financial market.

In the work of Zhang (2005a), he is of the opinion that the PPPs involve various kinds of risks that may emerge at different stages in the life cycle of a project. He argued that PPPs should be seen as merely a vehicle for governments to develop infrastructure projects by transferring all the risks to the private sector and thus shedding of all their responsibilities. The risks require appropriate allocation and management. He further reiterated that private finance initiatives do not automatically lead to successful infrastructure projects. He then advocated that a PPP project procurement should be based on a public – private win – win principle. It is under this premise that he was able to identify five CSFs and a number of SSFs. These are: favourable investment environment; economic viability; reliable concessionaire with strong technical strength; sound financial package; and appropriate risk allocation via reliable contractual arrangements.

STUDY OBJECTIVES

The objectives of the study are to:

1. identify and assess the criticality of SFs,
2. identify and assess the significance of SSFs, and
3. evaluate the degree of agreements between the public and the private sectors regarding the criticality of SFs and significance of SSFs.

RESEARCH METHODS

A literature review was conducted for the research. A number of CSFs and success sub factors were identified. The authors made use of the factors identified by Zhang (2005a) based on the comprehensiveness of the factors due to the PPP experts' opinions. A questionnaire survey was then developed and used as a research tool to assess and rank these main factors and sub factors. The population for the research was senior/middle-level managers, and project managers/officers in public ministries, banking institutions, law firms, construction companies, consulting firms, academia, and investment companies that are directly responsible for managing and administering construction related PPP projects. The respondents were based in Lagos, the commercial nerve-centre of Nigeria where there were ongoing PPP projects or where the offices of stakeholders in PPP projects were located. The respondents' sample were obtained with the use of non–probability sampling technique. Respondents were asked to rate the criticality of CSFs on a scale of 0 – 5 (with '0' being 'not applicable', '1' being 'not critical', '2' being 'fairly critical', '3' being 'critical', '4' being 'very critical', and '5' being 'extremely critical'.

Also, they were asked to rate the relative significance of the success sub factors on a scale of 0 – 5 (with ‘0’ being ‘not applicable’, ‘1’ being ‘not significant’, ‘2’ being ‘fairly significant’, ‘3’ being ‘significant’, ‘4’ being ‘very significant’, and ‘5’ being ‘extremely significant’.

120 questionnaires were administered. Of this number, fifty nine (59) respondents returned complete questionnaires. The effective return rate is, however, 49%. This is higher than 23% and 12% reported by Zhang (2005a) and Hardcastle et al. (2005) respectively.

RESULTS

The ‘criticality index’ of each SFs was calculated as follows:

Criticality index = $(5n_5 + 4n_4 + 3n_3 + 2n_2 + 1n_1) / 5(n_5 + n_4 + n_3 + n_2 + n_1)$

Where n_5 = number of respondents who answered ‘extremely critical’; n_4 = number of respondents who answered ‘very critical’; n_3 = number of respondents who answered ‘critical’; n_2 = number of respondents who answered ‘fairly critical’; n_1 = number of respondents who answered ‘not critical’.

The ‘significance index’ of each of SSFs was calculated based on the formula provided by Zhang (2005a).

Significance index = $(0R_{i0} + 20R_{i1} + 40R_{i2} + 60R_{i3} + 80R_{i4} + 100R_{i5})/(R_{i0} + R_{i1} + R_{i3} + R_{i4} + R_{i5})$

Where R_{i0} = number of responses as ‘0’ for the ith factor or sub factor;
R_{i1} = number of responses as ‘1’ for the ith factor or sub factor;
R_{i2} = number of responses as ‘2’ for the ith factor or sub factor;
R_{i3} = number of responses as ‘3’ for the ith factor or sub factor;
R_{i4} = number of responses as ‘4’ for the ith factor or sub factor;
R_{i5} = number of responses as ‘5’ for the ith factor or sub factor.

The criticality indices and rank of the five main SFs are shown in Table 1 based on the responses from public sector, private sector, and all the sectors respectively. It was observed that public sector ranked economic viability (0.896) as being the highest and favourable investment environment (0.768) as being the least. In the case of the private sector economic viability was also ranked highest while reliable concessionaire consortium with strong technical strength (0.612) was ranked least. The ranking of the overall responses is not different from the results of the private sector: economic viability (0.888); appropriate risk allocation via reliable contractual arrangements (0.838); sound financial package (0.804); favourable investment environment (0.766); and reliable concessionaire consortium with strong technical strength (0.684).

Table 1: Criticality Indices and Rank of Success Factors

Success factors	Public		Private		Overall	
	C.I.	R.	C.I.	R.	C.I	R.
Economic viability	0.896	1	0.882	1	0.888	1
Appropriate risk allocation via reliable contractual arrangements	0.880	2	0.806	2	0.838	2
Sound financial package	0.832	3	0.782	3	0.804	3
Reliable concessionaire consortium with strong technical strength	0.768	5	0.764	4	0.684	5
Favourable investment environment	0.784	4	0.612	5	0.766	4

Note: C.I. = Criticality Index
R.= Ranking

Appropriate risk allocation via reliable contractual arrangements is another factor critical to the success of any kind of PPP project. Ability to appropriately and reliably allocate risk in: 1. concession agreement; 2. shareholder agreement; 3. design and construct contract; 4. loan agreement; 5. insurance agreement; 6. supply agreement; 7. operation agreement; 8. off-take agreement; 9. guarantees/support/comfort letters; goes a long way in making PPP projects a success and the lack of which may result in projects failure to reach closures due to the inability to resolve legal issues. This factor is adjudged critical because of the fact that PPP procurement system is still at the infant stage here in Nigeria and this is further complicated by the presence of no specific framework guiding PPP contract arrangements.

Reliable concessionaire consortium with strong technical strength was ranked least as being critical to the success of PPP projects. Government support is needed with a stable political system devoid of currency exchange risk under a promising economy. For PPP procurement route to triumph in Nigeria the investment environment must be favourable and attractive to investors.

Table 2 shows a summary of the significance indices from the public sector, private sector, and all the sectors.

For all the responses under favourable investment environment, the first five most ranked SSFs are stable political system (95.0%), favourable economic system (90.8%), government support (84.4%), the project is well suited for privatisation (82.4%), and predictable risk scenarios (81.6%). Under the economic viability, long-term demand for the products/services offered by the project (89.2%) ranked highest. Others are: sufficient profitability of the project to attract investors (86.8%), long-term cash flow that is attractive to lender (86.8%), long-term availability of suppliers needed for the normal operation of the project (72.8%), and limited competition from other projects (65.8%). In reliable concessionaire consortium with strong technical strength, the first five most ranked SSFs are: good relationship with host government authorities

(86.2%), leading role by a key enterprise or entrepreneur (84.8%), strong and capable project team (86.2%), effective project organisation structure (80.0%), and sound technical solution (77.2%)

Table 2 Significance Indices and Ranks of Success Sub factors

	Public		Private		Overall	
Success sub factors	S.I.	R.	S.I.	R.	S.I.	R.
Favourable investment environment						
Stable political system	93.6	1	95.8	1	95	1
Favourable economic system	92.8	2	89.4	2	90.8	2
Government support	90.4	3	80	4	84.4	3
The project is in public interest	85.6	4	75.8	6	82.4	4
Predictable risk scenarios	84.8	5	79.4	5	81.6	5
The project is well suited for privatisation	82.4	6	82.4	3	80	6
Adequate local financial market	80.8	7	68.2	8	76	7
Predictable and reasonable legal framework	80	8	73	7	73.6	8
Supportive and understanding community	74.4	9	63	10	68.4	9
Predictable currency exchange risk	71.2	10	66.4	9	67.8	10
Promising economy	61.6	11	61.2	11	61.4	11
Economic viability						
Long-term demand for the products/services offered by the project	88.8	1	89.4	1	89.2	1
Long-term cash flow that is attractive to lender	87.2	2	86.4	3	86.8	2.5
Sufficient profitability of the project to attract investors	85.6	3	87.6	2	86.8	2.5
Long-term availability of suppliers needed for the normal operation of the project	68.8	4	75.8	4	72.8	4
Limited competition from other projects	60.0	5	70	5	65.8	5
Reliable concessionaire consortium with strong technical strength						
Good relationship with host government authorities	90.4	1	83.0	2	86.2	1.5
Strong and capable project team	87.2	3	85.2	1	86.2	1.5
Leading role by a key enterprise or entrepreneur	88.8	2	81.8	3	84.8	3
Effective project organisation structure	80.8	5	79.4	4	80.0	4
Sound technical solution	81.6	4	74.2	7	77.2	5
Cost - effective technical solution	78.4	6	75.8	5	77.0	6
Low environmental impact	77.6	7	75.2	6	76.2	7
Public safety and health considerations	66.4	9	73.0	8	71.6	8
Multidisciplinary participants	70.4	8	72.4	9.5	70.2	9.5
Partnering skills	63.2	11	70.6	11	70.2	9.5
Innovative technical solution	67.2	10	72.4	9.5	67.4	11
Rich experience in international PPP project management	58.4	12	61.8	12	60.4	12
Sound financial package						
Appropriate toll/tariff level(s) and suitable adjustment formula	93.6	1	86.4	1	89.4	1
Abilities to deal with fluctuations in interest/exchange rates	88.0	2	84.8	2.5	84.8	2
Sound financial analysis	82.4	3	84.2	4	83.4	3
Investment, payment, and drawdown schedules	80.8	4	79.4	5	81.6	4
Sources and structure of main loans and standby facilities	77.6	5	84.8	2.5	80.0	5
Long - term debt financing that minimises refinancing risk	76.8	6	78.2	6	77.6	6
Stable currencies of securitisation (debts and equity finance)	73.6	7	75.8	7	75.0	7
Fixed and low interest rate financing	70.4	8	73.6	8	72.2	8
Low financial charges	61.6	9	71.2	9.5	67.2	9

High equity/debt ratio	58.4	10	71.2	9.5	65.8	10
Appropriate risk allocation via reliable contractual arrangements						
Appropriate and reliable risk allocation in:						
Concession agreement	86.4	1	81.8	1	83.8	1
Off take agreement	78.4	3	73.6	7	80.0	2
Guarantees/support/comfort letters	81.6	2	78.8	3	79.4	3
Loan agreement	77.6	4	80.6	2	76.6	4
Shareholder agreement	76	5	74.8	5.5	75.6	5
Operation agreement	74.4	7	78.2	4	75.2	6
Insurance agreement	75.2	6	74.8	5.5	75	7
Design and construct contract	70.4	8	63	8	66.2	8
Supply agreement	65.6	9	59.4	9	62	9

Note: S.I. = Significance Index R = Ranking

For sound financial package, the five most ranked SSFs are: appropriate toll/tariff level and suitable adjustment formula (89.4%), abilities to deal with fluctuations in interest/exchange rates (86.2%), sound financial analysis (83.4%), sources and structure of main loans and standby facilities (81.6%), and investment, payment and drawdown schedules (80.0%). Under the appropriate risk allocation via reliable contractual arrangements, the following are the five most ranked SSFs: concession agreement (83.8%), loan agreement (79.4%), guarantees/support/comfort letters (80.0%), operation agreement (76.6%), and off take agreement (75.6%). It will be noted that the lowest percentage significance in all is 60.4%. This shows that all the SSFs are significant and therefore very important to the success of PPP projects.

A rank agreement analysis was carried out between the Public and Private sectors by the use of Spearman's rank correlation coefficient, r_s.

Table 3. Agreement Analysis of Ranking of Success Factors

Success factors	Public S.I.	Public R.	Private S.I.	Private R.	Agreement Analysis
Economic viability	0.896	1	0.882	1	
Appropriate risk allocation via reliable contractual arrangements	0.880	2	0.806	2	
Sound financial package	0.832	3	0.782	3	$r_s = 0.90$
Reliable concessionaire consortium with strong technical strength	0.768	5	0.764	4	
Favourable investment environment	0.784	4	0.612	5	

Note: S.I. = Significance Index R.= Ranking
r_s = Spearman's coefficient of rank correlation

The higher the value of r_s, the higher the agreement between the two groups. An r_s of zero means perfect disagreement, and an r_s of 1 means perfect agreement. r_s for SFs and SSFs are shown in Tables 3 and 4 respectively. It can be seen that the minimum r_s is 0.75 which shows that there is a good agreement between the public and private sectors

Table 4. Agreement Analysis of Ranking of Success Sub factors

Success sub factors	Public S.I.	Public R	Private S.I.	Private R.	Agreement Analysis
Favourable investment environment					
Stable political system	93.6	1	95.8	1	
Favourable economic system	92.8	2	89.4	2	
Government support	90.4	3	80.0	4	
The project is in public interest	85.6	4	75.8	6	$r_s = 0.92$
Predictable risk scenarios	84.8	5	79.4	5	
The project is well suited for privatisation	82.4	6	82.4	3	
Adequate local financial market	80.8	7	68.2	8	
Predictable and reasonable legal framework	80.0	8	73.0	7	
Supportive and understanding community	74.4	9	63.0	10	
Predictable currency exchange risk	71.2	10	66.4	9	
Promising economy	61.6	11	61.2	11	
Economic viability					
Long-term demand for the products/services offered by the project	88.8	1	89.4	1	
Long-term cash flow that is attractive to lender	87.2	2	86.4	3	
Sufficient profitability of the project to attract investors	85.6	3	87.6	2	$r_s = 0.90$
Long-term availability of suppliers needed for the normal operation of the project	68.8	4	75.8	4	
Limited competition from other projects	60.0	5	70.0	5	
Reliable concessionaire consortium with strong technical strength					
Good relationship with host government authorities	90.4	1	83.0	2	
Leading role by a key enterprise or entrepreneur	88.8	2	81.8	3	
Strong and capable project team	87.2	3	85.2	1	
Effective project organisation structure	80.8	5	79.4	4	
Sound technical solution	81.6	4	74.2	7	$r_s = 0.92$
Cost - effective technical solution	78.4	6	75.8	5	
Low environmental impact	77.6	7	75.2	6	
Multidisciplinary participants	70.4	8	72.4	9.5	
Public safety and health considerations	66.4	9	73.0	8	
Innovative technical solution	67.2	10	72.4	9.5	
Partnering skills	63.2	11	70.6	11	
Rich experience in international PPP project management	58.4	12	61.8	12	
Sound financial package					
Appropriate toll/tariff level(s) and suitable adjustment formula	93.6	1	86.4	1	
Abilities to deal with fluctuations in interest/exchange rates	88.0	2	848	2.5	
Sound financial analysis	82.4	3	842	4	
Investment, payment, and drawdown schedules	80.8	4	79.4	5	
Sources and structure of main loans and standby facilities	77.6	5	84.8	2.5	$r_s = 0.95$
Long - term debt financing that minimises refinancing risk	76.8	6	78.2	6	
Stable currencies of securitisation (debts and equity finance)	73.6	7	75.8	7	
Fixed and low interest rate financing	70.4	8	73.6	8	
Low financial charges	61.6	9	71.2	9.5	
High equity/debt ratio	58.4	10	71.2	9.5	
Appropriate risk allocation via reliable contractual arrangements					
Appropriate and reliable risk allocation in:					
Concession agreement	86.4	1	81.8	1	
Guarantees/support/comfort letters	81.6	2	78.8	3	
Off take agreement	78.4	3	73.6	7	
Loan agreement	77.6	4	80.6	2	$r_s = 0.75$

Shareholder agreement	76.0	5	74.8	5.5
Insurance agreement	75.2	6	74.8	5.5
Operation agreement	74.4	7	78.2	4
Design and construct contract	70.4	8	63.0	8
Supply agreement	65.6	9	59.4	9

Note: S.I. = Significance Index R = Ranking
r_s = Spearman's coefficient of rank correlation

A null hypothesis (H_0) was set up thus: There is no significant difference in the perception of public and private sectors regarding the criticality of success factors The alternative Hypothesis (H_1) was: There is significant difference in the perception of public and private sectors regarding the criticality of success factors.The level of significance for this test was set at 5%. Table 5 shows the result of the computation of Spearman's rank correlation coefficient, the t-values, and the decision rule of null hypothesis for the criticality of success factors as perceived by the public and private sectors.

Table 5. Test of Agreement of Ranking

Sectors	rs	t-cal	t-tab	Decision
Between public and private	0.9	3.58	1.18	Reject null hypothesis

Note: r_s=Spearman's rank correlation coefficient; t-cal=t-calculated; t-tab= t-tabulated;

From Table 5 it can be observed that *t*-cal of 3.58 is greater than *t*-tab of 1.18 with 3 degrees of freedom, hence the rejection of the null hypothesis and the acceptance of the alternative hypothesis. It can then be concluded that there is no agreement between the public and private sectors on there perception regarding the criticality of success factors.. This result is illuminating and can be explained by the fact that the private and public sectors from commercial perspectives are two different entities. Both sectors have their own definition of what is success on PPP projects. The implications of the findings are profound.

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

This study has identified in order of importance five critical success factors. Economic viability was ranked as being the most critical factor to the success of any kind of PPP projects in Nigeria. Other success factors in descending order of criticality include 'appropriate risk allocation via reliable contractual arrangements', 'sound financial package', 'favourable investment environment', and 'reliable concessionaire consortium with strong technical strength'. Furthermore, the findings of this study revealed that there is no agreement in the perceptions of both the public and private sectors on the criticality of success factors and significance of SSFs based on hypothesis tested. The lack of homogeneity in perceptions between the public and private sectors on PPP projects suggests a gap in perceptions between the two sectors.

This perception gap has to be appropriately managed for consensus building and to carry along relevant stakeholders in Nigeria. A study of this nature can be replicated in other developing countries

REFERENCES

Ababutain, A.Y. (2002). *A multi-criteria decision-making model for selection of BOT toll road proposals within the public sector*. PhD Thesis, Civil and Environmental Engineering Department, University of Pittsburgh.

Algarni, A.M., Arditi, D. and Polat, G. (2007). Build-Operate-Transfer in infrastructure projects in the United States. *Journal of Construction Engineering and Management,* 133(10), 728-735.

Asika, N. (2002). *Research methodology in behavioural sciences.* Ikeja, Longman Nigeria PLC.

Chege, L.W. and Rwelamila, P.D. (2001). *Private financing of construction projects and procurement systems: An integrated approach.* Proceedings of the CIB World Building Congress Paper No: 259, Wellington, New Zealand.

George, D. and Mallery, P. (2000). *SPSS for windows step by step- A simple guide and reference 9.0 update.* Buston, Allyn and Bacon, 2nd Ed.

Hardcastle, C., Edwards, P.J., Akintoye, A. and Li, B. (2005). Critical success factors for PPP/PFI projects in the UK construction industry: A factor analysis approach. *Construction Management and Economics,* 23(5).

Ho, S.P. (2006). Model for financing renegotiation in public-private partnership projects and its policy implications: Game theoretic view. *Journal of Construction Engineering and Management*, 132(7), 678-688.

Jefferies, M., Gameson, R. and Rowlinson, S. (2002). Critical success factors of the BOOT procurement system: reflections from the Stadium Australia case study. *Engineering, Construction and Architectural Management*, 9(4), 352-361.

Montanheiro, L. (2008). Public-Private Partnerships and their Economic Contribution. *International Journal of Applied Public-Private Partnerships,* 1(2), 1-18.

Morledge, R. and Owen, K. (1999). Developing a methodological approach to the identification of factors critical to success in privatised infrastructure projects in the UK. In S.O Ogunlana(ed.) *Profitable Partnering in Construction Procurement*) pp 585-594, CIB N92 Proceedings, Publication 224

Tiong, R.L.K. (1996). CSFs in competitive tendering and negotiation model for BOT projects. *Journal of Construction Engineering and Management,* 122(3). 205-211.

Zhang, X. (2004). Improving concessionaire selection protocols in public/private partnered infrastructure projects. *Journal of Construction Engineering and Management,* 130(5), 670-679.

Zhang, X. (2005a). Critical success factors for public-private partnerships in infrastructure development. *Journal of Construction Engineering and Management,* 131(1), 3-14.

Zhang, X. (2005b). Criteria for selecting the private sector partner in public-private partnerships. *Journal of Construction Engineering and Management.* 131(6), 631-644.

INNOVATIONS IN TALL BUILDING CONSTRUCTION IN TURKEY FROM PAST TO PRESENT

Aysin Sev,
Mimar Sinan Fine Arts University, Istanbul, Turkey
aysinsev@yahoo.com

Aydan Ozgen
Mimar Sinan Fine Arts University, Istanbul, Turkey

From the first generation in the 19th century to the present day, tall buildings have always been a dominant landmark in the cities, visible from far, identifying the skyline and symbolizing the economic power of the community. Although its origin is the North American cities, the boom moved to Asian countries including Turkey in the last decades. This paper tends to give information about the recent trends in the construction of tall buildings, thus presenting tallest commercial and residential high-rises, especially constructed in Istanbul, which is economically the most developed city of the country. In the conclusion the functions which tall buildings commit in the context of Istanbul are discussed.

KEYWORDS: tall buildings, skyline, commercial, residential.

INTRODUCTION

Tall buildings are playing an increasing role in the development of cities. They can be iconic structures for an individual use, signify areas of regeneration and act as symbols of economic activity. Initially it will be useful to define the tall building, since tallness is a relative matter and cannot be defined in terms of height or number of floors. Beedle (1971) defines the term by stating [The multi-storey building is not generally defined by its overall height or by the number of stories, but only by the necessity of additional operation and technical measures due to the height of the building] (Ali and Armstrong, 1995). He also mentions in another publication (1974) that the typology is a building in which tallness strongly influences planning, design and use or a building whose height creates different conditions in the design, construction and use, than those that exist in common buildings of a certain region and period. The definition also depends upon a range of contextual factors. The modern movement and urbanization with the rural exodus resulted in change in many cities, and the 20th century witnessed the rapid metamorphosis of urban skylines dressed with tall buildings.

Tall buildings symbolize the dominance of particular cities and cultures over others. They are often seen as beacons of capital and political power (Kostoff, 2001). They have the capacity of capturing the public imagination (Höweler, 2003), and no matter what their function are, they cannot be ignored (Abel, 2003).

Although the origin of the tall building is the North American cities, such as New York and Chicago, in the last two decades the boom moved to Asian countries, such as China, Hong Kong, Japan, Malaysia, United Arab Emirates and Qatar. According to the evaluation by Ali and Moon (2007), about 49% of the world's tallest buildings were located in North America in 1980s. The distribution of tall buildings has changed radically with Asia, recently having the largest share with 32% and North America's at 24%. Also eight of the ten tallest buildings of the world are now in Asia (World's Tallest Skyscrapers, 2008).

Tall building construction, which is occurring at an expanding pace in many cities of the world, is also accelerating in the big cities of Turkey, such as Istanbul, Ankara, Izmir, Bursa, Antalya and Adana. A large number of tall commercial and residential buildings are being planned and constructed in city centres and their periphery. Istanbul, which is economically the most developed city of the country, is the first to stand out with the construction of commercial and residential tall buildings (Table 1). This paper, mostly focusing on Istanbul, presents the development of tall building construction from a historical perspective and gives an idea about the architectural and constructional tendencies from past to the present.

Table 1. Population and number of tall buildings in the big cities of Turkey (Turkey, 2008)

	Population	Number of Tall Buildings
Istanbul	10.121.565	2123
Ankara	3.561.187	417
Izmir	2.515.818	88
Bursa	1.467.072	71
Adana	1.265.782	42
Antalya	777.203	42

DEVELOPMENT OF TALL BUILDINGS IN TURKEY

The tall building is a relatively new building type for Turkey, when compared with USA, as well as Middle and Far East. The densification of large cities is evident and tall buildings arguably are the inevitable elements as the solution to scarcity of land in city centres. The impact of large-scale buildings on the urban context and their specialized planning requirements present new challenges to designers and engineers. The symbolic power of the tall building is also being recognized in Turkey, thus initiating a race of height.

Istanbul, carrying the banner in tall building construction in Turkey, has its significance of being a historical and traditional city, as well as having a special character of topography, which enhances the skyline (Sev, 2000). It is the world's only city on two continents; Europe and Asia. A narrow water canal, called the Bosporus, divides the city in two parts, and two suspension bridges link the two parts of the city, as well as linking the two continents. It is also the only city in history, which have been the capital of three great empires; the Roman, Byzantium and Ottoman, and has a well-defined historic core and a silhouette dressed up with Islamic motifs especially on the overlooking hills (Figure 1 and 2). However, from 1950 onwards, administrative efforts in the field of urban development and the increase in national and international, socio-cultural activity restored this immortal city to its prime position in the social and political life of the country. As the city's population grew and its economy expanded, many institutions underwent changes in scale, context and appearance by 1950s. Buildings that reflected technological progress and the fashionable architectural trends of the day endowed Istanbul with a new urban landscape and new image (Batur, 1996). The late 1990s and the introduction of the 21st century faced an escalation in the number of tall buildings and the rapid changes in the skyline of the city (Figure 2).

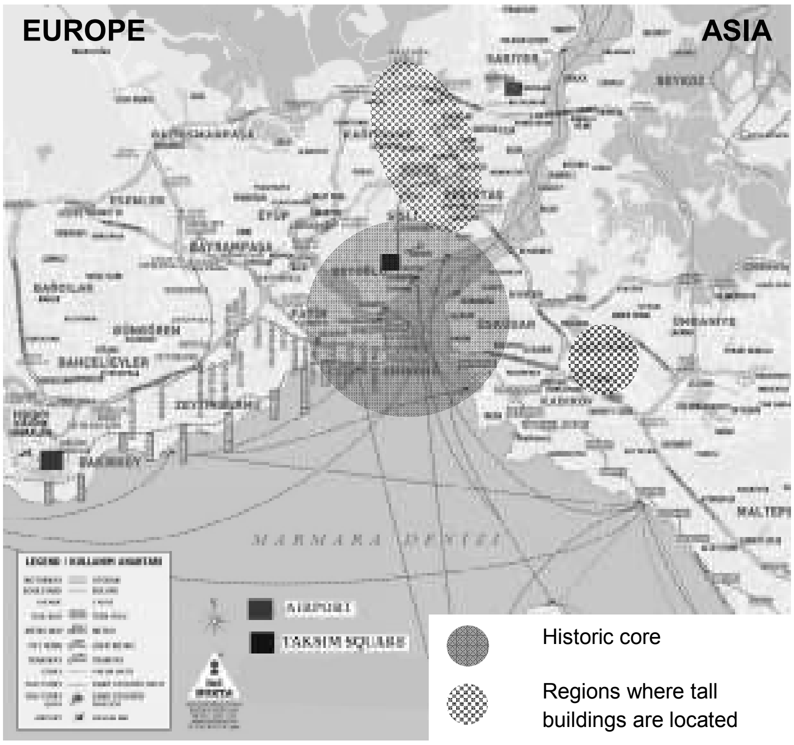


Figure 1: Istanbul city map and historic core.

Figure 2: Istanbul's historical skyline.

The history of tall buildings in Istanbul can be traced back to 1970s with the construction of 17-story Marmara Etap Hotel in Taksim (1973), 21-story Odakule Business Center in Tarlabasi (1973), 15-story Karayollari 17th Region Director's Office in Zincirlikuyu (1975), and 23-story Ceylan Intercontinental Hotel in Taksim (1975), which were the most remarkable examples of the era being erected in the new commercial district of the city. 1980s and 1990s, as the years of economic and social development, witnessed the rapid erection of tall buildings, which also changed the historical silhouette of the city. Although not located in the historical district of the city, they all had an impact on the historical heritage of buildings, and changed the silhouette of Bosporus, due to the topography of the city (Yurekli, at al., 1992) (Figure 3). Parallel to the increase in land values of the business district, which expanded on the Besiktas-Zincirlikuyu-Maslak strip, the number of tall buildings increased and the heights reached to a range of 50 stories. Today, there are 2123 tall buildings in Istanbul, and the tallest building of the city is the 52-stories Is Bank Tower 1 with a height of 181 m, whose construction was completed in 2000. The 28-story Harbiye Military House, Sabanci Centre Towers 1, 2 and 3, 20- and 34-stories Maya Akar Business Centre, 17-, 20- and 27-story Ak Merkez, Is Bank Tower 1, 2 and 3, 28-story Tekfen Tower, 32-story Tatlici Twin Towers, 34-story Taksim Commercial and Business Centre are the most remarkable examples of the city, which were all constructed until the introduction of 21st century.

Although most of the tall buildings erected between the period 1990 and 2000 were commercial buildings, the 21st century began with the rapid erection of tall residential buildings in addition to the commercial high-rises, due to the demand for living spaces nearby the working spaces throughout the central business district. In Table 2 the 10 tallest buildings of Istanbul are presented according to the data provided from Emporis.com, and Figure 4 illustrates the escalation in the number of stories based on years. Today 50% of 100 tallest buildings of the city are residential towers, whereas the 40% are commercial and 10% are hotel buildings. Elit Residence (2001), Polat Tower (2001), Metro City Millennium (2003), Sun Plaza (2005) and Sisli Plaza (2007) are the most remarkable high-rise residential buildings of the city, which are recently constructed. When completed, Diamond of Istanbul will be the tallest residential building of the city. Also the Sapphire, Selenium Twins, Flora Residence and Mashatten Towers are the examples of tall residential buildings, which are under construction at the time of writing.

TYPICAL EXAMPLES OF TALLEST BUILDINGS OF ISTANBUL

In this section the selected examples from the tallest buildings of Istanbul are presented according to the architectural and structural features. The examples are mostly constructed with reinforced concrete except for the Diamond of Istanbul, which has a composite structure.

Tall Commercial Buildings

Sabanci Centre 1, 2 and 3 (1993)

Topped off on November 1993, the Sabanci Centre 1 and 2, is located in the central business district of Istanbul (Figure 5). Within the Centre are the Sabanci Holding and Akbank Headquarters with 34 and 39 storeys respectively. The towers house a 707 person conference room, three multi-purpose conference rooms, restaurants and cafeterias capable of serving 2500 persons, 600 open and closed vehicle parking space, a library, and a command centre which is fully managed by computers. The vertical circulation of the occupants is provided by 24 elevators, and also 2 fire and 8 express elevators which serve during emergency.

The architectural design, performed by Haluk Tumay and Ayhan Boke, was a combination of aesthetic and technological factors. The complex, which is the product of the latest technology, has a monolitic characteristic since it integrates the aesthetic and technology within a structure of this height (Sabanci Centre, 1994). In the design process, accommodating the future needs of the occupants and tenants was the main objective. The office levels are designed to have an open workplace instead of executive office levels. The infrastructure is designed to meet the future needs of these workplaces. When renewals become a current issue, they are provided successfully by the technology installed in the building. Each system is monitored and controlled by a computer-based system. A fully integrated Building Automation System monitors and controls all the mechanical, electrical, plumbing, elevator and lighting systems in the building, providing a well accommodation between all these systems (Sev, 2001). The structural system comprises an outer rigid frame with widely spaced columns on the two sides of the central shear core. The frames consist of four columns of 0.7 m x 1.20 m size and one 0.7 m x 1.5 m size, and band beams connecting the columns to each other and to the shear walls on the edges of the floor plates. The interaction between the outer frame, shear walls and the shear core is provided by a 20 cm floor plate (Uysaler, 1995; Ozgen and Sev, 2000).

Table 2. The 10 tallest buildings of Istanbul (Istanbul, 2008).

	Function	Height [m]	Floors	Year	Status
Diamond of Istanbul	Residential	270	53	2008	Under constr.
Sapphire	Residential	261	54	2008	Under constr.
Isbank Tower 1	Commercial	181	52	2000	Constructed
Sisli Plaza	Residential	170	46	2007	Constructed
Tekstilkent Plaza 1	Commercial	168	44	2000	Constructed
Tekstilkent Plaza 2	Commercial	168	44	2000	Constructed
Sabanci Centre 1	Commercial	158	39	1993	Constructed
Suzer Plaza	Residential +hotel	154	34	1998	Constructed
Polat Tower	Residential	153	40	2001	Constructed
Sun Plaza	Residential	147	38	2005	Constructed

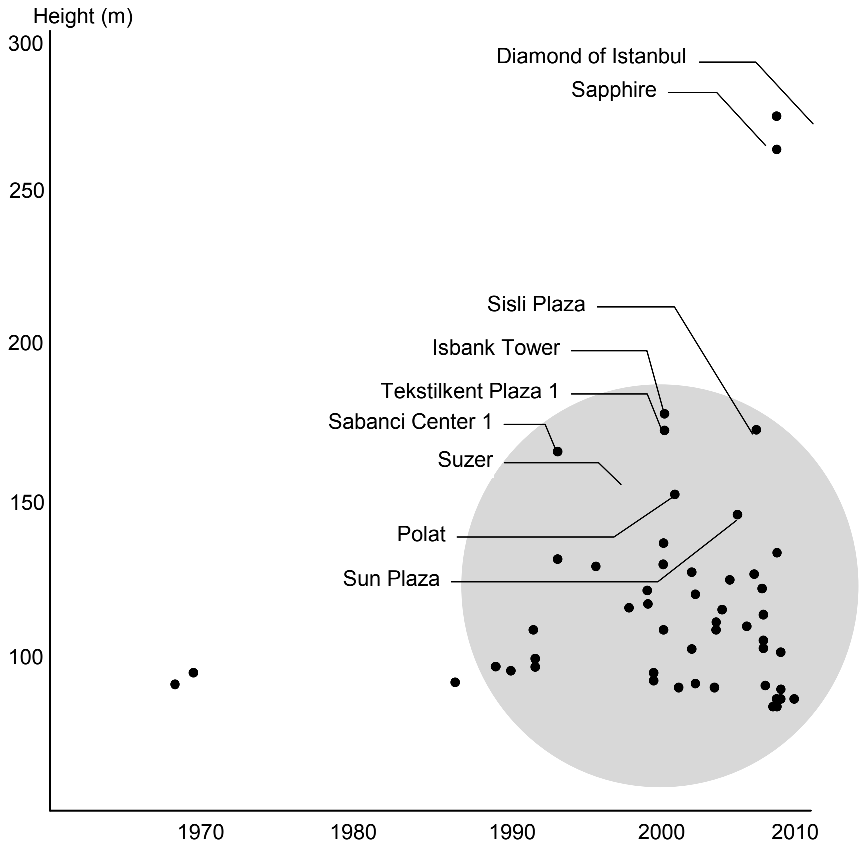


Figure 4:The escalation in the height of tall buildings in Istanbul based on years.

Isbank Towers 1, 2 and 3 (2000)

Isbank Headquarters Complex consists of a 52-story and two 36-stories tall commercial buildings with a total area of 224 357 sq.meters (Figure 6). Being an integral part of the central business district, the complex is the largest of its kind on the European continent. Designed by architects Dogan Tekeli &Sami Sisa in conjunction with Swanke Hayden Connell Architects, the complex includes a conference hall for 800 guests, parking capacity for 3000 cars under-ground and a 900-seat employee cafeteria. The 52-story, reinforced concrete tower has its own lobbies, cores and entrances for executives and employees. The 36-story towers have a central shopping mall and the bank's main branch office. The heating, ventilating and air-conditioning (HVAC), plumbing, elevator, lighting, fire and life safety systems of the towers are controlled by the building automation system, thus labelling the complex to be intelligent. General public access is limited to the lower two floors, which hold retail space and a food court. Public lounges and visitor rooms accommodate clients and business meetings (Sev, 2001). The structural engineer designed the towers to resist an earthquake magnitude of 9.0 on the Richter scale. The towers resist the lateral loads by a framed tube at the perimeter. The sizes of the columns, spaced 3.5 m on the centres, are 600 x 900 m on the taller tower, and 600 x 600 mm on the lower towers. The spandrel beams are designed as flat beams with a height of 350 mm, whereas the sizes of the spandrel beams of the lower towers are 600 x 750 mm. The towers also contain inner cores comprising of shear walls and including the vertical service elements (Ozgen and Sev, 2000; Sev, 2001).

Tekstilkent Plaza 1 and 2 (2006)

Tekstilkent is situated on a site, which is considerably out of the historical core of Istanbul. Being the Europe's largest wholesale retail facility with a total construction area of 927 000 sq.meters, the complex includes two 44-story office towers with a height of 168 m (Figure 7). Designed by OVA Design of Istanbul, the reinforced concrete towers have total construction area of 125 000 sq.meters and gross floor area of 1406 sq. meters. The floors are envisioned to have flexible workspaces, and in the state of demand, the floor area can be divided into four office units and hired out to four different companies. The central core incorporates all the vertical service elements, such as elevators, fire stairs and plant rooms. The towers are supported by a reinforced concrete frame interacting with shear walls located perpendicular to the façade and as well as the shear walls in and around the central core (Tekstilkent, 2008).

Figure 5: Sabanci Center.

Figure 6: Isbank Towers.

Figure 7: Tekstilkent Plaza.

Tall Residential Buildings

Polat Tower (2001)

Polat Tower, which is located in a dense residential and business district, is recently the second tallest residential building in Turkey with 153 meters height and 40 stories (Figure 8). Designed by the architectural office of Polat Construction, the reinforced concrete tower comprises 400 flats on the 33 upper floors of 1300 sq.meters gross area, a heliport on the roof, sports and recreational facilities including a fitness centre, swimming pool, service areas such as a restaurant, a dry-cleaning shop on the lower floors and a parking capacity for 3000 cars under the ground floor. A state-of-the-art automation system serves the building for the security and life-safety of occupants, thus controlling more than 33 000 parts of the building by an advanced computer system. Each flat is also equipped with remote controlled domestic equipment. The tower, with a square plan of 36 meters on sides, has a structural system comprising of inner and outer shear walls arranged in orthogonal directions. In addition to the shear walls two giant columns of 100 cm x 100 cm are located in one side of the plan and linked to the primary structural system with beams of 60 cm x 60 cm size (Sev, 2001).

Elit Residence (2001)

Elit Residence is built on a 4500 sq.meter site in Sisli, an important business region in Istanbul (Figure 9). Designed by BSB London Architects, the project has been nominated for the MIPIM Award (Marche International des Professionnels de l'Immobilier) 2001 in the Residential Development category. With 61 flats of floor areas varying between 170 and 532 m^2, the building is designed to create a lifestyle coupled with all the comforts of the 21st century, the high standard of construction and wide range of social and recreational activities help to make it one of the city’s most exclusive multi-story residential tall buildings. The tower has earmarked 15 000 sq.meters of indoor facilities to be allocated as residential space. It features sports and recreational facilities including a fitness centre, swimming pool, sauna, steam-room, tennis and squash courts, and service areas such as a restaurant, a dry-cleaning shop and an indoor garage (Sev, 2001). The 35-story residential tower has a structural system comprising of a reinforced concrete frame interacting with shear walls located both in the eccentric core and throughout the elliptical plan in an orthogonal arrangement and perpendicular to the façade. (Elit Residence, 2008; Sev, 2001).

Sisli Plaza (2007)

The Sisli Plaza project, performed by one of the leader construction corporations of the country, Yapı Merkezi, is built on 15 000 sq.meters site next to the Elit Residence (Figure 10). The complex, with a total construction area of 103 000 sq.meters, consists of two low-rise and a 46-story residential tower, which has a significant impact on the skyline of the city. The reinforced concrete tower is supported by a structural system of rigid frame and shear walls located in and around the elevator core. Reaching a height of 170 m, it has 40 residential floors above the four retail facility floors, and a 2-story radio station on the top. Designed to withstand the major earthquakes, the building is also equipped with the state-of-the-art life-safety and security systems. The plan shape allows most of the occupants enjoy the amazing view of the Bosporus Strait. Consisting of 4 retail facility, the building also features sports and recreational facilities including a fitness centre, a swimming pool, sauna, steam-room, squash courts, conference halls, and kids club (Sisli Plaza, 2008).

Selenium Twins (2008)

The Selenium Twins, designed by architects Dogan Tekeli and Serdar Sipahioglu, are located on a prominent site next to the Polat Tower, and are intended to be a landmark in the skyline of Istanbul when topped out (Figure 11). The project consists of two identical residential towers of 34 stories, and comprises 215 flats of variable floor areas. Equipped with intelligent building systems, the towers feature sports and recreational facilities including a fitness centre, swimming pool, and a tennis court, as well as service facilities such as house keeping for clean-up. Each tower incorporates a central core comprising of shear walls, an individual shear wall and outer frame of gigantic columns and perimeter band beams as the structural system. Band beams also link the outer frame to the inner core, as well as the individual shear wall (Selenium Twins, 2008).

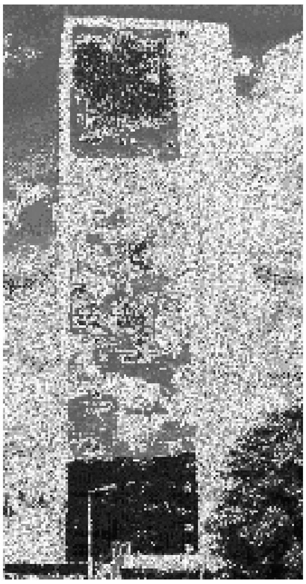


Figure 8: Polat Tower.

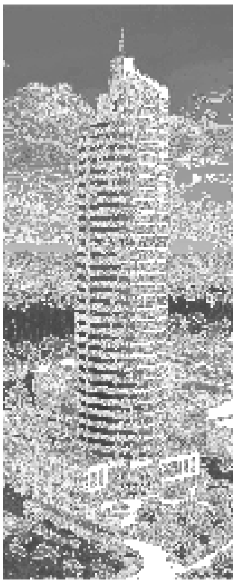


Figure 9: Elit Residence

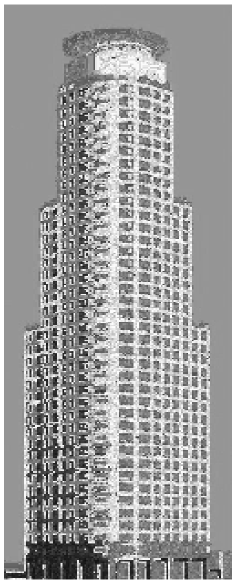


Figure 10. Sisli Plaza

Sapphire (2008)

Designed by Tabanlioglu Architects of Istanbul, the 261 m Sapphire is a residential, leisure zone and shopping centre project located on the central business district, and will be the second tallest building of Turkey when topped out (Figure 12). The appearance of the tower tapers slightly as it rises upwards, and fully clad with glass, it provides a sense of lightness and transparency. The lower four floors are designed for high-quality brand shopping, cafes, restaurants and movies, maintaining the integrity of retail and social zones. The façade incorporates two independent glass skins; the inner skin involves storey-height glazing of manually operable by the occupants. The interior spaces are protected from extreme weather conditions by the outer skin, which incorporates opening operated by the building automation system. Labelled as the first ecologic high-rise of the country, the building is planned as four separate housing zones, with a common zone between the sections of indoor gardens, social areas, maintenance and support facilities, and the mechanical systems. In addition, recreational facilities are located on every ninth floor, such as a swimming pool and a mini golf course. Environmentally conscious systems serve the building to ensure low energy consumption during the operation of the tower. Access and parking issues have been solved by the public transport system and under-ground level car park (Istanbul Sapphire, 2008).

Diamond of Istanbul (2010)

Diamond of Istanbul, with a height of 270 m and 53 storeys, will be the tallest building of the country when topped off in 2010 (Figure 13). Its design, performed by Dome Architects and Murat Yilmaz, consists of three wings constructed with steel and connected to the reinforced concrete central core. The single structural body with three wings comprises a 20 000 sq.meters and 300 room luxury hotel, a 18 000 sq.meters residential block, and a 16 000 sq.meters office block. The wings rise from the common podium of a five-story, 35 000 sq.meters shopping mall, 3 above and 2 below the ground level. The complex will also include a large aquarium, a botanic garden, cinemas, and concert halls. 5 of the 8 underground levels will be used for car parking. The 48-storey of hotel wing has two panoramic restaurants presenting unobstructed views of entrances to the Bosporus Strait. The construction of the tower began in February 2002 with the demolition of an 9-story office building, which has completed its useful lifetime, and recently gained momentum with the start of the steel beams' assembly on December 25th, 2006. Thornton-Tomasetti Engineers of New Jersey and Tuncel Engineering have performed the structural design, and the steel columns and beams of the wings have been produced by Arcelor Commercial Sections S.A. of Luxembourg. (Diamond of Istanbul, 2008).

Figure 11: Selenium Twins.

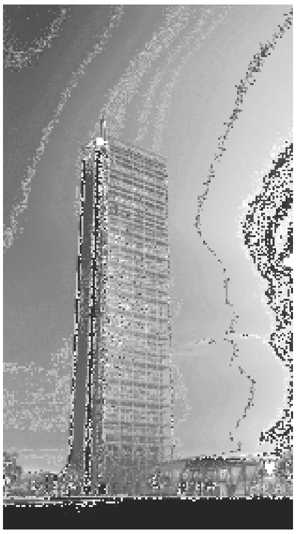


Figure 12: Sapphire.

Figure 13: Diamond of Istanbul.

LIVING AND WORKING IN THE TALL BUILDINGS IN TURKEY

The gradual proliferation of tall office buildings in the big cities of Turkey is in response to the corporate need for both face to face communication and expansion of business operation. These buildings act a significant source of revenue and a business focus for the entire metropolitan area. People working in these prestigious plazas embrace these high-rises, and feel themselves safe, since they are sure that these buildings are designed according to the state-of-art technology. Most of the public prefer to be in a high-rise building in the case of an earthquake, rather than a low-rise building. However, a proportion of the public is non-supportive of the tall buildings for the reason that they create problems of ventilation and natural light in addition to inadequate number of elevators. Also they believe that they increase traffic congestion and parking problem, since the infrastructure of the big cities in Turkey are not developed yet for tall buildings. Also for a proportion of the public, living in a high-rise residential building is safe as well as being prestigious. From this perspective, high-rise is often seen as an icon of a developed society. However, it is clear that, with more people living in taller buildings, there is a need in research to go beyond the physical and engineering concern to consider liveability and impact of the built environment on its users. High-rise residents are anxious of being trapped by a power failure, unable to escape and fearful of crimes in the lifts, such as robbery and murder. Also a house that is not adequate from the engineering or design dimensions is not considered to be satisfactory by the occupants. The adequacy of the housing unit, the structural quality, the household facilities and other amenities and qualities within the wider housing environment, will influence the extent to which the inhabitant is satisfied with the unit.

CONCLUSION

The big cities in Turkey, especially Istanbul standing first on the list, have been faced with the rapid increase in tall building construction by the introduction of the 21st century. The symbolic power of tall buildings being recognized, a notable phenomenon occurred from the turn of the century. Although commercial buildings have been striking in the skyline of the city until the end of the 1990s, residential and mixed-use construction gained momentum by 2000s. Success of the former projects led many real estate investors to develop mixed-use high-rise. In the context of Istanbul, these buildings serve a number of functions that;

- Create a distinctive skyline that projects a new image for the city,
- Form key landmarks,
- Contribute to a cluster signalling a key area,
- Demonstrate a growing economic position, and
- Set a precedent for maximising densities, and proximity to transport.

REFERENCES

Abel, C. (2003). Sky High: Vertical Architecture, London: Thames & Hudson.

Ali, M. M. and Armstrong P. J. (1995). Architecture of Tall Buildings, Council on Tall Buildings and Urban Habitat Committee 30, New York: McGraw-Hill, Inc.

Ali, M.M., Moon, K.S., (2007). “Structural Developments in Tall Buildings: Current Trends and Future Prospects”, Architectural Science Review, 50(3), 205-223.

Balioglu, I. (1999). “The Structural System Project of Is Bank General Headquarters Complex” Design Construction, 160, Istanbul, 74-76.

Batur, A., (1996). World City Istanbul, Istanbul: The Economic and Social History Foundation of Turkey.

Beedle, L. S. (1971). What’s a Tall Building? Preprint no.1553 (M20), ASCE Annual and Environmental Engineering Meeting, St. Louis, Mo., October; American Society of Civil Engineering, New York, N.Y.

Beedle, L. S. (1974). “On Tall Buildings and the Esthetic Environment”, Proceedings of Conference on Tall Buildings, Kuala Lumpur; December 2-5, Institution of Engineers, Kuala Lumpur, 1-6.

Diamond of Istanbul, (2008), “Diamond of Istanbul”, available at: http://en.wikipedia.org/wiki/Diamond_of_Istanbul

Elit Residence, (2008).“Elit Residence”, available at:http://www.yapikredikoray.com/en/elit.asp

Höweler, E. (2003). Skyscraper: Designs of the Recent Past and for the Near Future, London: Thames & Hudson.

Istanbul, (2008). “High-rise buildings (all)”, available at: http://www.emporis.com/en/wm/ci/bu/sk/li/?id=100460&bt=2&ht=2&sro=1

Istanbul Sapphire, (2008). Yapı, 317, Istanbul: The Building and Industry Centre, 68-75.

Kostoff, S. (2001). The City Shaped: Urban Patterns and Meanings through History, London: Thames & Hudson, Ozgen, A., Sev, A. (2000). Load-Bearing Systems in Multi-Story High-Rise Buildings (in Turkish), Istanbul: Birsen Publisher.

Sabanci Center, (2004). Yapı, 147, Istanbul: The Building and Industry Centre, 57-64.

Selenium Twins, (2008). "Selenium Twins, Istanbul", available at: www.emporis.com/en/wm/cx/?id=113561

Sev, A, (2000). Impact of Tall Buildings on a City's Skylines, Proceedings of the Second International Conference on Decision Making in Urban and Civil Enginnering, (Ed.) J. C. Mangin and M. Miramond, CUST Clermont-Ferrand LIP& Paris Université de Valencinnes, November 20-22, Lyon, 945-956.

Sev, A., (2001). Analysis of Tall Buildings in Turkey and at Abroad from the Architectural and Structural Point of Views. Doctoral Dissertation, Mimar Sinan University, Institute of Science and Technology, Istanbul.

Sisli Plaza, (2008). "Sisli Plaza", available at: http://www.emporis.info/en/wm/bu/?id=131418

Tekstilkent, (2008). Tekstilkent, available at: www.tekstilkent.com.tr

Turkey, (2008). "Turkey's most active cities in terms of skyscrapers", available at: http://www.emporis.com/en/bu/sk/st/ma/ct/co/ci/?id=100173

Uysaler, D., (1995). Sabanci Center, International Symposium on Recent Trends in Building Construction, Mimar Sinan University, Istanbul, 3-5 May 1995, 133-148.

Yurekli, H. Yurekli, I. Akpinar, I.,(1992). The Visual Effect of Buyukdere Avenue to the Skyline of the Bosporus, Proceedings of the 2nd National Symposium on Tall Buildings, November 4-6, Istanbul Technical University, Faculty of Architecture, Istanbul, 92-99.

World's Tallest Skyscrapers, (2008). "Official World's 200 Tallest High-rise Buildings", available at: http://www.emporis.com/en/bu/sk/st/tp/wo/

FEASIBILITY STUDY ON THE APPLICATION OF HIGH POWER DIODE LASERS IN CERAMIC TILE JOINT SEALING

Yu Hoe Tang
School of Civil Engineering, University of Nottingham Malaysia Campus, Malaysia
ioannes.tang@nottingham.edu.my

Rodger Edwards, Andrew Gale and Lin Li
School of Mechanical, Aerospace & Civil Engineering, University of Manchester, UK
rodger.edwards@manchester.ac.uk

Ceramic tiles have been used extensively as an architectural material for covering surfaces due to its good appearance and outstanding properties. One inherent weakness of ceramic tile surfaces is the presence of grouted tile joints that do not have the same properties as ceramic tiles and are susceptible to failures. Most industrial users have turned to epoxy grouts for applications that require high standards of hygiene and resistance to chemicals. Epoxy grouts are nevertheless more tedious to apply and pose health risk to the tilers. This research evaluates the scope and viability of applying an alternative laser-based process for sealing tile grouts by comparing the life cycle cost of the new laser-based sealing process with epoxy tile grouts. Information regarding tile grout performance and cost data for the life cycle costing analysis was collected through a survey of UK tiling contractors. The study found that that laser sealed tile surfaces are generally more economical when compared with epoxy grouted surfaces. Sensitivity analysis conducted indicates that the life cycle cost for the laser sealed tile surfaces is most sensitive to changes in labour costs, tile size, tile laying rate and the laser processing speed. To improve the commercial viability of the laser-based sealing process, it is recommended that the nominal processing speed should be improved and the process automated to provide consistent on-site sealing quality and to reduce its dependence on skilled workers.

KEYWORDS: Innovation, Feasibility, LCC

INTRODUCTION

Ceramic tiles have been used extensively as an architectural material throughout the world because they are extremely cleanable and offer good resistance to water, oil, acids, alkalis and other agents, durable and have very long service life (Elder and Vandenberg, 1984). These properties make ceramic tiles a very popular choice for residential and commercial surfacing. Ceramic tiles are not continuous and their installation requires joints between abutting tiles that are filled with in-situ cement-based grouts. Cement-based grouts, or simply referred to as cement grouts in this study do not have the same chemical and physical resistance as ceramic tiles and therefore are more susceptible to chemical attack, physical abrasion, discolouration and contamination (Potter, 2002). In order to improve the performance of tile joints, specifiers and industrial users have increasingly turned to the use of epoxy resin-based grouts, also known as epoxy grouts which are more difficult to apply and clean off when compared with conventional cement grouts.

Lawrence and Spencer (1999) successfully developed a new two-stage process for sealing tile joints using high-power diode lasers (HPDLs). Experimental results from their study paved the way for further development in the application of laser processing to architectural materials. Consequently, the Laser Processing of Architectural Materials as a New Manufacturing Technology Applied to Construction Processes (LACON) project was launched with the aim of improving the original sealing process and to develop a prototype handheld laser delivery system for applying the process to on-site tiling work. Since the year 2000, the LACON project team has made significant progress in improving the quality and rate of the tile joint sealing process using a HPDL. Subsequent research led to the development of new materials that could be sealed with a single pass of laser and thereby reduces the overall sealing duration (Lawrence *et al.*, 2002). Following the success of the single-stage laser tile sealing, a study was commissioned with the aim of evaluating the feasibility of applying these processes to the tiling industry, in particularly the application of ceramic tiling in industrial buildings. Critical issues such as potential market of the processes, performance requirements, economic feasibility and on-site applications of the processes are examined with the aim of transferring the processes developed to on-site applications. This paper specifically discusses the economic feasibility of applying the process to the UK tiling industry.

PROBLEMS WITH CONVENTIONAL GROUTING TECHNIQUES

A typical configuration for ceramic tile floor system is illustrated in Figure 1. Ceramic tiles are laid directly on a structural base if a good standard of levelness could be achieved. Alternatively a layer of screeds could be laid above the structural base to provide level background for placing tiles. The visible elements in the ceramic tile system are the installed tiles, the grouted joints and the movement joints.

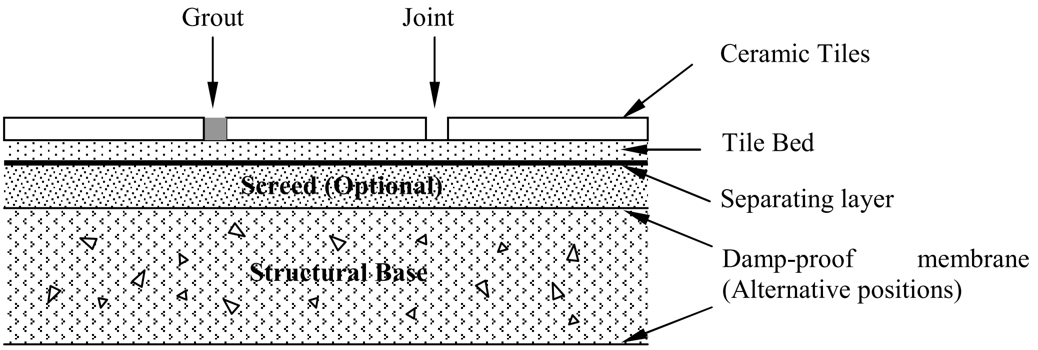


Figure 1: Elements of a Typical Tile Floor System

The joints between adjoining tiles are filled with grouts, usually based on Portland cement, mixed with fillers, admixtures and pigments. The sand-grading limits for cement:sand grouts for joint widths and the recommended widths for installing various tiles are provided in the British Standards. Typical joint widths ranges from not less than 1.5 mm for dust pressed tiles and 6 mm for extruded tiles. Floor tiles are often laid with regular joints of not less than 3 mm and not more than 10 mm. Special installation techniques using vibration tile flooring have been developed which enable ceramic tiles to be jointed at a maximum width of 2 mm (Kemtile, 2001).

Tile grouts should have properties such as good working characteristics, low shrinkages and good adhesion to the sides of the joints. In addition, special properties such as impermeability, resistance to water, heat, cleaning agents and chemical attacks, resistance to mould growth and bacteria, resilience and compressibility may be required depending on the service condition. In addition to the cement:sand mortar grouts, specialised jointing materials have been developed and used in the industry including epoxy and polyester resin grouts, furane resin grouts, silicate grouts, sulphur grouts, phenol-formaldehyde grouts, cashew nut resin grouts and rubber latex grouts (Pye and Harrison, 1997).

The presence of tile joints is one of the weakest links in the performance of tile surfaces. Cement grouts with added fillers, admixtures and pigments are porous and are susceptible to erosion and contamination. The erosion of tile joints grouted with cement grouts can be caused by exposure to corrosive materials, such as hydrochloric acid, use of aggressive cleaning materials and abrasion of grouts (Potter, 2002). Excessive machine scrubbing and the use of highly alkaline cleaners as well as solvent-based systems can have a detrimental effect on grouted joints. The penetration of moisture, chemicals and oils through the porous grout or in the case of sealant, around the edges of the seal along the sealant/tile interface could also cause the joint to break down and/or lose adhesion to the background in normal service condition. The grout surfaces could also be discoloured by materials that splashed or spilled on the tiling. Residues of spilled materials that remained on or sipped through porous joints contaminate the tile joints. Usual cleaning techniques would remove residues from the surface of the tiles but may leave residues on the grout surface which provide nutrient for micro-organisms such as moulds for example *aspergillus niger* to grow (Potter, 2002). In extreme cases, the bacteria could also induce corrosion in the grout (Tatnall, 1981), thus enabling the hyphae of the micro-organisms to penetrate into the grout, making cleaning difficult. As a result of grout erosion or contamination, the life expectancy of fifty years for a typical ceramic tile surface could be drastically reduced, incurring costly and disruptive grout reinstatement or tile replacement work to facilities.

Since the introduction of the Food Safety Act (1990), the potential growth of bacteria in the tile joints has been a major concern in the food and drink processing industry (MBD, 1999). As a result, epoxy grouts have largely displaced most of the jointing materials previously used in chemical resistance application. they are widely used for bedding and jointing tiles in the hygiene industries such as dairies, breweries, pharmaceuticals and general good and meat processing facilities. They have the advantage of high adhesion, impermeability, good resistance to a wide range of solvents and chemicals over a broad pH range, low shrinkage, and good resistance to abrasion and impact (Wittenwyler, 1986). However, due to the high cost of the epoxy and polyester resin grouts, they are usually mixed with fillers such as limestone or dolomite which have poor resistance to acids. They are generally more difficult to apply and could cause skin irritation with repeated use.

DEVELOPMENT OF LASED-BASED TILE JOINT SEALING PROCESS

Lawrence and Spencer (1999) developed a two-stage laser-based ceramic tile grout seal consisting of the amalgamated oxide compound grout (AOCG) that provides a tough, heat resistant bulk substrate, and a HPDL glazed enamel. In the process, the AOCG is mixed with diluted sodium silicate solution to create a manageable paste and placed into the void between the tile joints. The grout is left to cure for two days before it is irradiated using a HPDL. Next, a thin layer of enamel glaze (250 μm) is placed on top of the AOCG and left to dry for two hour before being irradiated with defocussed HPDL beam to obtain an impermeable seal. Tests conducted on the two-stage laser-based ceramic tile grout seal found that the seal provides an impervious and cleanable surface. Further studies have been undertaken to develop a single-stage laser sealing process that would improve the efficiency of the sealing process. In the earlier two-stage sealing process, it was essential to irradiate the AOCG to improve enamel/AOCG wetting and bonding before applying the enamel frit (Lawrence *et al.*, 1999), a time consuming and expensive procedure. By replacing the AOCG with crushed vitrified ceramic tiles mixed with sodium silicate solution as bulk filler for the joints, the enamel frit could be applied directly onto the crushed tiles and sealed with a single pass of HPDL. Lawrence *et al.* (2002) successfully sealed ceramic tile joints using HPDL with power densities as low as 200 kW/mm^2 and at rates between 100-600 mm/min. Results of tests conducted indicate improvements in the mechanical, chemical and physical properties of the single-stage enamel seal over the two-stage approach with no discernible difference in either the wear resistance or the compressive strength being observed when the joint is subjected to corrosive chemicals. The single-staged joint also indicated marked improvements in wear life over the earlier two-stage process.

In conjunction with development of the single-stage tile grout sealing process, a prototype portable handheld HPDL device has been developed for on-site applications (Lawrence, 2002). The equipment is designed to scan at speeds of up to 600 mm/s, with irradiance levels of between 100 and 300 kW/mm^2. The variable spot sizes range from 1 to 5 mm diameter with the beam delivered through a fibre optic system. Additional safety mechanism such as interlock systems, guards, filtration and gas absorption devices will be added as required to meet the Class I safety requirement for laser processing. This development would enable the processes described earlier to be applied safely to any on-site grouting and grout removal works. To improve the quality and consistency of the laser-based sealing processes, Roussos (2002) investigated the feasibility of applying various sensors for detecting surface quality defects in the tile grout sealing and removal processes. In the study, a high-speed CCD camera, an infrared pyrometer and a photodiode were used to detect potential surface quality defects such as bubbles and holes formations, width and surface height variations, discontinuities, edge quality problems and laser beam misalignments. It was found that by combining the three sensors to form an integrated monitoring system, the reliability of defect detection and recognition could be improved significantly.

RESEARCH DESIGN

Ceramic tiles have been used in numerous locations due to their many outstanding mechanical, chemical and physical properties, particularly its ability to provide one of the most cleanable and durable surfaces. Although the initial cost of tiled surfaces is comparatively higher than most types of surfaces, studies have shown that the total lifetime cost of ceramic tiles remains competitive when their longer service life and lower maintenance cost are taken into consideration (Flanagan *et al.*, 1989; Gatfield, 1998). As such, life cycle costing (LCC) analysis is used to evaluate the feasibility of applying laser-based tile grout sealing process when compared conventional grouts.

LCC is often used to support a decision when deliberating upon a selection of options (Dale, 1993). It converts all the cash flows that occur during the life of each option from acquisition to disposal into comparable form so that the total cost consequences of the options, rather than just then initial cost, can be considered. The concept of LCC is based on the premise that the trade-off between initial cost and operating cost of an asset will give the minimum life cycle cost for the asset. It is nevertheless worthwhile to note that in some instances, the use of more costly materials may results in higher maintenance cost and therefore the trade-off mentioned above would be invalid (Ashworth, 1996).

Several studies have been conducted to study the life cycle cost of ceramic tiled surfaces. Gatfield (1998) compared the life cycle cost of several floor surfaces using the unit rate prices calculated from statistical sample of prices tendered since 1985 and adjusted for inflation and market conditions to represent tender prices in the second quarter of 1995. The studies indicate that although the initial cost of ceramic tile floor is higher, the NPV for maintenance cost is lower than most applied flooring system due to its longer service life. Life cycle studies conducted by Flanagan *et al.* (1989) which compares ceramic tiles surfaces with other wall and floor finishes indicate that ceramic tiles would only be economical if its service life is in excess of 20 to 25 years.

Data Requirements and Collection

The cost of ceramic tiled surfaces can be divided into two basic types: tangible and intangible. The tangible cost is readily quantifiable, but the latter is difficult to measure in monetary terms yet it represents an important aspect of the overall cost. In this study, the primary focus is on the tangible cost, although some aspects of the intangible cost and benefit are considered. The tangible life cycle cost of tiled surfaces includes the initial capital cost and the service or running costs. The initial capital cost is the cost of the tiles, adhesives, joining grout, substrate and other allied construction costs. The service cost includes regular cleaning, annual and recurrent maintenance, replacement of cracked or damaged tiles, and finally disposal. Since some of these cost components are identical for both conventional grouts and laser sealed tile joints, they are excluded from the overall calculations to simplify the overall LCC analysis. The major differences between the laser sealed grout and conventional grouts are the added steps of placing the enamel frit on the grout surface and irradiating the joints with a HPDL and its associated equipment, labour and material costs.

The primary data for the study was gathered through questionnaire survey and telephone interviews conducted with tiling contractors in UK who are members of the Tile Association (TTA) with is the main organisation representing the UK tile industry. The overall response rate for the survey has been good and it represents the tiling industry's interest in alternative grouting technologies. From sixty-four (64) questionnaires that were mailed to tiling contractors throughout UK in mid-October 2002, seventeen (17) or 26.6% of tiling contractors responded to the questionnaire survey. In addition, nine telephone interviews were successfully conducted during the data collection period, resulting in an overall response rate of 35.6% from the seventy-three companies contacted. Data collected from the questionnaire survey and telephone interview include general data regarding the tiling companies, problems relating to grout failures, tiling production rate and responses to the potential introduction of new laser based sealing system were collected in the survey. The SPSS software package is used to analyse the data collected from the survey and telephone interview.

LCC EVALUATION AND RISK ANALYSIS

Assumptions for LCC Analysis

The analysis of the survey data (Table 1) indicates that the difference between the production rates for floor and wall tiling operation are significant. This paper will present the LCC evaluation for floor tiles where the tile laying and grouting rates are comparatively lower and hence more expensive. In addition, floor surfaces are usually subjected to more onerous service conditions when compared with wall surfaces such as spillage, contamination, exposure to corrosive cleaning reagents, higher cleaning frequency and more intense cleaning regime which reduces the grouts' services life. Therefore, the LCC analysis is limited to floor surfaces where laser-based sealing process could potentially replace existing conventional floor tile grouts. The formulation of LCC model for conventional grouts and laser-based sealing process requires a breakdown of all costs associated with the construction, maintenance and disposal of tiled surfaces. Since many of the cost items such as construction costs for background, screed, movement joints, cleaning costs and landfill disposal costs are identical for all the grout types, these costs are not be included in the LCC analysis to simplify the overall evaluation process. In addition, only the labour cost for direct hire workers is used for evaluation as the difference in the hourly rate could be attributed to the lack of additional benefits for contract workers.

Table 1: Summary of data collected for LCC analysis

Grout Types	Cement Grout	Epoxy Grout	LSTJ
Labour rate	£14.32 /hr	£16.58 /hr	£14.32 /hr
Equipment rate	-	-	£8.26 /hr
Additional mobilisation cost	-	-	£50.00
Tile laying rate	2.267 m^2/hr	1.865 m^2 /hr	2.267 m^2 /hr
Grouting rate	11.016 m^2/hr	3.447 m^2 /hr	0.8 $\times$ 11.016 m^2 /hr
Grout cost	£0.28 /m^2	£4.33 /m^2	4 $\times$ £0.28 /m^2
Typical processing speed	-	-	4 mm/s
Grout removal rate	2.491 m^2/hr	1.212 m^2 /hr	-
Tile removal cost	£14.50 /m^2	£17.50 /m^2	£14.50 /m^2
Service life	8 years	11 years	30 years
Annual grout failure: Percentage of tiled area	3.34%	2 $\times$ 0.33%	0.33%

The production and cost data used for formulating the life cycle cost model of the laser-based tile grout sealing process is derived from experimental and survey results. For example, the production rate for laying floor tiles for lased sealed grouts is assumed to be the same as that of cement grouts, while the grouting rate for laser sealed grouts is taken as a fraction of the grouting rate for cement grouts due to the similarity in both the processes. The reduction in the grouting rate stems from the requirement to apply a thin layer of the enamel prior to the laser irradiation process. Two scenarios are considered in the evaluation of epoxy grouts. The first scenario assumes that all the failed grouts are removed and replaced at the end of the grout service life while the second envisions the complete removal and replacement of the tiled surfaces at the end of the grouts' service lives. These scenarios represent the worst-case outcomes for the conventional tile grouts. For the laser-based grout sealing process, the optimal irradiation speed of 3 mm/s is used for the initial analysis based on the latest results from laboratory experiments.

Comparison of Laser Sealed Tile Joint (LSTJ) with Epoxy Grout

The costs for installing, repairing, replacing and removal epoxy grouts and LSTJ are enumerated in Table 2. The application of laser sealed grout is the most economical of the three scenarios under consideration although the difference between the NPV of LSTJ and intermittent replacement using epoxy grouts is marginal at less than one pound sterling per square meter. The LCC profile of the NPV indicates that LSTJ is more economical than intermittent retiling of the ceramic surface. Results from the analysis show that if the tile surface is required to be replaced once throughout the life of the project, it would be more economical to seal the tile joints with the newly developed laser-based tile grout than with epoxy grouts. LSTJ is only marginally more economical when compared with the intermittent replacement of epoxy grout. However, if epoxy grout is replaced more than twice throughout the life of the project or if the cost of downtime is significantly higher for replacing epoxy grout, then it would be more economical to utilise the laser-based process for sealing tile joint. Sensitivity analysis on the effects of changes in the discount rates indicates that the intermittent replacement of ceramic tile surface is the least economical of the three options when the discount rate is less than ten percent. LSTJ is more economical than the intermittent replacement of epoxy grouts when the net discount rate is less than 4.32% and vice versa.

Table 2: Cost Breakdown, NPV and IRR for Epoxy Grouts and Laser Sealed Tile Joint (LSTJ)

	Absolute Approach			Incremental Approach	
Costs	**Regrout (A)**	**Retile (B)**	**LSTJ (C)**	**Regrout vs. LSTJ (A - C)**	**Retile vs. LSTJ (B - C)**
Construction	£15,765	£15,765	£25,225	-£9,460	-£9,460
Annual repair	£62	£62	£96	-£34	-£34
Intermittent replacement	£9,446	£25,515	-	£9,350	£24,219
Tile removal	£8,750	£8,750	£7,250	£1,500	£1,500
NPV (4%)	£29,576	£45,723	£29,091	£485	£16,633
IRR	-	-	-	4.32%	11.44%

Risk Analysis

Monte Carlo Simulation

Although the results of the initial LCC analysis are deterministic, there are many uncertainties with regards to the actual cost of the equipment, labour and material in an actual project. Furthermore, variability in the prevailing discounts rate, tile size, production rate and rate of grout failure could significantly affect the outcome of the LLC analysis. Therefore, risk analysis is employed to evaluate commercial viability of the LSTJ relatively to epoxy tile grouts. The @RISK software is used to perform risk analysis and Monte Carlo simulation of variables in the life cycle cost models. Each uncertainty variable is represented by a probability distribution function in the @RISK software. Three different simulations were conducted to test the consistency of the simulation results and to determine the number of iterations required. The total number of iterations for each simulation was initially set at 1,000. A comparison of the NPV distributions for intermittent regrouting shows that the simulations result is not affected by either the random seeds or the sampling methods used. Therefore, it can be argued that the number of iterations is adequate for the risk analysis results to converge.

Cumulative Probability Distributions

The mean NPV for 500 m^2 of tile surface sealed using the laser-based process is £28,484. Using the cumulative probability distribution (CPD), the probability of the NPV value falling between any two values could be calculated. In this study, the five percentile and ninety-five percentile are taken as the lower and upper range for all the probability distributions as they represent the main points of inflections for the s-curves that represent the cumulative probability of the life cycle costs. The mean life cycle cost for LSTJ is lower when compared with the mean LCC of epoxy-grouted surfaces (Table 3). The NPV for surfaces that are intermittently retiled is expected to be higher than the NPV for LSTJ under the conditions simulated in the risk analysis at £38,546 and £52,470 respectively. The mean NPV for regrouting and retiling with epoxy grout based on incremental approach are £9,979 and £23,902 respectively. The LCC difference ranges from -£23.79 to £74.79 per square meter for regrouting while the cost difference for retiling versus LSTJ ranges from £2.49 to £108.20 per square meter. The probabilities that the NPVs would be negative are approximately 28% and less than 5% for regrouting and retiling respectively, indicating the advantage of the LSTJ when compared with epoxy grouts. Table 3 indicates that the IRR for regrouting ranges from –1.70% to 28.86% while for retiling, the IRR ranges from 4.07% to 35.23% with the mean at 10.76% and 17.35% respectively. The probabilities that the IRRs are higher than 4% are approximately 72% and 95% for regrouting and retiling respectively. In the current climate of low interest rates, it is advantageous to apply the laser-based sealing process in the UK tiling industry.

Table 3: Summary of Cumulative Probability Distribution

Grouting Methods	NPV			IRR		
	Mean	5%	95%	Mean	5%	95%
Laser Sealed Tile Joint	28,484	18,446	63,756	-	-	-
Epoxy Grouts (Regrout)	38,546	20,350	65,646	-	-	-
Epoxy Grouts (Retile)	52,470	32,700	81,511	-	-	-
Epoxy (Regrout) - LSTJ	9,979	-11,895	37,397	10.76	-1.70	28.86
Epoxy (Retile) - LSTJ	23,902	1,224	54,102	4.07	17.53	35.23

Sensitivity Analysis

The sensitivity of the NPV for LSTJ to changes in the input variables is calculated using regression analysis and the results are displayed in the form of tornado graphs according to the strength of the relationships between the input and the NPV. Sensitivity analysis of the life cycle cost model (Table 4) indicates that the most significant variables affecting the LSTJ's NPV are the labour cost, tile sizes, tile laying rate and laser processing speed respectively. The changes to the life cycle cost of the LSTJ are mainly affected by variables that directly contribute to the initial construction cost of laser sealed tile surfaces. The cost of labour and laser processing speed are two key parameters that could be improved to increase the efficiency of the laser process. Despite the high initial cost of the laser equipment, the impact of the equipment running cost is not shown to be significant, as the utilisation rate for the laser equipment has been fixed at 80% level. However, the impact of the running cost on the NPV would be significant if the utilisation rate for the equipment is lower than 80%. It is therefore essential to determine that there is sufficient market for the technology prior to its deployment. The NPV for both regrouting and retiling are most sensitive to changes in the cost of labour when grouting with epoxy grouts and to a lesser extent by the labour cost of the laser sealing process. In addition, the life cycle cost of regrouting is influenced mainly by changes in the cost of intermittent grout removal while the LCC for retiling is affected by tile laying and grouting rates.

Table 4: Results of Sensitivity Analysis

Variables	Laser Sealed Tile Joints	Epoxy (Regrout) - LSTJ	Epoxy (Retile) - LSTJ
Rank 1	Labour Cost (+0.587)	Labour Cost – Epoxy (+0.519)	Labour Cost – Epoxy (+0.535)
Rank 2	Tile Sizes – Grout length (+0.410)	Grout Removal Rate (-0.271)	Tile Laying Rate (-0.382)
Rank 3	Tile Laying Rate (-0.367)	Labour Cost – Laser (-0.205)	Grouting Rate – Epoxy (-0.273)
Rank 4	Laser Processing Speed (-0.357)	Discount Rate (-0.157)	Labour Cost – Laser (-0.260)
Rank 5	Tile Cost (+0.134)	Grouting Rate – Epoxy (-0.147)	Discount Rate (-0.259)

CONCLUSIONS

From the LCC analysis, LSTJ is found to be more economical when compared with conventional grouts for surfaces that are intermittently retiled. Although the life cycle cost is sensitive to the discount rate used, the analysis results suggest that LSTJ is more economical under most conditions due to the high cost of tile replacement. Laser-based grout sealing would be the preferred choice if the tiles grouted with conventional grouts are expected to be completely replaced at least once in the building life. When the LSTJ is compared with the option of regrouting using epoxy grouts, the probability that the that the return of investing is positive is approximately seventy percent thus indicating that the option of LSTJ is generally viable when compared with epoxy grouted surfaces. These estimates are considered conservative as downtime costs from regrouting or retiling work would greatly increase the cost of epoxy grouted surfaces.

In order to improve the commercial viability of the laser seal process, laser sealing should be used in conjunction with larger sized tiles, thus reducing the sealing length required. Secondly, the processing speed should be increased. Alternatively, an automated system could be designed to reduce its dependence on labour as the labour cost is the main variable affecting the life cycle cost of all tile surfaces. An automated system would also provide better control over the process speed and reduce the risk of laser exposure. However, the cost for developing an automated on-site laser delivery system is expected to be significantly high and may not be commercially viable.

REFERENCES

Ashworth, A (1996) Estimating the Life Expectancies of Building Components in Life-Cycle Costing Calculations, *Structural Survey* 14(2), 4-8.

Dale, S J (1993) ‘Introduction to Life Cycle Costing’ in Bull, J W, eds, *Life Cycle Costing for Construction*, Blackie Academic & Professional, London, 1-22.

Elder, A J and Vandenberg, M (1984) *AJ Handbook of Building Enclosure*, The Architectural Press, London.

Flanagan, R and Norman, G (1989) *Life Cycle Costing in Construction*, RICS, London.

Flanagan, R, Norman, G, Meadows, J and Robinson, G (1989) *Life Cycle Costing*, Blackwell Scientific Publications, London.

Gatfield, M J (1998) *Screeds, Floorings and Finishes: Selection, construction and maintenance*, Construction Industry Research and Information Association, Report 184, CIRIA, London.

Kemtile (2001) Kemtile Limited 21 Years, *Food Trade Review*, Vol. 71, November, Food Trade Ltd., UK.

Lawrence, J, Li, L and Spencer, J T (1999) The Effects of High-Power Diode Laser Radiation on the Wettability, Adhesion and Bonding Characteristics of an Alumin/Silica-based Oxide and Vitreous Enamel, *Surface and Coatings Technology* 115, 273-281.

Lawrence, J, Schmidt, M J J, Li, L, Edwards, R E and Gale, A W (2002) A Portable High-Power Diode Laser-Based Single-Stage Ceramic Tile Grout Sealing System, *Optics & Laser Technology* 34 (1), 27-36.

MBD (1999) The UK Industrial Flooring Market Development: Quarter Four 1999, Market and Business Development, Manchester.

Potter, C (2002) Keeping Up Appearance, *Tile UK* 7(2), Spring, CMP Information, London, 30-32.

Pye, P W and Harrison, H W (1997) Floor and Flooring: Performance, Diagnosis, Maintenance, Repair and Avoidance of Defects, BRE, London.

Roussos (2002) In-Process Monitoring of Laser Tile Grout Sealing and Removal Process, MSc Thesis, UMIST

Tatnall, R E (1981) Fundamentals of Bacteria Induced Corrosion, *Materials Performance* 20(9), National Association of Corrosion Engineers, Texas, 32-38.

Wheat, M (2001) Factors Affecting Grout Performance in Swimming Pools, *Tile To*day 9(33), Australian Tile Publications, Victoria, 22-25.

Wittenwyler, C V (1986) 'Epoxy Resin Chemically Resistance Mortars' in Sheppard, W L Jr., eds, *Corrosive and Chemical Resistant Masonry Materials Handbook*, Noyes Publications, New Jersey, 252-266.

THE PERCEIVED PERFORMANCE OF DIFFERENT PROCUREMENT METHODS IN THE AUSTRALIAN MEDIA

Peter Raisbeck
Faculty of Architecture, Building and Planning,
The University of Melbourne
raisbeck@unimelb.edu.au
Colin Duffield
Faculty of Dept. of Civil and Environmental Engineering,
The University of Melbourne,

In Australia as PPPs have gained acceptance as a procurement method they have been the subject of considerable debate which has also attracted media interest. Sometimes media attention intensifies as a PPP project encounters difficulties, and this is compounded by project stakeholders with sectional interests who may use the media in order to gain a bargaining advantage. Often media interest appears to match the lifecycle of a project's construction reaching a peak just prior to delivery and then tapering off. For these reasons issues regarding what constitutes the 'public interest' in Public-Private Partnerships (PPP) are a constant source of controversy in the Australian media. Our initial hypothesis was to test the idea that given similar circumstances such as size of project and budget cost over-runs the media are more likely to focus on a PPP project rather than a traditional project. To do these we sourced and compared data on PPP and traditionally procured projects in the public domain. For the largest of these projects we employed a news archive search engine to compare news volume generated by PPP projects against projects procured by other methods. In addition, we looked at 4 case studies, 2 PPPs and 2 non PPPs where we compared time and cost outcomes with news volume. We conclude that in Australia more information about PPPs circulates in the public domain than for traditional projects. This conclusion raises issues about the perceptions of Australian PPPs with regard to their performance in the Australian media.

KEYWORDS: PPPs, traditional procurement, media, performance metrics, project management

INTRODUCTION

In this paper we look at the role of the media in its coverage of PPP projects in Australia procurement projects. This research is generated from our study entitled "Performance of PPPs and Traditional Procurement in Australia" which was completed in December 2007. This research has been widely reported in the Australian media as a "Landmark" study and has had a significant impact on the PPP debate in Australia (see: *Private partners would save $6bn on major projects,* Financial Review December 3 2007). This research was innovative because it responded to the methodological criticisms raised by the UK Unison report in relation to the UK's NAO and Mott McDonald studies. Moreover, our PPP research was based on more recent data in Australia's PPP market than previous research (e.g. Hodge, 2005).

We then provide details for 4 case studies that illustrate particular factors relating to the success and failure of projects and how these issues are perceived more broadly. Our initial intention was to test the proposition that given similar circumstances, such as size of project and budget cost over-runs, the media are more likely to focus on a PPP project rather than a Traditional project. Given the obvious difference between the selected projects in this study, we refined this hypothesis and tested the notion that more information is likely to circulate in the public domain with respect to PPP projects compared to Traditional projects.

Sources of information about PPPs in Australia

In Australia, like the UK, research into the delivery of public infrastructure has been clouded by public debates surrounding the PPP model. Often these debates are supported by research concerned with the economic morality and governance of PPPs (Hodge, 2007 issues of probity and accountability in PPPs (English 2005). A key issue in these studies is the issue of transparency and accountability. However, very little research has been conducted into comparing project performance alongside measurements of transparency between different procurement models in different Australian states.

In Australia there are a number of different public sources of information regarding PPPs. In Australian construction management scholarship PPP research is most closely aligned with research into procurement decisions and systems. This work ranges from studies focused on procurement decision making (Skitmore and Marsden 1998; Love, Skitmore and Earl 1998) to studies focused on different procurement methods. There have also been studies of procurement models as they have gained initial acceptance (Hampson, et. al. 2001). Recent Australian procurement research has tended to focus on issues of concern to contractors within the procurement lifecycle such as tendering and bidding costs. (McGeorge et. al, 2007). Information about PPPs has also been generated by studies related to issues of public policy. This work has examined issues surrounding performance auditing (English 2007) and commercial- in- confidence (de Maria, 2001).

In procurement practice a significant amount of work has been conducted via the states' various treasury departments which have produced and published various VfM measures and practitioners guides concerning new forms of procurement such as alliancing and PPP contracting arrangements. (Partnerships Victoria 2006, NSW Technical paper 2007). Complementing this body of work is the research produced by government auditors into different PPP projects. Again, research is complicated by the fact that audit mechanisms differ between states and in some jurisdictions getting publicly available performance data on traditional projects is more difficult than gaining data on projects procured by PPPs or alliances. These latter projects are often audited and usually attract a greater degree of interest in the public media.

Nationally the Australian National PPP forum has sought to gather project data and to work towards a national benchmarking study which enables both PPPs and traditional public sector projects to be evaluated. In Victoria PPPs there have been 17 PPP projects either complete or underway with a total investment value of $5.5B. Two of these projects have been subject to audits and for some of these projects the contract details are available in the public domain. In November 2007 the Victorian government undertook to provide project summaries including information regarding value-for-money and public interest considerations for all future PPP projects. Under this policy, project summaries would be released within three months of the finalisation of the contractual and financial arrangements for Public Private Partnership (PPP) projects. Under the policy project summaries would also provide a snapshot of the rationale for the project, its value, the parties involved and key commercial features of the project.

Critics of PPPs have often pointed to a lack of transparency and accountability. For example, English and Guthrie (2003, p.508) concluded that for PPPs the complexity of supporting documentation, commercial-in-confidence clauses, and the reluctance of governments to make crucial aspects of their dealings transparent, make real-time accountability problematic. However, given the range of sources cited above, in particular the audit reports, it would appear that a greater volume of information about PPPs circulates in the public domain in comparison to projects procured by traditional public sector methods. This is surprising given the relatively small size of the PPP market in Australia in comparison to the market for traditional procurement.

Methodology

Project Selection

Using Google's news archive search engine, we analysed each of the projects in our selected PPP and Traditional project sets in order to ascertain the news volume generated in the Australian public domain for each project. Each of the project sets or pools were formed by applying a number of selection criteria. Firstly we selected projects undertaken since about 2000 including those projects that had been largely completed by June 2007. Moreover, the projects selected had a capex budget of $20M or greater. Given these criteria we found information about a total of 206 projects that met these criteria in the public domain. These projects included 50 PPPs and 156 projects procured via traditional processes. In evaluating these projects we attempted to have a balance or projects of similar complexity and type. On this basis our final set of projects comprised a final sample set of 54 projects which included 21 PPP project and 33 traditional projects. All the information about these projects was obtained from sources in the public domain. As indicated in the table there appears to be less complete data available in the public domain for publicly procured projects compared to PPP projects. Arguably, the involvement of private sector agencies and the greater scrutiny of PPPs by state treasury and audit offices may account for more PPP project information being in public circulation.

Using these two project pools (PPP and traditional) and the information in the public domain we then set using the following search criteria:

News Volume Analysis

1. A News Volume Search was made using the project's designated name via the Google exact phrase search function.

2. The News Volume Search was limited to the years between 2000 and 2007.

3. Search Results were only accepted or counted where they referred to information regarding the project's procurement. In some cases this meant applying an exclusionary search term. For example the Alfred Centre in Victoria was searched for minus the word 'King'. In other cases words such as 'PPP', 'development' or 'upgrade' were added. For example, the search for Victoria's County Court was supplemented with the word 'PPP'. These additional search terms tended to diminish the news volume results for PPPs.

4. The number of search results for each project was then counted and collated.

Table 1 Selection of PPP project Pools showing % of incomplete data in the public domain

	NSW	VIC	QLD
Total PPP Projects	25	18	2
Total with complete data	5	7	2
Total Complete to Incomplete %	20.0%	38.9%	100.0%
No. Selected into Project Pool	11	8	0
PPP Complete data	7	7	0
PPP Incomplete data	4	1	2
Traditional Projects	77	47	32
Total with complete data	5	11	1
Total Complete to Incomplete %	6.5%	23.4%	3.1%
Selected into Project Pool	8	17	7
Traditional Complete data	5	11	2
Traditional Incomplete data	3	6	5

Comparative Analysis

Table 2: News Archive Volume Coverage: PPP vs Traditional Projects

	0-10	**100**	**200**	**300**	**400**	**500+**	**Total**	**Average**
PPPs	27	5	1	0	1	5	39	232.5
Traditional	11	18	3	0	1	2	35	80.2

As indicated in Table 1 the average news archive volume for PPPs was 232.5 compared with 80.2 for the pool of traditional projects. However, the projects with the most news volume in the PPP sample were the Cross City and Lane Cove tunnels in Sydney. These projects had 3,490 and 2,040 news hits respectively. Removing these projects entirely from the sample set would give the PPP projects an average volume per project of approximately 92, which is not very different from the 80.2 average for traditional projects. Hence, the attention of the media appears to be concentrated on a few key projects, and it is possible that it is the performance of these few projects that is likely to influence broader perceptions of PPPs.

Tables 2 and 3 below display a number of Traditional and PPP projects and rank them by the number of media hits, showing the associated procurement type and jurisdiction. The greatest number of 'news hits' by far was scored by the two Sydney PPP tunnel projects, the Cross City Tunnel (CCT) and the Lane Cove Tunnel (LCT). The Western Sydney Orbital (480 news hits), was not far behind. Interestingly, most of the top 9 projects ranked by news hits were all transport related, even though we have classified the Southern Cross Station as social infrastructure in this study. This indicates that transport and transport related infrastructure tends to attract the most media attention and PPPs are over-represented among the top news hit stories relative to the proportional contribution of PPPs to the transport sector.

Another notable feature of the transport group within the top 9 is that the PPP projects were all completed on budget and ahead of time (compared with Contractual Commitments), while some of the Traditional projects were completed late (Regional Fast Rail) or early, but behind budget (Lawrence Hargrave Drive).

‘Iconic buildings’ like Melbourne’s Federation Square and the Southern Cross Station were also subjected to a similarly large number of news hits. Both these projects were behind time and behind budget. However, the Federation Square Traditionally procured project suffered significantly higher cost over-runs and time delays than the PPP-procured Southern Cross Station.

Table 2 also shows that a number of PPP and Traditional projects had attracted hardly any media attention even though some of them were completed behind schedule. Hence, it is only a small number of projects that are subjected to disproportionate publicity in the media, and while these tend to be transport-related PPPs, some transport-related Traditional projects are also highlighted.

Table 3: PPP Media Volume

Project	State	Media Volume
Cross City Tunnel	NSW	3,490
Lane Cove Tunnel	NSW	2,040
Southern Cross Station	Victoria	638
Paramatta Transport Interchange	NSW	91
Western Sydney Orbital	NSW	480
County Court	Victoria	86
Mobile Data Network	Victoria	4
Casey Community Hospital	Victoria	3
Mobile Data Network	Victoria	4
Middleborough Road Tulla Calder Interchange	Victoria	4
New Schools Project #1	NSW	0
Alternative Waste Technology Facility	NSW	1
Metropolitan Mobile Radio	Victoria	0

Table 4: Traditionally Procured Projects Media Volume

Project	State	Media Volume
Federation Square	Victoria	891
Regional Fast Rail	Victoria	538
Craigieburn Bypass	Victoria	359
Lawrence Hargrave Drive	NSW	146
Bondi Junction	NSW	31
Geelong Road upgrade	Victoria	25
Alfred Centre	Victoria	24
North Kiam Bypass	NSW	21
Relocatable classrooms	Victoria	18
Albury Wodonga Freeway	Victoria	4
Upper Coomera State College	Queensland	17
Bonville Bypass	Traditional	3
Casey Community Hospital	Victoria	3

4 case studies Project performance vs media attention

The four case studies that were chosen for review represent a mix of Traditional and PPP projects, holding constant the jurisdiction (Victoria and New South Wales) and sector (transport and social). The key metrics of these four case studies (Bangor Bypass, City Cross Tunnel, Austin Health and Mercy Hospital for Women, Southern Cross Station) are set out in Table 4

Table 4: Case Studies and Media Volume.

	Bangor Bypass	Cross City Tunnel	Austin Health & Mercy Hospital	Southern Cross Station
Case Study No.	1	2	3	4
Procurement type:	Traditional	PPP	Traditional	PPP
Sector	Transport	Transport	Social	Social
Jurisdiction	NSW	NSW	Victoria	Victoria
Actual cost	$95 million	$680 million	$376 million	$322 million
Media 'hits'	0	3,490	3	638
Time:				
Final vs Original	+8.9%	-1.9%	-10.7%	+25.3%
Final vs Contractual	+0.3%	-3.3%	+18.2%	+9.4%
Cost:				
Final vs Original	+58.3%	6.3%	+17.5%	+34.3%
Final vs Contractual	26.7%	0.0%	+17.5%	+12.6%

At a general level, it will be noticed that the number of media 'hits' is not correlated to the time and cost performance statistics displayed in Table 4. In construction cost terms the two PPP projects were superior outcomes, particularly on Stage 4 costs (Final vs Contracted cost), but also on time. It is understandable that the Cross City Tunnel (CCT) should attract far more media coverage than the Bangor Bypass on the basis of relative size and location of the former in central Sydney. However, in terms of the performance that matters to the community as a whole, CCT's performance was far superior. In the case of Austin Health and Mercy Hospital for Women (Austin Health), we again find that on projects that are similar in size, the project with arguably worse performance (Austin Health) attracted hardly any media attention. As discussed below, this can be partly seen as due to the 'iconic building' stature of the Southern Cross Station.

4 Case Studies

Case Study 1: Bangor Bypass

The Bangor Bypass project was approved by the NSW Minister for Planning on 22 November 2002 subject to 113 conditions of approval. It was originally expected that construction of the Bangor Bypass would commence in late 2002, with the East-West Link completed by 2004. In the next phase it was expected that Construction of the North-South Link would follow in February 2002. It was originally proposed that the Bangor Bypass would cost approximately $100 million, with the East-West Link costing $60 million and the North-South Link costing approximately $40 million. Stage 1 was opened to traffic on 7 February 2005, providing a four-lane, divided road between Woronora Bridge and Alfords Point Road, bypassing Menai Road. Stage 1 was fully funded by the State Government and cost approximately $95 million.

Additional construction costs resulted from increases in the project's scope which included changes to the road designs to incorporate two sections of over-pass roads and two bridges; and alterations to the program of works to incorporate the northern section of the North–

South Link. In addition, there were design changes as a result of the extensive community consultation process and additional planning approval conditions including a pedestrian cycleway, additional noise walls and additional drainage requirements

Case Study 2: Cross-City Tunnel

The Cross City Tunnel (CCT) comprises two main east and west 2.1 km tunnels running between the eastern side of Darling Harbour and Kings Cross, linking the Western Distributor to New South Head Road. The eastbound tunnel also connects with the southbound Eastern Distributor. Construction work for the Cross City Tunnel commenced in January 2003, and the tunnel was originally scheduled to open in October 2005. The official opening of the tunnel was earlier, on Sunday 28 August, 2005.

After opening, the tunnel’s revenues were impacted by low traffic volumes. Subsequently, the operators announced a freeze on toll increases for twelve months and the fee for casual (non-electronic tag) users was waived. This was prompted by negative publicity and low traffic volumes. The toll-free period was then extended for a further two and a half weeks, until the end of November, 2005. In November 2006, it was reported that the motorway was in financial difficulties, and that additional equity would be required from the tunnel's investors in order to avoid placing the tunnel in administration. On December 27 2006, a syndicate of 16 Australian and International banks appointed the insolvency firm KordaMentha as receivers and managers for Cross City Motorway Limited after the project accrued debts exceeding $AUD 560 million. In June, 2007 ABN AMRO and Leighton Contractors purchased the tunnel.

Case Study 3: Austin Health and Mercy Hospital for Women

The Austin Health Redevelopment and Mercy Hospital for Women Relocation project (Austin Health), valued at about $400 million, is Victoria's largest hospital redevelopment project. The original BOO project process was terminated due to a change of government. In 2000, the Bracks Government progressed the project as a Traditional spend, with a budget of $320 million comprising $225 million to redevelop acute services at the Austin (including 440 inpatient beds; a new emergency department, intensive and critical care units and a 30 bed adult mental health unit); $30 million teaching, training and research precinct; $65 million for Mercy Hospital’s move (scheduled to be completed by 2004 and include 128 adult beds, 60 neonatal cots and 17 delivery suites); and Private sector funding was sought for a 1200 to 1400 space car park to be built under the new acute wing.

A major factor in the Austin Health case was the changes that took place in the scope of the works. The original 440 beds became 400 beds from August 2002, while the original 30-bed adult mental health unit expanded to 55 beds at October 2006. The concept of a single teaching and training precinct was expanded to a teaching space and laboratory on every level in May 2005, and the two operating theatres were expanded to four operating theatres in May 2005. A 26 bed high-tech spinal unit was added in October 2006. The final cost was higher than originally anticipated, and the project was completed ahead of time.

Case Study 4: Southern Cross Station

Southern Cross Station was formerly known as Spencer Street Station. The station is one of the largest PPP projects undertaken in Australia. In July 2002 the Civic Nexus consortium was awarded the contract for the station. Under this deal Civic Nexus will operate the station for 30 years after which time the station will revert back to public ownership. The original consortium, owned by ABN AMRO Australia, included Leighton Contractors (Leighton), Daryl Jackson architects in association with the London based Grimshaw architects. In August 2002 the Victorian State Government finalised its agreement with Civic Nexus. In the agreement the State Government would pay Civic Nexus an annual fee of $AUD 34 million.

By May 2004 Leighton indicated that the project would seriously impact on company profits. At this point in time Leighton cited the confined working environment, site access issues, the 'demands of the franchisee train operators' and 'complex design variations' as the primary causes of their problems. On the 6th of May 2002 Leighton issued a statement to the ASX indicating that these issues were resulting in time delays on the project and consequently Leighton downgraded its profit forecasts. This amounted to Leighton making provisions on the project amounting to $150 million. The final settlement between the Victorian Government and Leighton was $36 million.

As a public design Southern Cross Station has been a great success and was awarded a prestigious international architectural award, the RIBA Lubetkin Prize, in London. While the Southern Cross Station resulted in financial losses for the builder and its investors, the resulting building has been praised world-wide, and can be considered a success from society's perspective. Had things gone the other way, with the builder making large profits, these might have attracted criticism, but society would still have won by having access to a world-class building. These are the risks that investors take.

Conclusion

The results suggest that in Australia a greater volume of information about PPPs circulates in the public domain in comparison to projects procured by traditional methods. This is surprising given the relatively small size of the PPP market in comparison to the market for traditional projects. Arguably, the involvement of private sector agencies and the greater scrutiny of PPPs by state treasury and audit offices may account for more PPP project information being in public circulation. It could also be accounted for by the fact that a few high profile PPPs have attracted attention because they were perceived as having performed badly on time and cost outcomes. It may also be the case that because PPPs in Australia are a relatively new form of procurement that they have attracted greater media attention. Clearly this issue requires further research which might look more closely at the relationship between information in public circulation, media perceptions and the impact of these perceptions on policy makers who must make complex procurement decisions and other PPP stakeholders.

REFERENCES

Commonwealth of Australia (June, 2000), Australian Government Policy Principles for the use of Public Private Partnerships, December 2006

Duffield, CF (2001). An evaluation framework for privately funded infrastructure projects in Australia. PhD. Department of Civil and Environmental Engineering. The University of Melbourne.

English, L (2005), “Using public-private partnerships to deliver social infrastructure: the Australian experience”, pp.290-304 in Hodge and Greve (Eds.) The Challenge of Public-Private Partnerships: Edward Elgar, Cheltenham, UK, and Northampton, MA, USA.

Fitzgerald, P (2004). Review of Partnerships Victoria provided infrastructure: Final report to the Treasurer. Melbourne: Growth Solutions Group, .Melbourne.

Fitzgerald, Peter (January, 2004), Review of Partnerships Victoria Provided Infrastructure, Final Report to the Treasurer, Growth Solutions Group.

HM Treasury (2003), PFI Meeting the Investment Challenge, Norwich HMSO.

Hodge, G, (2007), “Public-Private Partnerships: An International Performance Review”, Public Administration Review, 67, 3, pp.545-558

Hodge, Graeme, (2005), “Public-private partnerships: the Australasian experience with physical infrastructure”, pp.305-331 in Graeme Hodge and Carsten Greve (Eds.) The Challenge of Public-Private Partnerships: Learning from International Experience, Edward Elgar, Cheltenham, UK, and Northampton, MA, USA.

Love, P.E.D., Skitmore, R.M., and Earl, G. (1998). Selecting an appropriate procurement method for a building project. Construction Management and Economics, 16, pp.221-223.

McGeorge, Denny, Marcus Jeffries, Katie Cadman and Chen Swee Eng (2007), Implications for Design and Build contractors bidding in Public-Private-Partnership Consortiums: an Australian perspective, Working Paper, School of Architecture and Built Environment, Faculty of Engineering and Built Environment, The University of Newcastle.

Mott McDonald (July, 2002) Review of Large Public Procurement in the UK, Report to HM Treasury.

Quiggin, John (30 August, 2007), “Beware the PPP pitfalls”, Australian Financial Review, p.70.

Raisbeck, P. (18-20 October, 2006), “PPP financing, architectural design, and risk mitigation in Melbourne’s Southern Cross station project”, Joint International Symposium of CIB Working Commissions W55/W656/W86, Construction in the XXI Century: Local and Global Challenges, Rome.

Raisbeck, P, Duffield, CF, and the Allen Consulting Group. (2007), Relative Performance of PPPs and Traditional Procurement in Australia. Infrastructure Partnerships Australia. (http://www.infrastructure.org.au/research/publications.htm)

Shaoul, Jean (2005), “The Private Finance Initiative or the public funding of private profit?”, pp. 190-206 in Graeme Hodge and Carsten Greve (Eds.) The Challenge of Public-Private Partnerships: Learning from International Experience, Edward Elgar, Cheltenham, UK, and Northampton, MA, USA.

Sheehan, Paul, (September 12, 2005), “Acts of bastardry on a toll road to nowhere”, Sydney

Victorian Treasury (June 2000) Partnerships Victoria.

RANKING CONSTRUCTION PROJECT CHARACTERISTICS

Favié, Ruben
Eindhoven University of Technology
r.favie@bwk.tue.nl

Maas, Ger
Eindhoven University of Technology
g.j.maas@bwk.tue.nl

This paper is concentrated on ranking project characteristics in order to be able to choose the type of procurement method (such as Traditional or Design & Construct) that can best be used for the design and build stage of a construction project in the future. There are several project characteristics that are defined in literature. But which of these project characteristics are the most important ones? If we know that, a client, in the future, might be able to choose his procurement method better, because the project characteristics are the main criteria for selecting a procurement method. To reach this goal, the first step is to list the relevant project characteristics from literature and practice. The second step is to make these criteria measurable in order to be able to match the characteristics with the procurement method characteristics. This paper will include the relevant project characteristics and the ranking of those by comparing literature with practice. In the future the most relevant project characteristics can be compared with the characteristics of the existing procurement methods in order to be able to make the right choice for a procurement method.

KEYWORDS: project characteristics, procurement method, procurement, ranking

INTRODUCTION

The construction sector in The Netherlands is, just like in other countries, in motion. Increasing project complexity forces the traditional sector to change. This complexity is to a large extent caused by the increasing demands of clients, society and the people living near the project. Other causes are, in addition to this, the technological developments and legislation. The changes in the construction sector are next to development and renewal of products, also concentrated on the processes. These processes are necessary to be successful in the ever changing and complex environment.

One of the changes is the use of new, more integrated procurement methods. The question is when to use which of these methods? There are several parameters that can influence the choice of a certain procurement method. These are, for example, the economical and political situation, the legislation and the type of client.

This paper is concentrated on the characteristics of building projects. These characteristics are a major parameter for the choice of a procurement method. The aim of this paper is to find the most important project characteristics that distinguish one project from another.

The construction process

The construction process is split up into phases that follow each other in time. The output of phase 1 is the input of phase 2, etcetera. The construction process phases are:

- Programme phase
- Design phase
- Preparation phase
- Realisation phase
- Maintenance phase

Every phase has its own characteristics and therefore asks for specific competences from the persons and companies that are cooperating in that phase. Next to the different phases, the construction industry also knows different branches. Traditionally, the market is divided into residential building, non-residential building and civil engineering. Even within these branches, a lot of different projects with a big number of typical characteristics are possible.

Procurement

One of the processes in the construction process, that receives a lot of attention in the international, scientific world as well as in the national building practice, is the way that clients select their contractors. Contractors are companies that execute jobs ordered by a client. Selecting a contractor can be seen as a purchasing or procurement process. The procurement process is seen as the process that starts with the specification of the client’s demands and ends with the follow-up and evaluation of the contract. The aim of it is to acquire the construction work that meets the client’s needs.

Van Weele (2007) describes the following steps in a company’s procurement function:

1. Determining specification
2. Selecting supplier

3. Contracting

4. Ordering

5. Expediting and evaluation

6. Follow-up and evaluation

Applied to the construction sector, determination of specifications (fully elaborated technical specifications or only a couple of drawings or functional ideas), the selection procedure (which procedure and criteria) of the contractor en the contracting, are the most important. These are the first three steps of Van Weele's (2007) procurement function. He calls this the initial or tactical part of procurement. The way of handling this part of the process determines to a large extent how, later on in the process, the quality assurance, the payments and the follow-up are arranged and who is responsible for which part.

Specifically for the construction sector, Kumaraswamy en Dissanayaka (1998) have described this initial procurement function and the possible choices that can be made. The next choices have to be made:

- Work packaging;

- Functional grouping

- Payment modalities

- Form of contract

- Selection methodologies

Functional grouping

One of the decisions that has to be made is the functional grouping of a project. There are a lot of different ways to set up a construction project organization. The traditional process, in which a contractor is contracted based on specifications and drawings, is much segmented. More integrated organizational forms, in which one company or consortium of companies is responsible for the design and execution of a project, like a Design and Construct contract, requires a total different attitude of the contractor as well as the client. Organizational forms like Design-Build-Finance-Maintain (DBFM) integrate even more tasks and responsibilities.

The above-mentioned contractual forms differ from one another in the division of responsibilities, tasks and roles and functions. Next to that, they also differ in the moment on which the contractor is contracted. In the traditional process, the client (usually together with a consultant) develops a design and specifications until the final design. The moment on which the contractor is contracted is then just before the starting of the realization phase. In a Design and Construct contract, the contractor also develops a part of the design. In that case, the contract has to be signed earlier in the process. In a DBFM contract, the contractor also is responsible for (a part of) the financing and the maintenance. In the two other contractual forms, the financing is clearly with the client, at the beginning of the process. This task is in a DBFM contract with the contractor which means that the moment of contracting is at the front of the process.

These shifts in the moment of contracting mean that each time different kind of performances are demanded of the client and the contractor. Therefore, in every single case, an other division of the roles and responsibilities is necessary. A visualization of this shifting moment of contracting can be seen in Figure 1. The visualization is originated in the logistic decoupling point of Hoekstra and Romme (1992).

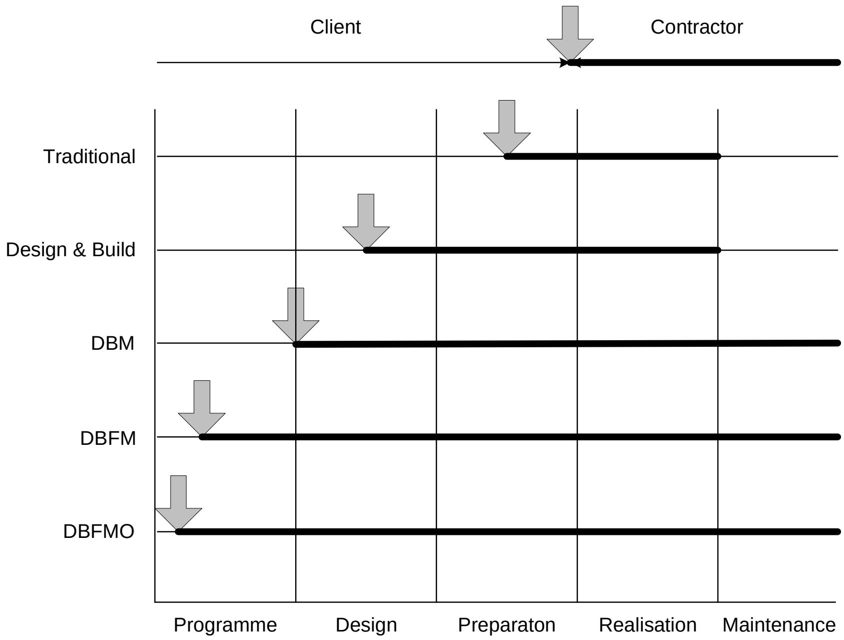


Figure 1. The Construction Process Transfer Point

As stated above, there are a lot of differences between the different procurement methods for construction projects. These differences lead to advantages or disadvantages for a client when he is planning to build something. Every client must look carefully for the right organizational for his project. According to Kumaraswamy and Dissanayaka (1998), the characteristics of the client and the project characteristics are the input for choosing the right procurement method. The choice for the right procurement method is of great importance to the project outcome.

The question that this paper deals with is: Which are the most important project characteristics that distinguish one project from another?

RESEARCH METHODS

In order to find the most important project characteristics, a literature study has been conducted. The characteristics that were found in literature, were listed and compared to each other.

Next to that, a workshop was held with 16 experts from the construction practice in which they were asked to list their most important project characteristics. The experts worked in groups of 4 and came with lists of characteristics.

The results from the literature study and the expert panel weren compared to each other and a list was made with a ranking of the characteristics. This ranking was made by counting the number of times that one characteristic was named in literature and by the experts.

RESULTS

Literature study

Eight sources of literature were chosen in this research. These were eight papers. These papers have all listed project characteristics. These papers are:

Baccarini (1996), Bennett (1991), Naoum (1989), Dissanayaka and Kumarawamy (1999) and Ling (2004) focus mainly on project characterics that only have to do with the project itself, like complexity, size and building type without regarding the project's environment. Only Bennett (1991) includes the economical situation as an important characteristic. Kuamaraswamy and Dissanayaka (1998), Chua (1999) and Tukel and Rom (1998), on the contrary, also include more environmental characteristics in their research like politics, local market situation and legislation.

The list of project characteristics that came from this literauture review, is shown in figure 2.

Expert panel

On 23 November 2007, a workshop was held with 16 experts from the construction practice in which they were asked to list their most important project characteristics. Eight of the experts work as a consultant, 2 as clients (1 public and 1 private), 3 as contractor and 3 work in construction research.

The experts worked in groups of 4 and came with lists of characteristics. The list of project characteristics that came from this workshop, is shown in Table 1.

Table 1. The list of project characteristics from literature, from the expert panel and the ranking of project characteristics.

	Project Characteristic	**#of times defined in literature**	**#of times deinened in workshop**	**Total # of times defined**
1	Complexity of project (e.g. special ground conditions or technology requirements).	6	4	10
2	Size of project (e.g. value; number of stories; floor area; km of road).	6	3	9
3	Effects of relevant political, legal and economic systems, including market conditions.	3	4	7
4	Importance for the project to be completed on time	3	4	7
5	Type of project (e.g. housing estate, road, dam, office building refurbishment).	5	1	6
6	Form of contract (functional grouping of contract: separated or integrated) and the division of responsibilities and liabilities	2	4	6
7	Specific location, special weather and environmental concerns.	2	3	5
8	Level of technological advancement	1	4	5
9	project life span / lifecycle	1	4	5
10	value of a project	2	3	5
11	quality of a project	1	4	5
12	Type of client (e.g. public/private/mixed; experienced/one-off/project staff caliber and their strengths, weaknesses and management style).	1	3	4
13	Any other special conditions.	1	3	4
14	project funding	1	3	4
15	Level of specialization required of contractors	2	2	4
16	Availability of information at project inception and points at which any remaining information will be required/be available.	1	2	3
17	Nature and status of local construction industry, including available capacities of potential project participants, scarcity of work in particular fields, competitiveness.	2	1	3
18	percent of repetitive elements	2	1	3
19	Availability of materials and equipment that are required for the works.	1	1	2
20	Ownership of building	1	1	2
21	Type of specification	1	1	2
22	Flexibility of scope of works when contractor is hired	1	1	2
23	Project scope definition completion when bids are invited	1	1	2
24	Importance for project to be completed within budget	1	1	2
25	Importance for project to be delivered	1	1	2
26	Selection process / methodology (bidding procedure, number of bidders, selection criteria, bidding environment)	1	1	2
27	Performance of available contractors and consultants on previous (similar) projects in the area in terms of meeting cost, quality and time targets; safety records and client satisfaction levels: as compared with the procurement modalities used.	1	0	1
28	Local familiarity and confidence in/disillusionment with, particular types of procurement with reasons (as perhaps verifiable from local professional institutions and techno-commercial ’networks’).	1	0	1
29	technical approval authorities	1	0	1

30	contractual arrangement	1	0	1
31	Payment mode to the contractor (payment modalities such as fixed price or cost plus fee)	1	0	1
32	Presence of special issues	1	0	1
33	Extant to which bid documents allow additions to scope	1	0	1
34	Design completion when budget is fixed	1	0	1
35	Bidder's knowledge of the budget	1	0	1
36	Time given to contractor to bid	1	0	1
37	Time given to owners / consultants to evaluate bids	1	0	1
38	Extent to which the contractor period is allowed to vary during bid evaluation stage	1	0	1
39	Number of bidders	1	0	1
40	Prequalification or short-listing	1	0	1
41	Bid evaluation and selection criteria	1	0	1
42	Bidding environment	1	0	1
43	density of a project	1	0	1

From this table we learn that all the experts (all 4 groups) name the complexity, the environment of the project (politics, legal, economic, market conditions), the importance of the project to be completed in time, the functional grouping, the level of technological advancement, the project life span / lifecycle and the required level of quality of a project as being important characteristics. In literature not one of the characteritics was defined by all sources. Six out of eight papers name complexity and size and only 5 papers defined type of project as being an important characteristic.

CONCLUSIONS

The results of this research are shown in table 1. As we can see, the project complexity is listed by almost every source. This means that in this research, this is listed as being the most important project characteristic. In order to be able to use this list for the selection of a procurement method, we should be able to measure the complexity of a project and compare it to the characteristics of the existing procurement methods. This research gives a start to that bigger research by listing the most important project characteristics that distinguish one project from another.

REFERENCES

Baccarini, D., 1996, *The concept of project complexity - a review*, International Journal of Project Management, 14, 201-204.

Bennett, 1991, *International Construction Project Management: General Theory and Practice*, Butterworth-Heinemann, Oxford

Chua, D.K.H, Kog, Y.C., Loh, P.K., 1999, *Critical Success Factors for Different Project Objectives*, Journal of Construction Engineering and Management, Vol. 123, nr. 3, pp. 142-150.

Dissanayaka, S.M. and Kumaraswamy, M.M, 1999, *Comparing contributors to time and cost performance in building projects*, Building and Environment, Vol. 34, pp. 31-42

Hoekstra, S. and Romme, J., 1992, *Integral Logistics Structures: Developing Customer Oriented Goods Flow*, McGraw-Hill, Londen.

Kumaraswamy, Mohan M. and Dissanayaka, Sunil M., 1998, *Linking procurement systems to project priorities*, Building Research & Information, 26:4, 223 - 238

Ling, F.Y.Y., 2004, *Key Determinants of Performance of Design-Bid-Build Projects in Singapore*, Building Research & Information, 32(2), March–April, 128–139

Naoum, S.G., 1989, *An investigation into the performance of management contracts and the traditional methods of building procurement*, Brunel University.

Tukel, O.I., Rom, W.O., 1998, *Analysis of the Characteristics of Projects in Diverse Industries*, Journal of Operations Managament, 16, 43-61

Van Weele, A.J., 2007, *Grondslagen van inkoopmanagement*, Kluwer, Alphen aan den Rijn.

A DYNAMIC POLICY MODEL TO MANAGE TEMPORAL PERFORMANCE AMONGST CONTRACTING FIRMS IN A COMPETITIVE SITUATION

Brian Dangerfield
University of Salford, UK
b.c.dangerfield@salford.ac.uk

Michael Quigley
University of Salford, UK
m.quigley@salford.ac.uk

James Rhys Kearney
University of Salford, UK
j.p.r.kearney@pgr.salford.ac.uk

Studies have been conducted to measure competitiveness in the construction industry. Such research has focused on all levels from the national picture to individual projects. While useful, the results are limited in that they present a snapshot picture at one point in time. Moreover, they do not suggest how under-performance might be improved. The research reported here is part of a large collaborative study to evaluate sustained competitiveness in the UK construction industry. It enhances previous research in that a system dynamics model of contracting firms operating in competition is used to not only measure each firm's temporal performance by means of a dynamic competitive index, but it can also suggest high leverage policies which mitigate against under-performance. The model structure is described and a simulated scenario run is presented. Besides the contribution to strategic policy making at the level of the contracting firm, the exemplar shows that the system dynamics methodology could have significant utility in the field of construction management.

KEYWORDS: competitiveness; modelling; contracting; policy

INTRODUCTION

There has been an interest in competition and competitive advantage in the construction industry since the early 1990's. Flanagan et al (2007) in their review paper list their earliest references from that period as those of Male and Stocks (1991) and Drew and Skitmore (1992). In business and management research generally, work at least a decade earlier can be cited (Porter, 1980), whilst the concern is undiminished even in the new millennium (Cockburn, Henderson and Stern, 2000).

Flanagan et al's (2007) review points out that research has been undertaken at three levels: that of the industry, the firm and the individual project. It is at the firm level where sustaining competitiveness is most crucial, for while under-performance on one project may be something which an individual firm may recover from – by dint of compensating strong performance on other projects – the firm is the legal entity and failure at this level may predicate liquidation.

Research on competitiveness inevitably hits an immediate problem in deciding how to actually measure this most abstract and ill-defined of concepts. Lu (2006) has proposed an index and this is the basis of a computer program which has been used to diagnose contractors' competitiveness and to place them in rank order of competitiveness. It is a system suitable only for Chinese general contractors according to Flanagan et al (2007). Similarly Sha, Yang and Song (2008) provide an index which is used to measure the competitiveness of the Chinese construction industry in various provinces.

All this work either provides a conceptual and theoretical basis for the consideration of competitiveness or provides an assessment of the magnitude of an individual unit's competitive strength at a single point in time. What this does not do however is suggest to firms how, if they are shown to be under-performing, they can improve their situation. There is a need to move on from understanding and measuring competitiveness to improving it. The research reported below is one small step towards making this advance.

A DYNAMIC MODEL FOR CONTRACTORS' OPERATIONS

If there is a desire to assess a firm's performance and, if deficient, to suggest how they might improve it, then one way forward is to design a model which reflects a competitive situation and allows performance of an individual constituent entity (a contracting firm in this case) to be changed by dint of changed policies. To this end a generic contractors' model has been formulated using the methodology of system dynamics (Sterman, 2000). The model incorporates three stylised general contracting firms, A-C, in competition (although any number of competitors could have been used). The methodology allows various resources to be modelled – materials, money, people – but, moreover, also considers the policies which govern the management of these resources which, in turn, determine the firm's competitive strength. The model, when run, dynamically traces out the performance of individual variables over a period of time. If a firm is under-performing then its 'competitors' can react and secure a further advantage.

The purpose of this study is to assess policy issues and highlight those which might result in a sustained performance, as opposed to policies which might predicate intermittent crises. The model does not purport to produce a 'forecast' of what might happen to a real-life construction firm, but rather is an instrument of learning – to suggest how some policies can lead to competitive benefits whilst others are deficient or capable of producing unexpected behaviour. The notional contracting firms are generic although their structure mimics typical firms in the industry and both that and the model's parameters have been determined through literature searches and interviews with industry executives. It is proposed to launch a questionnaire to selected industry members in order to further extend our knowledge on crucial parameter values. Although the firms in this model are generic, it would be perfectly possible to parameterise one of them to equate with a particular real-world contracting firm.

A High-level map

A representation of the overall view of the model in the form of a high-level map is depicted in figure 1. It shows that the typical contracting firm must manage human resources, money and materials. Its performance is affected by its competitor's actions but, aside from them, there are issues which affect a firm's reputation and which in turn have largely been determined by its own actions. These include control of project over-runs, late starts and financial shortfalls. These sort of issues affect a contracting firm's competitive position and thus its ability to win further contracts in the market place.

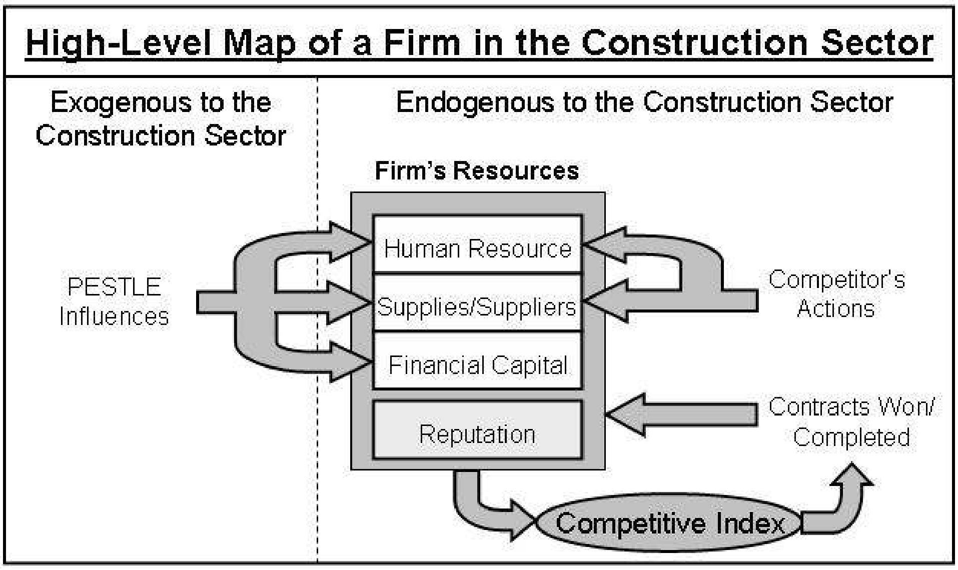


Figure 1: High-level map of a generic firm in the contractors' model

On top of the internal management issues there are exogenous influences which all the competing contracting firms have to face. These can have an impact on all of the firm's resources and range from Chinese economic development impacting on the world demand for construction steel through to governmental regulatory legislation directly targeted at the industry.

The Competitive Index

The factors affecting a contracting firm's reputation are handled in the model by the establishment of a competitive index. This is a means to embrace the range of factors which impact on competitiveness and implicitly recognises that the concept it is a multi-dimensional one. The references to Lu (2006) and Sha, Yang and Song (2008) in respect of the Chinese construction industry reveal that this is not a new idea. But whereas their index formulations are used on *ex post* construction industry data, ours is embedded in a dynamic model and so is continually being re-computed 'on the fly' as the simulation proceeds.

The design of our competitive index is as depicted in figure 2 for a single contracting firm. The spokes leading to the central ellipse are competitive factors (CF) each of which contribute to the calculation of the overall competitive index (CI) for that firm. The factors are each assigned weights (W). The spoke lengths are variable reflecting the strength of that factor at varying points in time. Lengthening of the spoke length may reflect an improved performance if the competitive factor was, say, revenue and a deteriorating performance if it reflected a late completion time on the contract. These spoke lengths can and do vary as the model simulation proceeds through time. The weights on the other hand will not: they reflect the relative importance of each competitive factor in the given market. This is emphasised by the diameter of the nodes representing the weights at the end of each spoke.

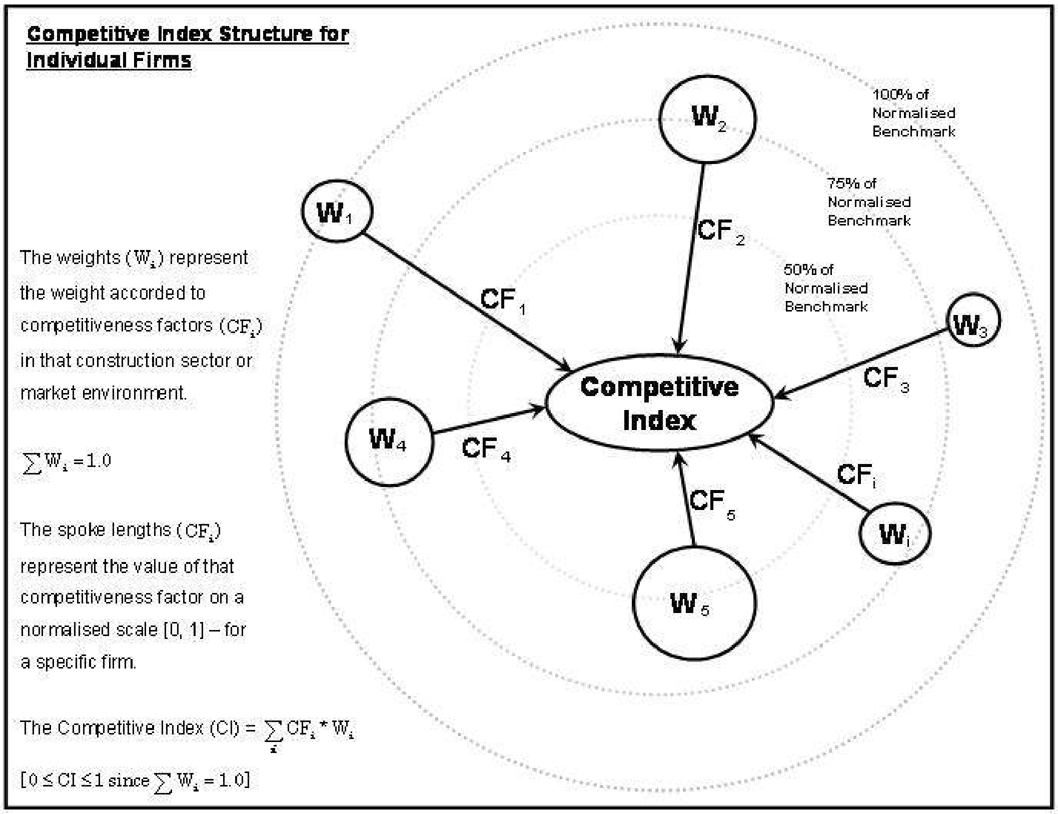


Figure 2: Diagrammatic representation of the competitive index as used in the model

The mathematics involved is highlighted in the figure. The weights are constrained to sum to 1.0 and the value of each competitive factor is normalised to a scale of 0-1. This is achieved by determining the best (largest or smallest as appropriate) of the three competing firm's values for a given CF and awarding this the value of 1.0. The other (two) values are then calculated as pro-rata values against the best value. This is the mechanism used by the World Bank to determine the competitiveness of different nations. It should be noted that this is not the same normalisation process as that adopted by Sha, Yang and Song (2008). Theirs ensures that the full range of the scale is used. Thus, under their method, one firm will always score 0 and another 1.0 on any given competitive factor.

Our method allows one to determine how far off the 'best' any given firm is for any given competitive factor. For instance, it can be seen that the hypothetical firm depicted scores the best for competitive factor 1 but is only at 75% of the normalised benchmark for CF's 2 and 4. It performs worst on CF 5 where it is at only 50% of the normalised benchmark and this performance might prove costly since CF 5 has the largest weight. All of this assumes that, for all CF's, largest is best.

The competitive index (CI) is the weighted sum of the individual weights times the normalised values of each competitive factor. It must result in a value in the range of 0 to 1.0 and is re-computed at every time step in the simulation. A firm will be awarded contracts in proportion to its CI value over the sum of all firms' CI values.

In this way its 'reputation' is fed back into its ability to secure future contracts. It should be understood that this means that if all of the firms have the same CI (whether that be, say, 0.33, 0.5. 0.6 or indeed 1.0) they will each receive the same share of the contracts on offer in the market: one-third in this case.

The sectors of the model

The model has three main sectors: contracts and work-in-progress; finance; and human resources. The first of these is shown in figure 3. Although there are assumed to be three competing firms in this market the diagrammatic representation is common: the differing firms are handled by an array facility in the software employed. The rectangles represent stocks (accumulations) whilst the valve symbols depict management control and thus the policy leverage points. Raising or lowering a flow affects the stock immediately before and/or after it. Two policy domains which are suggested by a consideration of figure 3 are, firstly, the allocation of contracts and whether to bid aggressively or take a measured view on future undertakings. Another obvious policy consideration surrounds the management of work-in-progress. Under-performance here will result in late contract completion – a major factor determining a contractor's reputation.

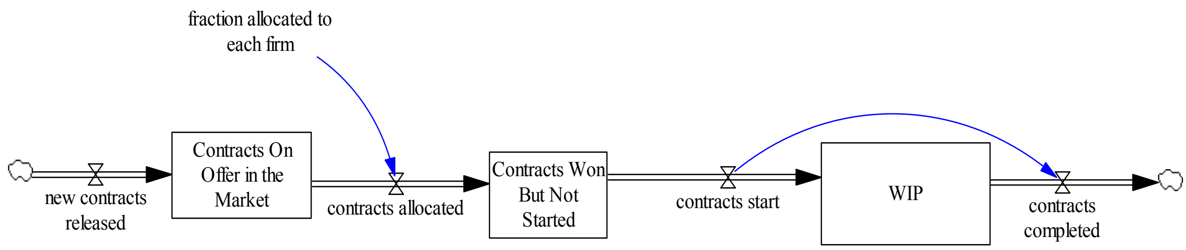


Figure 3: Flow diagram of the contracts and work-in-progress sector

The fraction of contracts allocated to each firm is, in a raw bidding process, determined by the competitive index as described above. Within the model the influences on this are as illustrated in figure 4. These number four: completion delay; start delay; financial factors; and workforce factors.

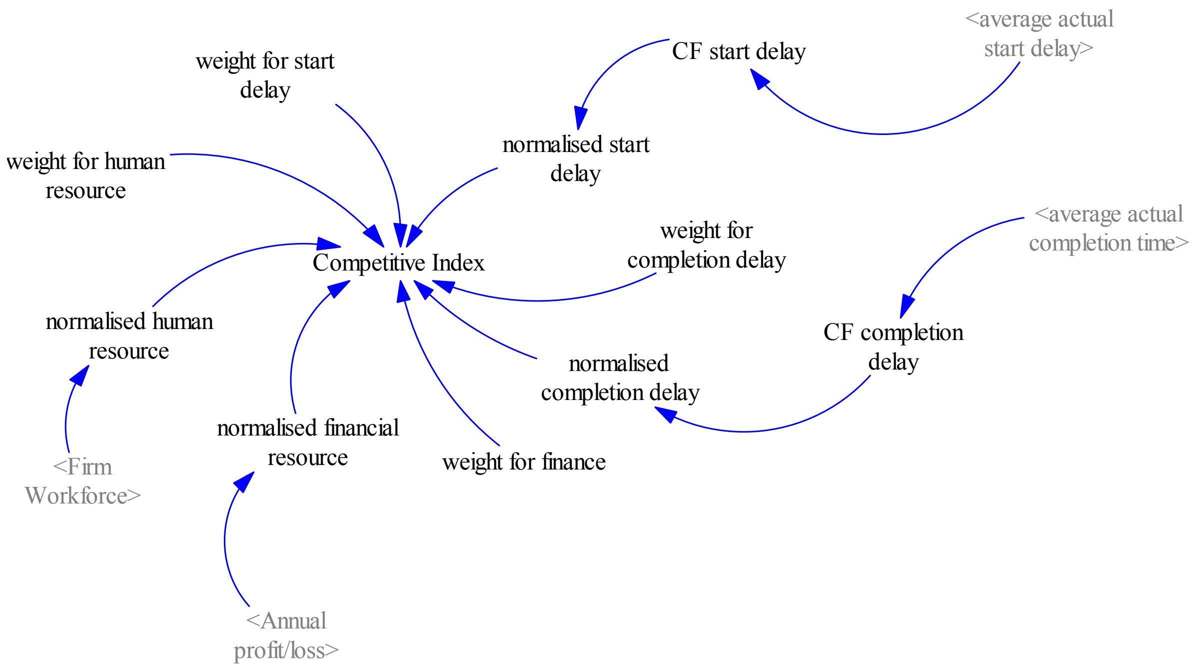


Figure 4: Influences on the competitive index in the model (Note: variables in angled brackets represent those computed in another model sector)

The remaining sectors consist of (i) finance and (ii) human resources including those employed directly by the firm and those sub-contracted. The financial sector is simply a revenue in : costs out arrangement, although fresh cumulations are made each year to mimic the normal annual financial reporting period. The simulations cover a period of 15 years and the fixed time step is one-eighth of a year. The parameter values currently adopted in the model are listed in table 1. Obviously these can be changed very easily, indeed a parameter change may form a component of a strategic policy experiment.

RESULTS FROM SPECIMEN SCENARIO RUNS

The research is a work-in-progress and so the following details some of the experiments which have been carried out to date.

Consider figure 5. Here the contracting firm A is arbitrarily given a temporary boost to its competitiveness at time t=3. Before this time the model is in equilibrium and so no dynamics are evident. The disturbance allows an assessment of the repercussions of a firm seemingly exceeding the short-term performance of its main competitors. Note that we are not trying to reproduce some real-world occurrence but rather provide a laboratory setting where strategic conclusions can be reached without resorting to a real-world experiment, the outcome of which might take many years to determine.

In figure 5 the success of firm A is evident: they have brought in more contracts in view of the arbitrary stimulus to their competitive index. However, this success does not last and a downturn is evident from around one year later. (Note that Firm B's plot is superimposed on

Table 1: Listing of Parameters in the model and their assumed values

Parameter Values

The following are the main parameter values in the model:

Delay in starting contract (normal)	1.5 years
Delay in completing contract (normal)	1 year
New contracts put on offer	50/yr
Hiring lag	1 year
Sub-contracting lag	3 months
Average number of employees on site (per contract)	50 people
Average revenue per contract p.a.	£4 million
Delay in receiving money	3 months
Delay in paying money	3 months
Average supply cost per contract p.a.	£0.5 million
Average cost per employee	£20,000 pa

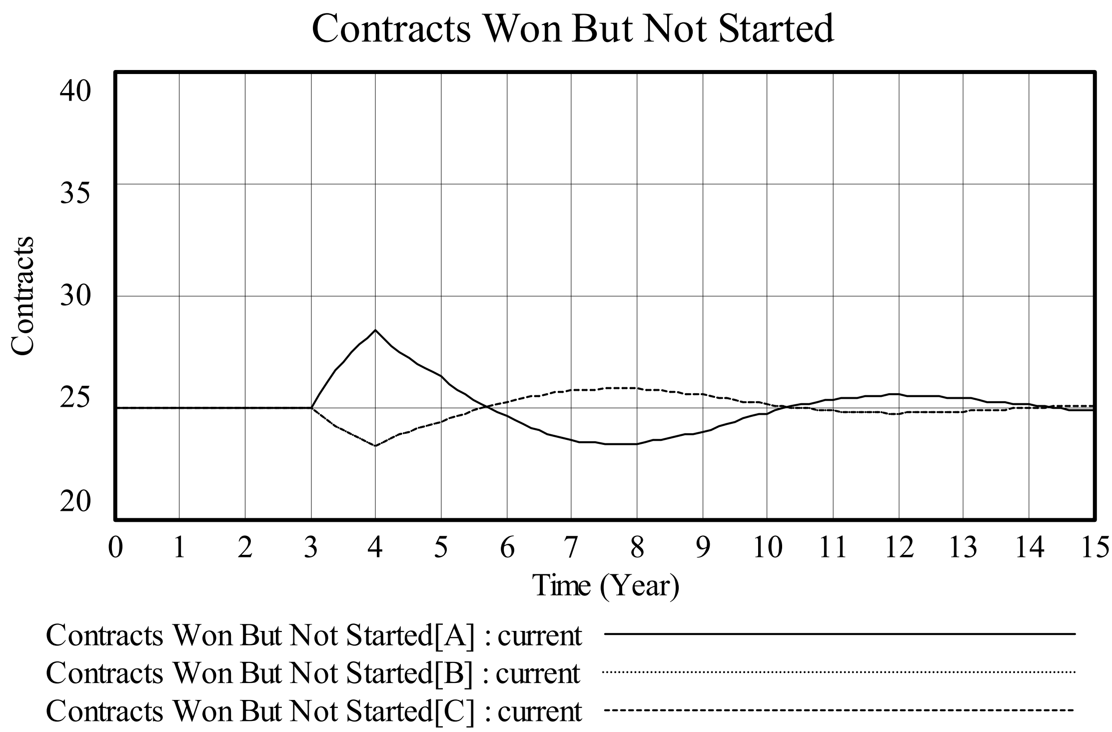


Figure 5: Effect of stimulus to Firm A on contracts won (NB 'Current' is the run name and is synonymous with 'Base Run')

that for Firm C since no differentiation is attempted between these two firms.) The reason for Firm A's superiority being merely transient is because it becomes overwhelmed by work-in-progress and the initial stimulus is reversed, primarily because of its poor performance in completing contracts (see figure 6). It hits its capacity limit. The strategic message has to be that capacity management is vital if a contracting firm is to experience sustained and not transient competitiveness. It is worth noting also that Firms B and C experience an upturn in contracts won over a four-year period from year 4 purely because Firm A has become uncompetitive (figure 5). These other firms have not been proactive but have simply benefited from A's poor policies on capacity. Surprisingly, their contract completions exceed those of A for the best part of three years (figure 6).

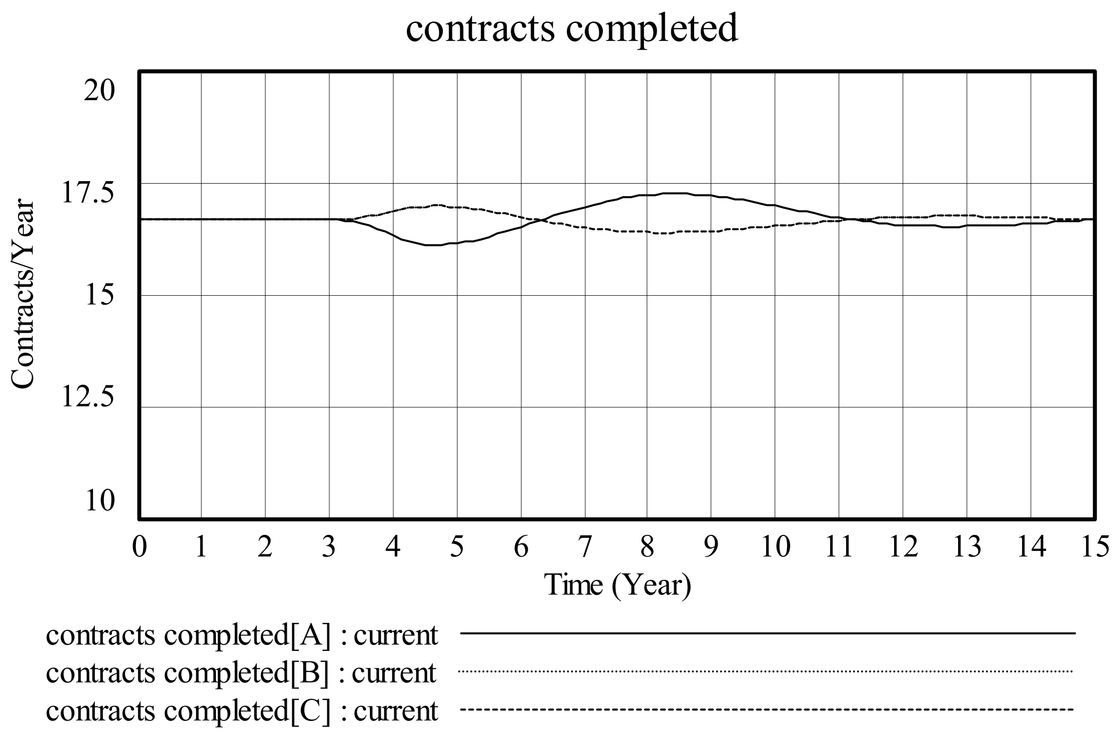


Figure 6: Reduced completions in years 3-6 by Firm A because of work-in-progress build up

CONCLUSIONS

Space prevents detailed discussion of further experiments which have been conducted with the existing model. For instance the strength of competitive behaviour (how avidly the firm pursues new contracts) has been shown to be a determinant of profitability. The more aggressive competitive behaviour produces the most severe oscillations in profits. A more measured approach produces oscillations which are much more attenuated. It is planned to assess the merits of frameworks as an approach to future contracting behaviour.

However, the over-riding conclusion is that the system dynamics methodology has been shown to be capable of providing a means to assess the forces which shape sustained competitiveness and, as such, it takes the assessment of strategic policy analysis in the construction sector onto a higher plane. The need to collect data and make retrospective assessments of competitiveness and strategic performance at the statistical level is not now the only *modus operandi* available. Models which capture the causative factors operating in the real-world and allow of easy experimentation offer a new paradigm for research on construction sector performance.

REFERENCES

Drew, D.S. and Skitmore, R.M. (1992) Competitiveness in bidding: a consultant's perspective. Construction Management and Economics, 10(3), 227-247.

Cockburn, I.M., Henderson, R.M., and Stern, S. (2000) Untangling the Origins of Competitive Advantage. Strategic Management Journal 21:(10-11), 1123-1145.

Flanagan, R., Lu, W., Shen, L., and Jewell, C. (2007) Competitiveness in Construction: a critical review of research. Construction Management and Economics, 25(9), 989-1000.

Lu, W.S. (2006) A system for assessing and communicating contractors' competitiveness. Unpublished PhD thesis, Department of Building and Real Estate, Hong Kong Polytechnic.

Male, S. and Stocks, R. (1991) Competitive Advantage in Construction. Butterworth-Heinemann, Surrey.

Porter, M.E. (1980) Competitive Strategy: Techniques for Analysing Industries and Competitors. Free Press, New York.

Sha, K., Yang, J., and Song, R. (2008) Competitiveness assessment system for China's construction industry. Building Research and Information, 36(1), 97-109.

Sterman, J.D. (2000) Business Dynamics. McGraw Hill, Boston.

REUSING BROWNFIELD SITES FOR HOUSING DEVELOPMENT IN THE UK

Karim Hadjri
Queen's University Belfast, Belfast, UK
k.hadjri@qub.ac.uk

Mohamed Osmani
Loughborough University, Loughborough, UK
m.osmani@lboro.ac.uk

Bousmaha Baiche
Oxford Brookes University, Oxford, UK
bbaiche@brookes.ac.uk

Re-use of brownfield sites in the UK presents particular challenges to national, regional and local policy makers. A significant proportion of brownfield land is a by-product of a past structural change within the economy and the decline of traditional industries. The paper reviews current UK government policies and industry practices for developing brownfield sites; assesses the viability of brownfield land for redevelopment; and examines the development of brownfield for housing by reviewing government targets and achievements. The results reveal that brownfield development programmes have been very encouraging due to attractive incentives broadly categorised under spatial planning, technical and financial support, and direct development. The paper concludes that the UK government has exceeded its targets and that as a result greenfield use for housing development has decreased considerably.

KEYWORDS: brownfields, greenfields, housing, UK.

INTRODUCTION

The term brownfield acquired political significance in the UK following the announcement in February 1998 by the government of a national target for England of 60% of all new housing developments to be built on brownfield land by 2008 (ODPM, 2000). In the UK, brownfield land can be either derelict or vacant (Syms, 1994; Urban Task Force 1999; Alker et al., 2000), although it has been argued that brownfield land must be capable of redevelopment in accordance with planning policies (Syms, 2001). In England, derelict land may be defined as land that has been so damaged by previous industrial or other development, that it is incapable of beneficial use without treatment (NLUD, 2000). There is currently no formal definition of the term "brownfield" and this has led to a misunderstanding of its usage i.e. viewed as a synonym for "contaminated" (Alker et al, 2000). The Joseph Rowntree Foundation (2001) pointed out that the term 'brownfield' relates to land with potential for redevelopment following current planning policies or urban renewal objectives. These brownfields can be developed regardless of whether or not they need treatment or are contaminated. The UK government has adopted the term Previously Developed Land (PDL) for use in land surveys and planning processes to avoid any misconceptions; and the term brownfields was used in 'Planning Policy Guidance Note 3: Housing' (DETR, 2000a).

Brownfield sites have also been defined as vacant, derelict, contaminated, partially occupied, or utilised with intervention. The meaning of intervention as action could include remediation, regeneration, infrastructure, planning regime, land assembly etc." (Alker et al, 2000). In November 2006, 'Planning Policy Statement 3: Housing' was published by the Department of Communities and Local Government - DCLG (NLUD, 2007, p. 51), and defined previously-developed land as a site "that is or was occupied by a permanent structure, including the curtilage of the developed land and any associated fixed surface infrastructure". Oliver et al. (2005, p.120) defined 'greenfield' as a land that has not been previously developed "which is often productive agricultural land, green space or important cultural-historical land.

This paper introduces brownfield sites as an issue with growing importance in the UK, and looks at how their development contributes to the sustainable construction agenda. It highlights how brownfield sites have come into fruition and what are the benefits and potential constraints for their development for housing in the UK.

VIABILITY OF BROWNFIELD LAND FOR REDEVELOPMENT

Brownfield sites present particular challenges to national, regional and local policy makers in terms of bringing them back into beneficial use. Most of contaminated land in England is a by-product of a past structural change within the economy and the decline of traditional industries. This is coupled with a severe loss of jobs and, as a direct consequence, the decline of the surrounding neighbourhoods. In this context, it is commonly recognised that underdeveloped brownfield land has adverse effects on not only the environment but also the economic and social health of a region (Ferber & Grimski, 2002). The social benefits to redevelopment of brownfield land are therefore valuable to the area as a whole in terms of urban regeneration. New homes, industries, services and infrastructure are likely to inject new life into what was a generally run down area.

The nature and character of brownfield land varies markedly in terms of its site characteristics and geographical location. Often the redevelopment of brownfield sites in urban centres can help make the best use of existing services and amenities, namely existing road infrastructure and public transport; and served by utilities such as electricity, water supply, sewer, telephone and natural gas. However, brownfield sites are often viewed as less attractive due to potentially high redevelopment costs. The potential 'extra' costs incurred vary dramatically from site to site depending on the nature of the cause. The cause of the additional costs could be due to contamination, existing foundations or other unforeseen ground conditions, land assembly, conservation and planning issues or infrastructure constraints. Therefore, not all brownfield sites are suitable for redevelopment since the cost of the 'abnormals' (commonly relate to contamination, land stability, site clearance etc.) outweigh the value of the end use making them uneconomically feasible developments (East of England Development Agency, 2005, p.49). This is illustrated in Figure 1, which compares the value inherent in a given use with the differing 'abnormals' involved in a range of brownfield sites at a given location. The upper horizontal line gives the value after development and the three columns represent the indicative costs involved in developing different sites for the same end use. The lower of the horizontal lines represents the value of soft end use developments such as amenity space, whereby the costs may be lower but the site is unlikely to achieve high value. Category1, which represents commercially attractive sites, are associated with development costs that are sufficiently below the value of the end use resulting in a commercial profit to the developer.

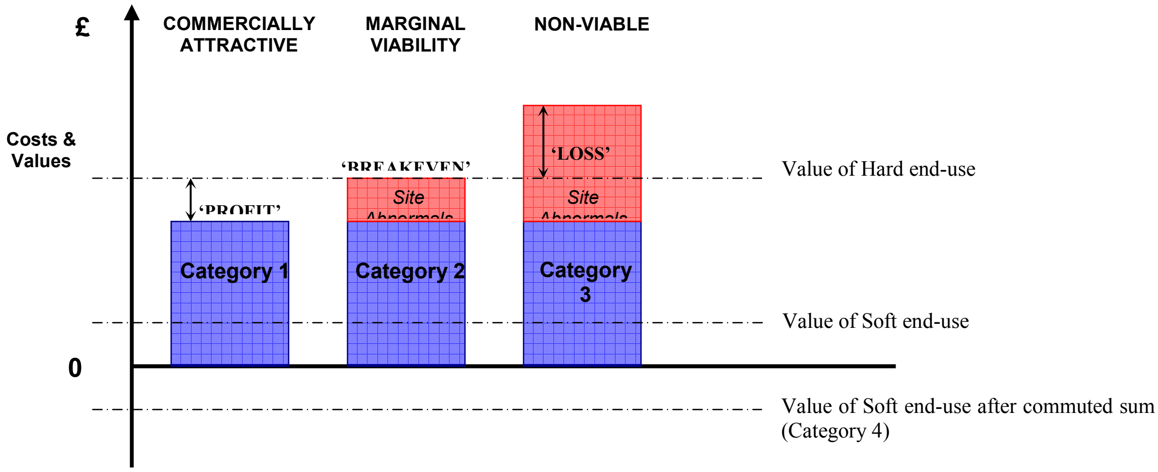


Figure 1: The Impact of Site 'Abnormals' on brownfield sites' redevelopment (Adapted from English Partnership, 2003a, p.12)

Category 2 indicates the real or perceived site abnormals that are sufficient to reduce the required profit margin of redeveloping the site. Hence, the sites are at best marginal, only achieving a breakeven situation between costs and profit. Market interventions may be required for these sites to make them attractive for commercial development. Category 3 brownfield sites erode the profit margin, as in Category 2, but additionally they exceed the anticipated value of the completed development. They are unlikely to be attractive to the developer unless the government aids the redevelopment or they could remain unused for significant periods. Non-viable sites are often referred to as 'hardcore sites' - land that have been vacant or derelict for 9 or more years - since the development constraints are generally more deep-seated and thus more expensive to resolve. (East of England Development Agency, 2005, p.9; English Partnership, 2003a, p.8)

The future development of a brownfield site may be deemed appropriate if it is for a soft end use such as open space, community woodland, or nature reserves (English Partnership, 2003a, p.14). In this case, development costs may be lower but they are unlikely to achieve high value as an end use. Furthermore, the site is likely to require long term maintenance after redevelopment, making the lifetime costs further erode end-use values. In extreme cases, the result can be a negative value, as shown by the bottom horizontal line in Figure 1; as such the private sector is unlikely to be interested in developing such a site. It is more likely that the benefits for such sites will rank under, ecological, environmental or safety reasons rather than financial return.

In examining the nature of the economic costs and risks involved in brownfield versus greenfield redevelopment, De Sousa (2000) pointed out that developers' perception for industrial brownfied development, which require vigorous policy and economic measures, led to the assumption that this was less cost-effective than its greenfield counterpart. On the other hand, he acknowledged that minor policy changes governing housing brownfied projects can increase profitability over similar greenfield residential developments. Saying that, current housing development practices suggest that greenfield sites are often cheaper and easier to require and develop (Breheny, 1997). This is mainly due to the lack of certainty about the funding on previously developed sites, concern over future legal liabilities (Banister, 1998), and reluctance by financial institutions to invest in unconventional developments (Cadman and Topping, 1995). To overcome the financial obstacles to brownfield land development, Oliver et al (2005) called for a combination of 'sticks', through taxation on greenfield development and 'carrots' through financial incentives such as tax relief.

POTENTIAL OF THE DEVELOPMENT OF BROWNFIELD SITES FOR HOUSING IN THE UK

One of the first steps taken by the UK government in identifying the potential for brownfield land was to fully assess the amount of previously used land in England. Brownfield sites in Wales and Scotland are recorded to a certain level, but for the purpose of this paper the figures for England are used to provide a more accurate overview of the brownfield supply. The National Land Use Database (NLUD) was first announced in February 1998. It is the most comprehensive survey of land use in the UK (NLUD, 2002). The primary purpose is to create a comprehensive record to assist in the identification of PDL. This includes land, which might be, or might become, available for new development using information on individual sites supplied by local authorities in England.

In 1985, the DOE reported that there were at least 10,000 ha of contaminated land in England. This situation presented "an actual or potential hazard to health or the environment as a result of current or previous use". However, it was not clear how much land could be developed for housing (Certa, 1998). It was estimated that there were 25,000 ha of vacant PDL and around 60,000 hectares of vacant land in urban areas in 1990 (The Urban and Economic Development Group, 1998); and 39,000 ha of derelict land in England in 1993 that needed significant treatment necessary for redevelopment viability (DOE, 1995). The NLUD (2007) reported that in 2006 there were an estimated 62,700 hectares of PDL in England, compared with 63,500 hectares in 2005; of which an estimated 55 per cent of the total that is 34,900 hectares of PDL was vacant or derelict. The remaining 27,900 hectares were in use but with potential for redevelopment. The NLUD (2007) went further by forwarding a breakdown of the 2006 total PDL in England:

- '13,330 hectares of vacant land, that is land that has been cleared and may be available for development;
- 17,850 hectares of derelict land and buildings requiring treatment before development;
- 3,670 hectares of buildings that had been vacant for 12 months or more;
- 18,430 hectares of land currently in use with planning permission or allocated for redevelopment in a local plan;
- 9,450 hectares of land currently in use with known potential for redevelopment but no planning permission or allocation in a local plan;
- 26,750 hectares of PDL assessed by local authorities as suitable for housing; and
- land assessed as suitable for housing could potentially accommodate 974,000 dwellings.'

The supply of brownfield land throughout England is relatively diverse, which will ultimately affect whether the demand can be met for the different regions. Besides, market demand factors hinder development in some regions. The demand in the North is generally lower than in the South, therefore affecting the attractiveness for development of some sites in the Northern regions. Two key growth regions are London and the South East (NLUD, 2007). The supply of land in these two regions is quite different; however, planning authorities usually cater for this by restricting development densities, i.e. higher number of houses per hectare for areas of high demand with low supply. During the period 2001 to 2006, the total of PDL declined by about 4 per cent. Derelict and vacant land was down by 15 per cent in 2006 compared with 2001, while land in use with potential for redevelopment increased by around 14 per cent. The amount of all PDL assessed as suitable for housing was about 5 per cent lower than in 2001; however the estimated housing capacity has increased by 6 per cent. (NLUD, 2007)

Government Target for the Development of Brownfield Sites for Housing

In 1995, the Conservative government announced that it wished to see half of all new homes in England built on reused sites (DOE, 1995). The current Labour government insisted that a more ambitious commitment by setting a target to build 60 per cent of additional mixed used housing developments on PDL and through conversion of existing buildings (DETR, 2000a). As such, Higgins and Karski (2000) and Thompson-Fawcett (2000) argued that it is apparent that the integrated development of brownfield sites for large mixed use developments can offer significant advantages for both the occupier and the developer, over the sporadic development on a number of smaller unrelated brownfield sites. However, not all brownfield sites are of a large enough size to allow the establishment of mixed-use developments and to provide and promote further development within the surrounding area. Development upon smaller sites may have to rely on the quality of existing services to achieve success. In order to deliver White Paper's objectives it essential that efforts must be co-ordinated at all levels: national, regional and local.

Restrictions on greenfield sites and the inherent problems of previously used land have brought an awareness of the need for a structured approach to deliver efficient use of brownfield land for housing. In 1998, the Urban Task Force (UTF) examined the causes of urban decline and recommended measures to bring people back into towns and cities (Urban Task Force, 1998). The Task Force included representatives of a range of organisations with an interest in urban regeneration and the report 'Towards an Urban Renaissance', made over 100 detailed recommendations for future action. These covered design, transport, management, regeneration, skills, planning and investment issues. One of the recommendations of the report was that new urban developments must be designed to much higher standards if they are to attract people back into towns and cities. It went further to state that urban developments should integrate with their surroundings and optimize access to public transport. The UTF reported that the 'best way' to enforce this is to discriminate the use of private cars and restrict parking spaces to just one space per new dwelling. However, house builders are concerned that in small towns the restrictions on car parking spaces will make any development unsellable (Chevin, 2000).

The UK government responded to the UTF's recommendations in the Urban White Paper: 'Our Towns and Cities: the Future' in November 2000 (ODPM, 2006, p.38). The White Paper recognised the effects of people moving out of urban areas and the changing trends of society and the importance of bringing brownfield sites within urban areas back into productive use. The following issues provide a summary of the Urban White Paper's thematic views:

1. *People shaping the future* of their community, and supported by strong and truly representative local leaders.
2. People living in *attractive, well-kept towns and cities* which use space and buildings well. It was suggested to revise the tax and planning systems to bring brownfield sites and empty property back into constructive use.

3. There was a call for good design and planning, which makes it practical to live in a *more environmentally sustainable* way, with less noise, pollution and traffic congestion.
4. Towns and cities ability to *create and share prosperity*, investing to help all their citizens reach their full potential. A particular focus will be on less prosperous areas to promote education and training facilities through various enterprises.
5. *Good quality services* – health, education, housing, transport, finance, shopping, leisure and protection from crime – that meet the needs of people and businesses wherever they are.

The suggestions made by the Urban White Paper have led to the introduction of Millennium Villages such as the Greenwich Peninsula.

Figure 2 shows that the total number of dwellings completed on brownfield sites between 1996 and 2006 (2006 being provisional). It can be seen that the number of dwellings built between 1997 and 2001 was comparatively stable. However, there has been a noticeable increase in brownfield developments since 2001, with a decrease of development on greenfield. (Dixon, 2006; ODPM, 2005a; Department for Communities and Local Government, 2008)

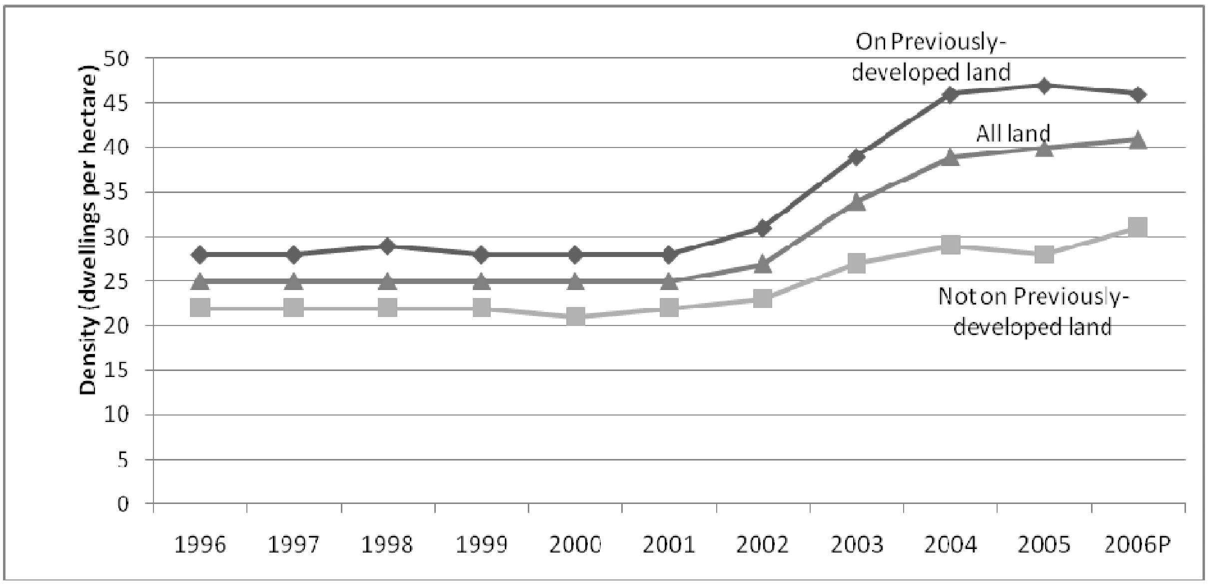


Figure 2: Dwellings built on brownfield land in England (Adapted from Department for Communities and Local Government, 2008, p.7)

The noticeable increase in developments on brownfields and consequent decrease of similar developments on greenfields are therefore very encouraging aspects of contemporary UK urban growth particularly for housing provision.

PROGRAMMES AND INCENTIVES TO SUPPORT BROWNFIELD REGENERATION IN THE UK

The redevelopment of brownfield sites in the UK is at present led largely by the private sector. The government bodies have very little direct involvement with developers, other than as "regulators", issuing and enforcing approvals and legal permissions. There are however specific programmes to support and encourage the development of brownfield sites. These programmes can be split up into four main categories: Spatial Planning, Technical Support, Financial Support, Direct Development (Denner & Lowe, 1999).

Spatial Planning

The current system of town and country planning promotes brownfield development but inhibits or restricts development upon greenfield sites. The system is responsible for identifying existing brownfield sites and making the land available for development. This is largely brought about by the planning policies set at national, regional and local levels with decisions made on the basis of the local circumstances. Additionally, councils are also sometimes reluctant to release previously used land for residential purposes (Chevin, 2000). This suggests that the complexity of the planning system and the number of objectives that planners have to adhere to could be a concern to potential developers. Research has shown that redevelopment could be accelerated by a more fine grained and participatory planning approach (Adams & Disberry, 2002). The decisions made regarding allocation of new housing development upon greenfield sites are subject to the results of a 'sequential test' (DETR, 2000b), whereby the local authority has to satisfy that there are no other suitable or available brownfield sites. Planning decisions on brownfield land are subject to assessment by the local planning authorities, and should follow the development plan. (Ferber & Grimski, 2002, p.110)

Technical Support

The technical support takes the form of both pro-active and re-active sides. With regard to the pro-active side, the national government and other private sector led groups fund research and development of 'best practice' advice to assist in the development of brownfield sites. On the re-active side the focus is upon addressing factors which might hinder brownfield development, which comes in the form of research and development of new remediation techniques for contaminated land. This is an area of improvement for brownfield development since contamination is one of the major physical characteristics that may prove to be an obstacle to the re-use of PDL (Joseph Rowntree Foundation, 2001). The re-active approach can also include confidence building initiatives with the financial and property sectors. The process of brownfield development involves a major aspect of risk due to its inherent problems, so these programmes help to build awareness with potential developers and financers to increase their knowledge of brownfield development. Programmes setting out a system of liability for contaminated land and reviewing the licensing system for land remediation activities are beneficial. These types of programmes review current procedures and form new standardized approaches to brownfield revitalization.

Financial Support

Direct public sector financial support is applicable to sites deemed necessary for redevelopment to achieve the social and economic policy objectives, which is provided in the form of grant aid or gap funding. The housing gap funding scheme is the investment tool available to the public sector to enable it to support regeneration and housing supply. The scheme enables Local Authorities, Regional Development Agencies (RDAs), the Welsh Development Agency, Scottish Enterprise and agencies such as English Partnerships to provide grants to private developers and housing associations for housing-led development (English Partnerships, 2003b). In recent years, there has been a reduction in government funding for private sector schemes due to legal problems regarding the EU competition policy (Ferber & Grimski, 2002, p.111). As such, projects requiring government funding have to have approval in advance with the EU Commission, placing strict limitations on the amount of support for private sector housing development. As a result, the 2000 Urban White Paper recommended that the UK government should investigate new fiscal instruments, such as reductions in stamp duty in areas of economic depravity and tax credits for cleaning up contaminated land. These financial measures would help housing developers to offset the costs of remediation against the profits on which they pay Corporation Tax, and in some cases, this is claimed as 'tax credit'. (Ferber & Grimski, 2002, p.112)

Direct Development

Local authorities and public sector regeneration agencies may also carry out 'direct development' projects (Ferber & Grimski, 2002, p.112). This can be in a variety of ways from fully worked up developments to simpler site clearance projects. 'Development platforms' are particularly helpful in the re-use of the less viable sites ('hardcore' sites) since they provide the developer with an incentive to select the site for redevelopment. Public sector involvement also includes providing roads and other infrastructure on or near the redevelopment area. New development initiatives particularly those considering sustainable design are greatly encouraged by the government. For example, test sites for new products have been built on brownfield sites in Salford (Persimmon Homes). Likewise, the Peabody Trust is actively redeveloping brownfield sites in London areas into mixed use developments and housing.

DISCUSSION

Provisional estimates show that the UK government has exceeded its target of 60 per cent of all new developments to be built on brownfield land in some areas. In England, the rate of development on brownfield land increased from 56 per cent in 1997 to 67 per cent in 2003. Moreover, in order to protect the green belt, proposals have been announced for stricter controls on housing densities particularly in areas where there is high housing demand (ODPM, 2005a). Nonetheless, urban brownfields should be carefully regenerated in order not" to become commodified spaces whose value is defined primarily in monetarist or functional terms" (Raco, 2006, p.510). This is acknowledged by the government, arguing that new development should have" high quality and inclusive design", avoids segregation, and brings people together. In so doing, urban spaces can be created that realistically" respond to their local context and create or reinforce local distinctiveness" (ODPM, 2005b, p.14-15). The UK government argues that the target of 60 per cent of new development to be built on brownfield land has been achieved in many areas in England. This was partially driven by a number of funding schemes, although none of these were specifically related to brownfield sites *per se*, but rather to retention and refurbishment of existing buildings. Nevertheless, developers appear to be encouraged to demolish rather than preserve and reuse, which is mainly due to all the remediation issues likely to be involved in brownfields.

CONCLUSIONS

It is evident that the redevelopment of brownfield sites is a fundamental part of the current housing development programmes in the UK. The government has put in place mechanisms and incentives to encourage the re-use of formerly developed land over the use of greenfield land in order to meet the UK housing supply. Additionally, the development of brownfield sites makes a significant contribution to the regeneration and rejuvenation of depraved and run-down areas in the process. Although many housing developers feel that brownfield land presents significantly more difficulties over greenfield land, they are supporting the government's aspirations by developing brownfield land wherever possible. There are however, a number of issues that lie within the brownfield development process, which are restricting the ability of developers to help the government to meet the housing demand. There are no specific 'hard' barriers, which are impeding the development of brownfield land. On the other hand, the 'soft' barriers, such as planning permission hurdles represent constraints for the developers to achieve successful development in an efficient manner. The main constraints come in the form of *planning, financial,* and *physical site condition* issues; in addition to concerns regarding ownership of brownfield land as well as technical and real or perceived difficulties. Brownfield redevelopment are however, still held back by the uncertainty over the eventual cost of a project due to unforeseen circumstances, namely 'abnormals'. A significant number of developers feel that potential buyers often view brownfield sites as less attractive with poor quality and value of the land, due to real or perceived previous contamination.

REFERENCES

Adams, D & Disberry, A (2002) Vacant Urban Land: Exploring Ownerships Strategies and Actions, Town Planning Review, 73 (4), Oct. 2002, 395-416.

Alker, S, Barrett, P, Clayton & Jones, P (2000) Delivering Regeneration: A Brownfield Renaissance - Reporting the findings of the National Brownfield Sites Project, Urban Mines Limited, Halifax, 2000.

Banister D (1998) Barriers to the implementation of urban sustainability. International Journal of Environment and Pollution, 10 (1), 65-83.

Breheny M (1997) Urban compaction: feasible or acceptable? Cities, 14 (4), 209-217.

Cadman D & Topping R (1995) Property Development. Spoon, London.

Certa (1998) SUCCESSFULLY DEVELOPING BROWNFIELDS SITES THE ENVIRONMENTAL IMPERATIVE FOR MEETING FUTURE HOUSING NEEDS. Memorandum by Certa (UK) Ltd (H60). Select Committee on Environment, Transport and Regional Affairs, Tenth Report, 22 July 1998, H187, available at: http://www.parliament.the-stationery-office.co.uk/pa/cm199798/cmselect/cmenvtra/495/49555.htm (23/04/2008)

Chevin, D, (2000) The Battle For Brownfield, Building Magazine, 265 (27), 7th July 2000, 18-22.

De Sousa, C (2000) Brownfield Redevelopment versus Greenfield Development: A Private Sector Perspective on the Costs and Risks Associated with Brownfield Redevelopment in the Greater Toronto Area. Journal of Environmental Planning and Management, 43, PART 6, 831-854.

Denner & Lowe (1999) Effective regeneration of Brownfield Land in the United Kingdom, paper presented at seminar on Brownfield Regeneration in Duisberg, Germany 1999.

Department for Communities and Local Government (2008) Land Use Change in England: Residential Development to 2006, Update - January 2008. ODPM, London.

DETR (2000a) Planning Policy Guidance 3 (revised): Housing, The Stationery Office, London.

DETR (2000b) Modernising Local Government, The Stationery Office, London

Dixon, T. (2006) An analysis of the UK development industry's role in brownfield regeneration. Journal of property investment & finance, 24 (6), p.521 -541.

DOE (1995) Our Future Homes: Opportunities, Choice, Responsibility, Cm 2901, HMSO, London.

East of England Development Agency (2005) Brownfield Land Action Plan. Final Report, April 2005.

English Partnerships (2003b) Beta Housing Gap Funding Scheme Discussion Paper, by English Partnerships, July 2003.

English Partnerships, (2003a) Towards a National Brownfield Strategy, research findings for the Deputy Prime Minister by English Partnerships, September 2003.

Ferber, U & Grimski, D (2002) Brownfields and Redevelopment of Urban Areas, on behalf of CLARINET 2002, published by Austrian Federal Environment Agency.

Higgins, M & Karski, A (2000) The built environment and design in: An Introduction to Planning Practice, John Wiley, London, 2000, 247-284.

Joseph Rowntree Foundation (2001) Obstacles to the Release of Brownfield Sites for Redevelopment, Joseph Rowntree Foundation, York, May 2001.

NLUD (2000) Final Estimates of Previously Developed Land in England: 1998, Department of the Environment, Transport and the Regions, London.

NLUD (2002) Statistical Release 2002, Land use survey for England, 2002, available at: http://www.nlud.org.uk/ (20/04/2008).

NLUD (2007) Previously-Developed land that may be available for Development: England 2006. Results from the National Land Use Database of Previously-Developed Land. Department of Communities and Local Government, London. June.

ODPM - Office of the Deputy Prime Minister (2006) Our towns and cities: the future. Full report. May.

Office of the Deputy Prime Minister (ODPM) (2000) Planning Policy Guidance (PPG) Note 3: Housing. March.

Office of the Deputy Prime Minister (ODPM) (2005a) Land Use Change in England: Residential Development to 2004 (LUCS-20), ODPM, London.

Office of the Deputy Prime Minister (ODPM) (2005b) Planning Policy Statement 1: Delivering Sustainable Development, ODPM, London.

Oliver, L., Ferber, U., Grimski, D., Millar, K. and Nathanail, P. Oliver, L., Millar, K., Grimski, D., Ferber, U. and Nathanail, P. (eds) (2005) The Scale and Nature of European Brownfields. *CABERNET. Proceedings of CABERNET 2005: The International Conference on Managing Urban Land* pp. 274-281. Land Quality Press, Nottingham.

Raco, M. (2006) Sustainable urban planning and the brownfield development process in the United Kingdom: Lessons from the Thames Gateway Source, Local Environment, 11 (5), 499 -513.

Syms, P. (1994) The Funding of Developments on Derelict and Contaminated Sites, in: Industrial Property: Policy and Economic Development (eds. R.Ball and A.C. Pratt), Routledge, London.

Syms, P. (2001) Releasing Brownfields, RICS Foundation, London.

The Urban and Economic Development Group (1998) HOUSING ENQUIRY. Memorandum by UEDG, Select Committee on Environment, Transport and Regional Affairs, Tenth Report, 22 July 1998, H187, available at: http://www.parliament.the-stationery-office.co.uk/pa/cm199798/cmselect/cmenvtra/495/495165.htm (23/04/2008)

Thompson-Fawcett, M, (2000) The contribution of urban villages to sustainable development in: Achieving Sustainable Urban Form, E&F.N. Spon, London, p.53-65.

Urban Task Force (1999) Towards an Urban Renaissance, E & FN Spon, London.

ICT SUPPORTED COST MANAGEMENT FOR SUSTAINABLE CONSTRUCTION: A HANDS-ON APPROACH

Wilfred M. Matipa [BSc, MSc, PhD, MCIOB, MAACE]
Department of Built Environment, Faculty of Technology & Environment, Liverpool John Moores University, Liverpool, Merseyside, UK
W.M.Matipa@ljmu.ac.uk

Denis Kelliher [BE, PhD, CEng, MIEI]
Department of Civil & Environmental Engineering, Informatics Research Unit in Sustainable Engineering [IRUSE], National University of Ireland Cork, Cork City, Ireland

Marcus Keane [BE, PhD, MIEI]
Department of Mechanical and Biomedical Engineering, National University of Ireland Galway, Galway, Ireland

The relevance and application of sustainability in the built environment is being implemented in a number of ways. Notable amongst them is the sourcing of renewable energy, reduction in the consumption, use, and or conservation of energy. The other important aspect is the design and specification of materials and components that embody sustainability from inception to decommission, if not disposal. In a nutshell, to achieve sustainable construction, there is a need for a critical analysis of every designed component and or system with a view to determining the possible whole life cycle cost, weighed against the anticipated market value of the facility before it is delivered on the market. Quantity Surveyors have got to deploy available Information and Communication Technology (ICT) systems to demonstrate the cost implications of implementing sustainable or green building elements of the designed product. This research demonstrates a case for the better deployment of Industry Foundation Classes (IFC) driven Building Information Models (BIM) in the analysis and appraisal of the level of sustainable components used in a constructed facility. It concludes that there is an untapped potential on the overall cost management of constructed facilities that is centered on building information models.

KEYWORDS: Cost Management, Information & Communication Technology, Industry Foundation Classes (IFCs), Sustainable Construction

INTRODUCTION

The Department of Trade and Industry (DTI-UK) once stated that "the future of our planet depends on our willingness to act now to ensure that as we build to improve the quality of life today we do not compromise the quality of life for future generations" (DTI, 2006). Most government policies and private initiative relevant to sustainable construction are aimed at increasing awareness of sustainability in the context of construction (DTI, 2006). Amongst the key areas for concern are sustainable consumption and production; climate change and energy; natural resource protection and environmental enhancement; and sustainable communities (ibid). Meaning buildings should to be designed to specifically reduce people's impact on the planet (QSWeek, 2008a). For example, Earthship – (a sustainability inclined high profile project of Brighton in the UK) combines the sun's energy with the thermal mass of the building's walls to heat and cool the interior while solar energy generates electricity (ibid). Rainwater is harvested and the building has systems in place to treat domestic waste (ibid). Even the very walls are eco-friendly being made of discarded tyres and other rubbish (ibid). Despite these fine credentials Earthship has a fundamental flaw – *they're not cheap to build*. They take up a relatively large plot of building land and low-energy materials can be costly and awkward to source (QSWeek, 2008a). Such projects require a high level of engineering analysis before implementation. "Engineers" and engineering – or more generally, the "application of scientific principles and techniques" are most often responsible for creating functional thing (Hollmann, 2006). However, engineering has multiple dimensions, and the most obvious is the dimension of physical design and the calculation and analysis tasks done to support that design (ibid). Beyond the physical dimension of design, there are other dimensions of money, time, and other resources that are invested in the creation of the designed asset (Hollmann, 2006) – *generally referred to as cost*.

Studies have indicated that a lot of time is spent during preconstruction to resolve project problems and constraints on paper; but that there is an excellent return on the investment of hours, money, and thought received; in savings; in the field-savings; in the costs of losses in labour and equipment productivity; rework, and so on (Kraus, 2008). No significant asset has ever been built without dealing with these cost dimensions in some way, and the more systematically and professionally these dimensions are addressed, the more successful the asset performance is likely to be; meaning cost is a necessary extension of traditional engineering, and that there is an intimate connection between the physical and cost dimensions of the asset (Hollmann, 2006). However, the speed with which cost options could be evaluated using 'what if' analyses is slower if ICT capabilities are not deployed. This research demonstrates a case for the better deployment of Industry Foundation Classes (IFC) driven Building Information Models (BIM) in the analysis and appraisal of the level of sustainable components used in a constructed facility.

RESEARCH METHODOLOGY AND PROCEDURE

To compile the research information, primary data was sourced from case studies carried out by Davis Langdon an international cost consultant firm. The data has been made public since 2005, and keeps being updated. This data was augmented by the more recent cost data published by QS

Week web page (www.qsweek.com). Secondary data was sourced from literature review on sustainable construction and how it is being implemented. Being a discussion paper, it was important to view current trends on the market using information from the industry.

SUSTAINABILITY AND THE PHYSICAL DESIGN – CAD MODELING

Products that represent a significant amount of investment – *such as construction* – require a successful implementation of the concept of lifecycle management for all the activities. This arises from the need to fulfill the customer and the community demand throughout the whole lifecycle of a product from initial conception through to final disposal (Mo and Zhou, 2003). Most government policies and private initiatives relevant to sustainable construction are aimed at increasing awareness of sustainability in the context of construction (DTI, 2006). For example, on the energy performance of buildings, designers should aim at: (a) Reducing the absolute demand for heating by improving energy efficiency; (b) Making more use of combined heat and power systems, and; (c) Increasing the proportion of heat generated through less carbon intensive technologies (DTI, 2007). Conservation of fuel and power as stipulated in Part-L of the building regulations sets energy efficiency rules that apply to the construction of new buildings, and to certain works associated with extending, altering and changing the use of existing buildings (BRE, 2006; Monbiot, 2006). Part L does not specify what materials and or equipment should be used in buildings to make them energy efficient; however, it does specify levels of required performance, giving designers and developers the flexibility and free reign to select innovative and cost effective solutions (Construction Manager, 2008a). To this effect, it has been observed that wholesale implementation of new technologies and systems bring considerable risk; where poor design and lack of understanding of new technologies and systems are central, the product users are the ones to pick up the cost (Farookhi, 2008). It could therefore be argued that for the construction industry to fully implement sustainable construction there is a greater need for collaborative working; hence support higher levels of 'interdisciplinarity' where participants are empowered to explore and negotiate meaning and generate conjecture (Garner and Mann, 2003).

Traditionally, construction projects are defined by numerous documents, among which there may be overlap and inconsistency. Different project participants maintain these documents separately, and inconsistencies are typically discovered only in the field – when trades-people working with different documents interact (Cyon, 2003). As a result data is re-entered in new and different formats, data is lost or corrupted, vital information is omitted or not fully exploited (IAI, 2003; Froese, 2003). This manual data re-interpretation and entry is a non-value adding activity; can often introduce errors into the project; and inhibits the use of better computational tools (Tarandi, 2003).

THE ROLE OF IFC DRIVEN BUILDING INFORMATION MODELS

There are several suggestions for data integration and software interoperability: some are web-based, such as WISPER (Faraj *et al*, 2000), and SABLE (Hietanen, 2004; Cheng *et al*, 2002; Plume and Mitchell, 2007). Others are stand-alone solutions such as project data repositories. Whatever the strategy, research shows that the ISO-STEP (International Standards Organisation – Standard for the Exchange of Product model data) has been a leading international effort in developing the construction industry standards in software interoperability (Turkaslan-Bulbul and Akin, 2006; Tolman, 1999; Plume and Mitchell, 2007). Using the model schema developed in EXPRESS modelling language, in accordance with the ISO-STEP, by the International Alliance for Interoperability (IAI), a software developer could use Industry Foundation Classes (IFCs) as building blocks for software development; hence enabling software interoperability (Plume and Mitchell, 2007; Fu *et al*, 2006). By definition, a building information model (BIM) is a digital information structure of the objects making up a building, capturing the form, behaviour and relations of the parts and assemblies within a building (Eastman, 1999). It is the data used in a construction project or *a computer interpretable description of a building, structured according to some building product data model* (Koivu, 2002).

The key driver to the creation and use of product data has always been the physical design or CAD modeling. Traditional 2D drafting packages have served the industry reliably; but have not been interoperable with other software on the construction market. Newer CAD modeling systems have been developed that can allow software interoperability by working through a standard file format called industry foundation classes (IFC) file. They are not just a 2D drafting package; the model one creates drive the documentation output, rather than having to create individual drawings (DDS, 2008). From the model it is possible to create multiple “views” which form the exported drawings, schematics, schedules, visualisations and bills of quantity (ibid). For example, the DDS-CAD Viewer allows you to open IFC files(as well as DDS-CAD file, DWG and DXF) to view the model in 2D or 3D on screen, and navigage through the model (ibid), as shown in Figure 1.

Cost Management Using IFC Driven Building Information Models: Hands On

Such technologies (as shown in Figure 1) are of great importance to the Quantity Surveyor because they to not only automate the creation of quantities, but also increase the speed with which the analysis of alternative options could be explored, hence reducing on the eventual design costs, as well as optimising whole life costs of components that could be incorporated in the design so as to achieve high levels of sustainability. In reality achieving sustainability requires a deeper understanding of how mechanical, electrical, instrumentation, heating; air conditioning and ventilation have been designed and incorporated in the overall scheme so as not to disport the aesthetic values as well as market values of the proposed development. To a large extent, the cost manager would have to deal with complex financial analysis of key components so as to determine the best options available to all parties without jeorpardising the profitability of the scheme. Take for instance the demands of the Code for Sustainable Housing (CfSH) of the UK, The Royal Institution of Chartered Surveyors have already observed that given the short timescale of typical new-build projects, commercial developers would be unlikely to welcome the CfSH, because it could add significant costs to new-builds without increasing their value, at a time when the sector was facing a significant dip in demand (QSWeek News, 2008). Research shows that 40% of energy consumption in the UK goes to heating and lighting buildings (Williams and Mackechnie, 2008); at the same time, energy costs are rising year on year (Tinsley, 2008). How we minimise the use of energy will have a great impact on building design and very importantly, how seriously we take determining the thermal performance of the products and design features used on buildings (ibid). The selection of the correct materials and innovation of new products will be essential. This means that the measurement has to be made taking into account of all the factors (Williams and Mackechnie, 2008). The key to success is simply to ensure that sustainability is designed in right from the start and to utilise the most appropriate and efficient renewable energy systems in order to keep a development's financial outlay to a minimum (Tucker, 2008).

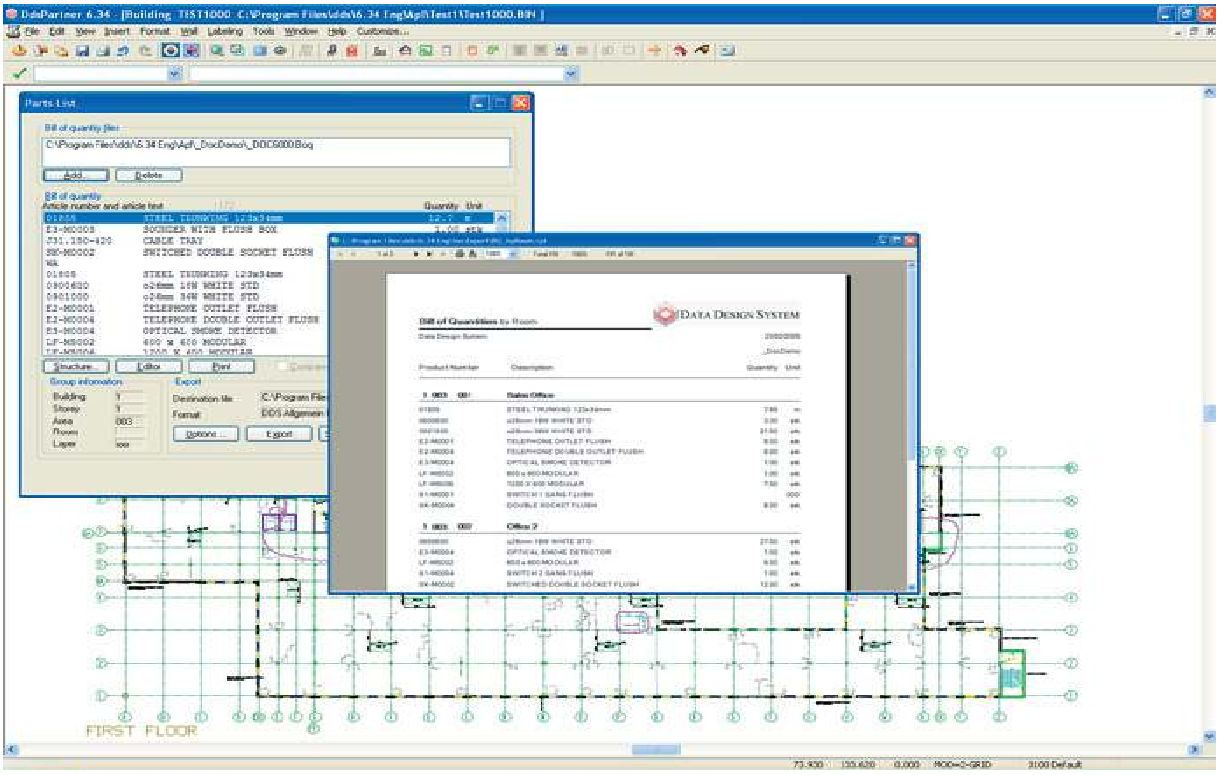


Figure 1: IFC Viewer – For Mechanical, Instrumentation and Electrical Design (Source: DDS-CAD Electrical, 2008)

In short, there are two simple areas that developers should focus on when looking to deliver environmental efficiencies; passive design and cost effective renewable energy sources (ibid). Passive design doesn't however simply focus on thermal efficiency; it also incorporates other simple cost effective design solutions such as the need for a reduction in water usage. This means that an opportunity exists to utilise cost effective renewable energy sources such as ground source heat pumps or thermal solar water systems to pre heat the water in a house, leading to greater energy and carbon emission savings. Another option for developers to consider in meeting the requirements of the CfSH is in the application of biomass fuelled boilers and air source heat pumps (Construction Manager, 2008b). Initial and or detailed financial analysis will have to commence from the national base-rate, as well as the predetermined desired return on the investment. The amounts involved will then have to be categorised into: (1) Single (one-off) payment at present amount (P) or future amount (F) for the determined time period (n), and a predetermined rate of interest (*i*) using equation 1, or the reciprocal of it depending on the use (2)

Uniform amounts to be paid per time period, usually referred to as annuity (A) or saved for the future (F) for the predetermined time period (n), and a predetermined rate of interest (*i*) using equation 2, or the reciprocal of it, depending on the factor required, and (3) Uniform series capital recovery to be paid per time period, usually referred to as annuity (A) or the present worth of such annual payments (P) for the predetermined time period (*n*), and a predetermined rate of interest (*i*) using equation 3, or the reciprocal of it depending on the factor required (Pilcher, 1992)

$$Equation\ 1 : P = F\left[\frac{1}{(1+i)^n}\right]$$

$$Equation\ 2 : A = F\left[\frac{i}{(1+i)^n - 1}\right]$$

.

$$Equation\ 3 : A = P\left[\frac{i(1+i)^n}{(1+i)^n - 1}\right]$$

Therefore, the cost manager should collect all cost data related, but not limited to: (1) Initial purchase and installation price, including transportation costs and the like; (2) Replacement costs, and how often they require replacement, for the whole system and its subsystems or subcomponents; (3) Quality standard in use, performance compliance and levels of reliability so as to allow for contingency sums in case of system failure; (4) Annual maintenance costs that include labour, tools and equipment, consumables and related technology instrumentation required at such times for the purpose of maintenance; (5) A collection of alternative systems that could provide the same or better service, according to the client value system, and information as to how the alternative system compares with the chosen one in terms of time, cost, performance and the like; (6) Adaptability to building regulations, and the possible implications that may ensue as a result of lack of compliance. Take for example in Table 1 that provide indicative rates for heating and ventilation installations; compiled by Davis Langdon cost consultants from medium sized contracts in the outer London area during September 2006 (QSWeek, 2008b).

Table 1: Indicative rates for heating and ventilation installations compiled by **Davis Langdon** cost consultants (Source: QSWeek, 2008b)

HEATING AND VENTILATION COSTS	£/nr
3000mm long one pipe system	220
3000mm long two pipe system	325 - 375
Pressed steel radiators	
1600 long	
600mm high, single panel	150 – 175
Chillers	£/nr
Air cooled chiller, reciprocating compressors, integral controls	
550 KW cooling	74,000 – 77,000
Water cooled chiller, reciprocating compressors, integral controls	

500 KW cooling	48,000 – 53,000

Using such readily available cost data, a Quantity Surveyor can easily set up a system, say using a spreadsheet to commence a detailed analysis of the proposals, alternatives and execute 'what if' or sensitivity analyses on the amounts to be invested now and or in the future. It must be noted that such analysis would also use generic discounted cash flow techniques as well as other financial analysis mechanisms present on the market such as Annual Percentage Rate (APR), Net Present Value (NPV) and Internal Rate of Return (IRR). All the possible savings and or costs should not be confused with the 'Market Value' of a constructed facility which can be determined professionally by valuation surveyors. It is important to gauge the possible market value implications of any sort of sustainable design components on the product before going ahead to construction and installation.

RESULTS FROM A CASE STUDY CONDUCTED BY DAVID LANGDON INTERNATIONAL

Matthiessen and Morris (2005) reported that for over 800 projects that Davis Langdon Cost Engineers and Quantity Surveyors International carried out between 2003 and 2005, they were able to collect cost data, cost control data and descriptors such as location and design intent so as to prove the thesis that green buildings cost more than conventional equivalents. Out of the 800 projects, 60 were actively pursuing sustainable construction, making it possible for Davis Langdon to collect research data as shown in Table 2; which presents examples of cost elements or variables that were used to implement their in-house assessments. Some of the factors that influence the cost of sustainable construction, according to Matthiessen and Morris (2005), are: Location; Design standards; Intent/Values; Climate; Timing of implementation; Building size; Point synergies; Point feasibility; Procurement; and Design Process. Using these factors, it was concluded that (i) there was no statistically significant difference between green-seeking and non-green seeking building, because the average costs for similar projects did not vary. (ii) Most people can build green buildings within the available funds (ibid).

Table 2: Case Study Data by Davis Langdon on Green Buildings Completed in 2005 (Source: HPAC Engineering, 2005)

Measure	Energy Savings	Cost Savings ($/yr)	First Cost	LEED^{TM} Points
Daylighting	16.9%	$32,645	$33,000	4
Lighting power density	7.6%	$10,051	$0	1
Glazing	0.4%	$810		0
Glazing	-0.2%	-$3,804		0
Underfloor air	4.0%	$5,649	$128,000; $5/sf	1
Radiant panel	6.0%	$11,279	$179,000; $7/sf	3

The alleged high cost of sustainable construction was not caused by 'greening the building product' per se, but, in most cases, was caused by architectural expression of the design [for example prestige value, or signature architecture and not the level of green it is achieving] (ibid). Therefore, sustainability is not an add-on; with an integrated design approach, green can be cost-effective. However, current 'traditional cost modelling tools' cannot meet the demand for green building – whose key drivers are: cost; expected benefits; government policies such as limitations on carbon dioxide emissions; and business competition within the construction business (Jerry, 2005). Therefore, it is important to get as much data as possible, not only from the proposed scheme but also from the general economy, if a Quantity Surveyor is to appraise a proposed development. Such data can be used to track the design decisions that could be improved upon; hence the need for integrated teams that could use automated systems so as to speed up the work. Integrating the design process is therefore essential to accomplishing sustainable design, because, if it is not done correctly, the process could negatively impact on the total cost of the project (Lewis, 2005). There is also a need for early collaboration before wrong decisions are made without knowing all the consequences (ibid). Therefore, if project professionals could share data using STEP files, it would be easier for the Quantity Surveyor to advise them on the cost aspects of the proposal; and hence improve the cost management of the scheme (Matipa, 2008). Figure 2 shows a prototype of an IFC based system that Quantity Surveyors could use to extract Quantities and commence detailed analysis. It could work alongside a CAD modelling tool if visualisation is required.

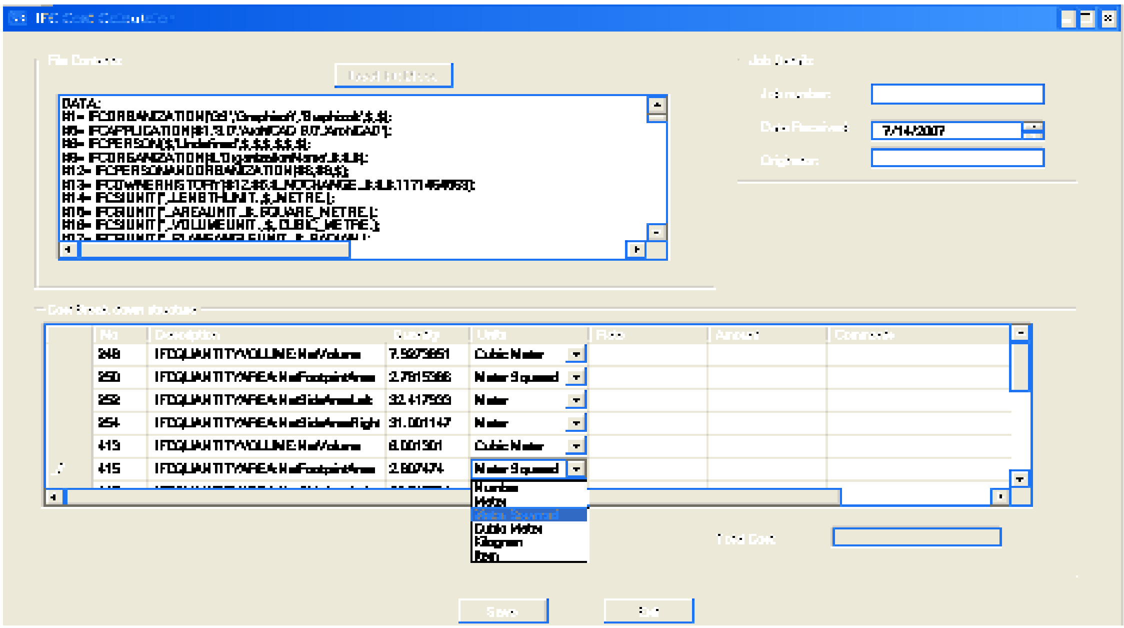


Figure 2: Standard Cost Breakdown Structure of the IFC Cost Calculator (Source: Matipa, 2008)

CONCLUSION AND DISCUSSION

To achieve sustainable construction, there is a need for a critical analysis of every designed component and or system with a view to determining the possible whole life cycle cost, weighed against the anticipated market value of the facility before it is delivered on the market. It has been observed that appraising and analysing project components require a detailed understanding of what is to be developed. Examples such as the "Earthship Brighton" which took-off – two years late and 50 per cent over budget" (QSWeek, 2008a) offer valuable lessons. Because this was an innovative project there was no template so we did not have that handle (QSWeek,2008a). Quantity Surveyors have got to deploy available Information and Communication Technology (ICT) systems to demonstrate the cost implications of implementing sustainable or green building elements of the designed product. There remains a huge potential to be untapped within the overall use of BIM quantity surveying practice.

REFERENCES

BRE (2006) Part L explained, BRE Press, Watford

Cheng *et al*, (2002) A question answering system for project management applications, Advanced Engineering Informatics, 16(4), 277–289

Construction Manager (2008a) Creating an air-tight building envelope, CPD Module, Construction manager, February 2008, Pp29 – 32

Construction Manager (2008b) Air source heat pumps, CPD Module, Construction manager, May 2008, 27 – 30

Cyon Research (2003b) The Building Information Model: A Look at Graphisoft's Virtual Building Concept. *White Paper*, January 2, 2003, www.cyonresearch.com [Accessed: March 2004].

Data Design Systems (DDS) (2008) Data Design System CAD, Electrical Model http://www.dds-cad.net/4x2x0.xhtml (Accessed: 17/05/2008)

Department of Trade and Industry (2006) Review Of Sustainable Construction 2006 - A Summary; October 2006 http://www.berr.gov.uk/files/file34997.pdf (Accessed: 18/05/2008)

Department of Trade and Industry (2007) Meeting the Energy Challenge: A White Paper on Energy, May 2007, DTI, Norwich

Eastman, C., (1999) Building Product Models: Computer Environments, Supporting Design and Construction. London: CRC Press.

Faraj *et al*, (2000) An Industry Foundation Classes Web-Based collaborative construction computer environment: WISPER, Automation in Construction, Vol. 10, Pp79 – 99

Farookhi, I., (2008) Supporting an Evolving Industry, "Sustainability", Building Engineer, January 2008, 83(1), 16 – 17

Fu *et al* (2006). IFC Model Viewer to Support nD Model Application, Automation in Construction, 15(2), 178 – 185

Froese, T., (2003) Future Directions for IFC-Based Interoperability, ITCon, 8, 203- 246, www.itcon.org (Accessed 15th January 2004)

Garner, S., and Mann, P., (2003) Interdisciplinarity: perceptions of the value of computer-supported collaborative work in design for the built environment. Automation in construction, 12(5), 495 – 499

Hietanen, J., (2004) Sable Domain Specific API requirements: Quantity Information for Cost Estimation, http://www.blis-project.org (Accessed: 2006-12- 20)

Hollmann, J., K (2006) What is Cost Engineering? Cost Engineering, 48(3), 8 – 9,

Husin, R., and Rafi, A., (2003) The Impact of Internet-enabled computer aided design in the construction industry. Automation in Construction, 12 (5), 509 – 513

International Alliance for Interoperability (2003) http://www.iai-na.org/membership/membership_brief.php Accessed 19th June 2003

Jerry, Y. (2005) "Marketing Green Buildings", Dollars and Sense of LEED and Green Buildings, HPAC Engineering Web Seminar, March 16, 2005, Publisher, Tanker Terry, HPAC

Koivu, T., (2002) Future of Product Modeling and Knowledge sharing in the FM/AEC industry. *ITCon, 2*, 139 –155, http://www.itcon.org/2002/9.

Kraus, W., E., (2008). What role is there for AACE International to play in the area of Building Information Modeling? Cost Engineering, 50 (2), 3 – 4,

Matipa, M., W., (2008) Total Cost Management at the Design Stage Using a Building Product Model, *Unpublished PhD Thesis,* Faculty of Engineering, National University of Ireland Cork (NUIC), Cork, Ireland

Matthiessen, F.L. and Morris, P. (2005) "Managing the Cost of Green", Dollars and Sense of LEED and Green Buildings, HPAC Engineering Web Seminar, March 16, 2005, Publisher, Tanker Terry, HPAC

McKenna, J., (2008) Severn barrage cost hits £23bn, New Civil Engineer, http://www.nce.co.uk/energy/2008/05/severn_barrage_cost_hits_23bn.html (Accessed: 17/05/2008)

Monbiot, G., (2006). Heat: How to stop the planet burning, Penguin Books, London

Pilcher, R., (1992). Principles of Construction Management, 3rd Edition, McGraw Hill International, London

Plume, J., and Mitchell, J., (2007). Collaborative design using a shared IFC building model – Learning from Experience, Automation in Construction, 16(1), 28 – 36

Qsweek News (2008) Builders reject carbon proposals http://www.qsweek.com/nav?page=qsweek.gen_obj_redirects.news&fixture_news=7135107&resource=7135107&view_resource=7135107 (Accessed: 17/05/2008)

QSWeek (2008a) Cost Bank - Earthship Brighton. http://www.qsweek.com/nav?page=qsweek.contentspage&view_resource=6580178 (Accessed: 17/05/2008)

QSWeek (2008b) Heating and Ventilation Costs http://www.qsweek.com/nav?page=qsweek.contentspage&fixture_page=5892685&resource=5892685&view_resource=5892685 (Accessed: 18/05/2008)

Tarandi, V., (2003). Future Directions For IFC-Based Interoperability, ITcon 8 (Special Issue), 231-246 http://www.itcon.org/2003/17 (Accessed August 15, 2003).

Tanyer, A.M., and Aouad, G., (2005). Moving beyond the fourth dimension with IFC-based single project database, Automation in Construction Vol. 14(1), 15 – 32

Tinsley, J., (2008) The need for Sustainable Heating for Our Homes, "Heating", Building Engineer, January 2008, 83 (1), 24 – 25

Tolman., F. P., (1999). Product Modeling standards for the building and construction industry: Past, present and future, Automation in construction, 8(3), 227 – 235

Tucker, A., (2008). It isn't easy being green, QSWeek, http://www.qsweek.com/nav?page=qsweek.contentspage&fixture_page=7147918&resource=7147918&view_resource=7147918 (Accessed: 17/05/2008)

Turkaslan-Bulbul, T. M., and Akin, O., (2006) Computational support for Building evaluation: Embedded Commissioning Model, Automation in Construction, 15 (4), 438 – 447

Williams, R., and Mackechnie, C., (2008) Is This the Drawing of the age of Real Thermal Properties?, Building Engineer, January 2008, 83(1), 12 – 14

PROJECT CONFIGURED SUPPLY NETWORKS: GOVERNANCE OF DELIVERY, AND FAILURES IN OPERATIONS

Christian Koch
Institute of Business and Technology, Aarhus University
7400 Herning, Denmark
christian@hih.au.dk

Abstract
Supply networks in complex B2B- construction deliver knowledge, materials, components, subsystems, competences, workforce and management. The delivery network and its governance forms are partly permanent, partly project specific. Integration upstream varies by project, constituting a range of delivery types; parts, components and subsystems. The project configuration and orchestrated governance forms are not always successful, and failures emerge. The paper aims at studying governance forms in delivery networks using operational failures as litmus. Operation management approaches is used as theoretical frame. The case study is a Danish architectural, engineering and construction supply network for one building project. The governance forms found were; internal integration and hierarchy, SCM-efforts, subsystem deliveries, and contracting per project. There was a very uneven upstream integration; Three engineering design areas were integrated with production and even the client. The architectural design is the most 'clear-cut' singular, whereas the supplies of pre-cast concrete core, elevator and kitchen were integrated knowledge, material, workforce and management subsystem deliveries. 160 failures occurred during three month observation. The costs were 8 pct. of the production budget. None of the mobilised governance forms fully prevented failures, especially subsystem delivery and internal integration was underperforming.

KEYWORDS: AEC-industry, governance, failures, quality, supply chain.

INTRODUCTION

Delivering complex large scale B2B products requires integrating and balancing the three elements of product design, supply chain, and production planning and execution. This requires establishment and governance of a mixed stable, and project configured, supply network from raw materials to end users. The aim of this paper is to analyse governance in project configured supply chains delivering such products, using operational failures as evaluation indicators. The paper proposes a theoretic conceptualization of governance, encompassing project, corporate and societal elements. The paper discusses a case example of an architectural, engineering and construction supply network (abbreviated AEC).

In such a setting, one can test the governance arrangement by a bottom up analyses. The assumption is that tension would occur between governance and operations. Coordination problems could occur. Consequently failures and quality problems will develop. Based on a study on failures in a Danish housing project (Apelgren *et al*., 2005), quality in the AEC-processes is examined from a supply chain perspective.

The paper is structured as follows. It opens with the methodological design regarding theory, the data sampling and analyses done. Then the theoretical frame is presented, focusing on governance project configured supply networks and defining quality in operations management. A presentation of the findings of the case is given, with two illustrative examples of how supply chain networks operate. Finally discussion and conclusions deals with the role of governance of supply networks in the handling of failures in the AEC-industry.

METHOD

Theoretically the article combines operation management approaches conceptualizing supply chain (e.g. Mentzer, 2004; New & Westbrook, 2004), quality and operations (cf. Galloway 1998), with management and economic theories on governance (Williamson, 1975; 1990 a. o.). Empirically the research behind the article focuses on one case of a project specific supply chain. The bottom up analyses commences by mapping out the failures as they occur downstream during the production of the complex product (the buildings), and the supplies are then pursued upstream. In the other direction the relation to the final customer is covered as well. In a period of three month an observer followed the daily execution of work in production, at the building site. In total 160 failures were sampled (one to ten failures per day) in 38 observation days. The project followed was a medium sized building project of 27 apartments in low buildings. The budget was at €4.4 millions. The upstream interviews covered ten actors in the knowledge, materials, subsystems and workforce chains. The interviews however aimed at tracing the failures as far back as necessary. Moreover an extensive document analyses was carried out including a number of different project documents such as drawings, survey plans, contracts, and minutes from nine project review meetings and as well as other meetings. The upstream analysis encompassed proximal as well as distal causes either in organisation, technology or human resources. Moreover a calculation of the material and man-hour costs was carried out for each failure in cooperation with the operation management of the building project. The single failure analysis was followed by a thematic cross-failure analysis. In the paper two cases of the process of a failure is chosen to illustrate how the failures are produced and transformed in the supply chains. The method adopted has its strength and weaknesses. Since the supply chain consists of several independent units the researcher has to gain access several times. The present analysis moreover does not study the chains in a “unit symmetrical” manner since the production unit is point of departure (See also Ellram, 1996; Hyll, 2005). Not all failures in the observation period were registered since it was not possible to follow all parallel activities on the building site (see also Josephsson *et al*, 1996). Finally it should be noted that neither board room activities, the use of IT nor the possible role of common architectures, norms or standards have been studied here. The paper is primarily based on (Larsen & Koch, 2006).

GOVERNANCE

Williamson's (1975) work on transaction economics are seminal for the understanding of governance, but it is well established that governance today has become a messy concept that cover issues related to projects, corporations and society (Peters & Pierre 2000). Governance can be defined as broadly coordination, steering and control mechanisms encompassing both structural and processual elements (Pietroforte 1997, OECD 1999, Turnbull 1997, Jain & Dubay 2005). As the governance discourse develops, it has widened its focus both in understanding of mechanisms and in coverage of business activities. Mechanisms have been widened from abstract structures to much more action oriented understandings. (Corporate) governance is often viewed as a newer form of managing, used to underline indirect forms of control, self-organisation and networks (OECD, 2004).

Supply chains might consist of a number of companies and cooperation between companies of a short and long term character. Establishing cooperation projects in delivering complex products need cross company governance arrangements in supply, such as delivery contracts or SCM efforts (Miller & Hobbs, 2005). Cooperation might encompass 'merely' dyads of two companies, but it can extend to chains and to networks. Cross company projects will thus exhibit constellations of corporate governance and cross company governance arrangements such as contracts, cooperation's and practices (Winch, 2001). Trust between company representatives might be profound, but would more often be present in diverse forms including cooperation at an arm's length. The increasingly important tight and agile integration of key intra- and inter-organizational business processes in supply *can* to a certain extent be exercised by creating classical hierarchies, integrating companies in corporate groups and through joint management enabled by mergers and acquisitions. However, there has for long been recognition of, drawing on the understanding of complementarity and core competency, that alliances and networking are an attractive business strategy (Pryke 2004, Miller & Hobbs, 2005. Which however create the need of developing new governance mechanisms (Miller & Hobbs, 2005). The identification of governance in supply chains and networks is still emerging (Wathne & Heide 2004; Jain & Dubey, 2005). Governance mechanisms and practices have tended to move away from the original transaction cost focus on direct processes (Binder and Clegg 2005, Tangpong *et al*., 2005). Since governance tends to drift away from direct operations, this potentially creates tension between the two.

PROJECT CONFIGURED SUPPLY CHAINS

The full implication of shifting customer demands is an engineer- and build-to-order strategy, and in complex products, this is often organised by project. This again implies supply networks, which in principle is configured project by project. According to client demands, smaller or larger part of the offered product will have to be sourced by new sub-suppliers. Moreover location and other factors will lead to special conditions unique for the single project. This conceptualization is in contrast with most supply chain literature, which assumes that the structures of the supply chain are stable (London & Kenley, 2001; Holweg & Pil, 2004; New & Westbrook, 2004; Mentzner, 2004). Moreover most SCM- writings adopt a more limited understanding of supply chains, more or less entirely devoted to the flow of materials (London & Kenley, 2001), even if Forrester (1958) in his seminal article on supply chain dynamics would demand a focus on five flows (information, materials , money, manpower and capital equipment). Construction value flows are distributed roughly as 60 pct. of construction costs are materials (measured against a buildings total cost), whereas labour on the building site is around 20 pct., production equipment around 10 pct. and design is around 10 pct.. The importance of the knowledge stream relates to its role as value-adder *vis-a-vis* the other streams. Behind these figures are considerable profits for material supply units (manufacturers, retailers, distributors), Hyll (2005) thus analyses a supply chain for radiators and finds a price augmentation of 272 pct. from manufacturer to client. In construction research the two flows of knowledge and materials are frequently described as independent (Hyll, 2005). In a knowledge and service economy however, material manufacturers are design partners and design and production need to be relatively integrated. In other words the two streams are increasingly intertwined. Moreover the construction delivery processes can be described as multi-channeled, since there are often multiple suppliers in both the knowledge and materials flow. Considerable parts of the materials supply chain in construction exhibit however rather traditional forecast based production and extensive stocks of materials at retailers as a main strategy of flexibility and responsiveness (Hyll, 2005). Moreover retailers are successful in attaching contractors to them through price and discount agreements. Thomassen (2004) describes the strategic supplier-relationships as 'islands of stability'. All of this implies that to each project there will often be a certain degree of traditional deliveries and a certain degree of project-specific deliveries, suggesting that the supply chain can be described as partially stable, partially project specific. As an important counter strategy to project delivery supply chains, a host of companies in construction and in other sectors, have strived at using supply chain management (SCM) strategies in order to lever the stability. Bhote (1989) describe how SCM can improve results by reducing the number of supplier and by creating partnerships for long term relationships, escaping adversarial relations. Azambuja and Formosa (2003) thus investigate design, procurement and installation of elevators in AEC in Brazil. They emphasize that the establishment of partnerships between construction companies, their designers and elevator manufacturers plays an important role, bringing more interaction among the different agents in the early design stages.

Linking Design and Supply – from materials to subsystems

There are important interrelationships between design structure and delivery and operations. Complex B2B products, like buildings, exhibit a number of characteristic features that link their conceptual structure (design) with the processes of delivering and producing. First the products are high cost hierarchical systems, consisting of numerous parts, components and subsystems, second they are produced in projects or in small batches often involving a number of firms, third they exhibit emerging unexpected properties and finally there is a high degree of involvement and contact to the client(Davies & Hobday, 2005). Systems are here defined as a device which is conceptually and physically integrating a number of different components with different technical content. Attempts of creating a stronger and further integration of such products involve increasing the degree of subsystems deliveries. Creating more subsystems is believed to enable simplified processes, cost reduction and quality improvements (Davies & Hobday 2005). Bundling of components in a subsystem thus enables reduction of similar operations. Another central strategy is to create modularity, standards and norms in order to handle interfaces and boundaries. Hereby products can be developed with smaller interchangeable units. The AEC-industry is characterized by very few full system concepts. Most deliveries of complex products rely on subsystems, components and parts (raw materials) in a project specific mix. Components and raw material are usually generic products, whereas subsystems and the system as such are customized. In several areas subsystems are accompanied by workforce, competences and management. In other areas of the operational processes deliveries are more frequently a combination of components, raw materials, work force and management.

QUALITY IN PROCESSES

Creating value and quality for both customers and enterprises is increasingly dependent of the ability to organise and coordinate material and knowledge elements in the supply chain. That the configuration is not always successful can be demonstrated by studying the emergence of failures occurring in the supply network (Love & Li, 2000). Meeting clients demands quite often means rework as part of the process, which is a considerable problem in construction (Love *et al.,* 1999). Quality is a central performance parameter for operations and Galloway (1998) proposes a distinction between three quality parameters: design, conformance, and operational quality. Design quality is concerned with the degree to which the product and/or service achieve the costumers' demand (Dale, 2003), both as fitness for purpose and value for the money. Conformance quality means producing a product or providing services to its design specifications (Slack *et al*., 2004). Operational quality is meeting the specifications the first time without failures (Galloway, 1998). In AEC, quality is often poorly defined, since the product is often one-of-a-kind and may not be described to an extent that provides a meaningful reference to quality. Nicolini *et al*. (2000) emphasizes the difficulties of keeping the focus on improving quality and reducing underlying costs in the construction sector, where actors tend to organize their procedures project by project in traditional inefficient ways. The design often prescribes certain measurable demands, but in the construction processes the interaction between trades, companies and professions imply that interpretations of process and product quality are multiple and continually negotiated and contested. A direct implication of this understanding is moreover that what constitute a failure is equally difficult to define since different actors comprehend situations differently (Apelgren *et al*., 2005). In a AEC setting operation processes, input and output are rarely fully described in a way which makes is meaningful to understand failures as merely deviations from defined quality.

Quality in Supply Chain Processes

Quality control in operations in supply chain could consist of three types of control for each supplier: 1) entrance quality control; 2) operational quality control and; 3) exit quality control, referring to quality control of input, transformation process and output, respectively. This means that each part of the supply network checks quality of the input when received then checks the quality in the transformation process and finally checks the quality of the output which is to be delivered to the next part of the supply network. In a multi-channel setting, like construction, quality concerns multiple material supplies as well as multiple knowledge deliveries. As discussed by Sousa and Voss (2004) integration between channels become crucial. In this manner it is strived to optimize quality in each part of the supply network to optimize the total quality of the end product (Deming, 1986; Dale, 2003). Supply Chain Management (SCM) tends to focus on delivery agreements in say one years cycles. The agreements specify delivery conditions and state a gross delivery. Quality is moreover specified in general terms. Such contracts of delivery create stability, and can be seen as overall governance creating trust and cooperation. They might also be accompanied with stronger communication tools such as web based IT-interfaces between the partners. But they rarely assure the quality of project specific deliveries however. Having the material suppliers involved as early as the design-phase seems to be a growing tendency, and this is often emphasized as a way of improving quality. It does also create further integration issues (Azambuja & Formosa, 2003). Apart from integration issues between channels, tensions are created in the delivery, when clients describe their demands not only through the design brief, but as a continual process during design. Similarly the delivery of the design is often done piecemeal *vis-a-vis* the contractor during construction (Pietroforte, 1997).

CASE STUDY PRESENTATION

The case study company (referred to as 'the group'), being an enterprise comprising both development, engineering and production, employs app. 2.000 employees consisting of both salaried employees (43 pct.) and hourly-paid workers (57 pct.), and has an annual turnover of €736 million. The group is involved in housing projects, office projects, factory building projects as well as civil engineering projects. The group has adopted a 'partnering concept' as an option for integration of engineering, architectural design and production, but not used in the present case. The integration with three engineering disciplines in-house was opted instead, encompassing delivery of electrical, Heating, Ventilation and Air Condition (HVAC) and building physics design. Over the last 5-6 years the group has made a strategic supply chain effort to reduce costs, heighten quality and strengthen relationships with suppliers. The number of suppliers has been minimized from approximately 7.000 to 1.700 including delivery of materials, workforce (sub-contractors) and knowledge based deliveries from architects and engineers. The group operates with records on past performance of all suppliers. Longer relationships are often sought through contracts where e.g. materials suppliers are guaranteed a certain sale based on forecasts of quantities (Larsen & Schultz, 2005). The number of current suppliers indicates that no suppliers are single-source within a category. There are no intentions of going as far as single-source suppliers and total co-operation as suggested by Bhote (1989). However the reduction of suppliers and the establishing of long term relationship suggest that the supply network is now that of co-opetition. Of the 17 sub-contracting firms working at the case-site, 6 were in-house personnel employed by the group. The remaining 11 sub-contractors was invited to submit tender, and the project manager hired them in on basis of different parameters where performance data from the suppliers' database was one and price another of several parameters. There were six main suppliers of knowledge to the project: three in-house suppliers; electrical engineering, HVAC-engineering and the building physics design and three external the architect, the elevator-company and the pre-cast concrete elements company. More than 50 suppliers participated in the material chain, related to the group and 17 subcontractors. Raw-materials, components and systems were supplied. However, as will be shown only a few failures could be traced back to material and component suppliers, exclusively. As indicated the knowledge and material chain were intertwined in a way that make them only partly distinguishable. Integration between the project specific suppliers and the group encompasses: 1) delivery of knowledge from architect; 2) delivery of knowledge, materials and workforce from the elevator-company and the pre-cast concrete elements company; 3) subcontractors delivering workforce and materials, and; 4) material-suppliers only for in-house production.

160 failures observed in the delivery network

The analysis of the 160 failures showed that the vast majority had multiple causes relating to more than one unit in the supply chain. 14 pct. of the failures however were entirely related to production, whereas the rest originated from elsewhere in the supply chains and subsequently led to further problems. Organisational problems like communication and coordination were the most prevalent. Out of the 160 failures problems with communication and cooperation occurred in 61 pct. of the processes behind, problems related to design in 45 pct., production planning and control in 42 pct., project review meetings in 36 pct., production work 34 pct., process and product control 29 pct., weather and theft 20 pct. and access to skilled workforce 15 pct.. Further causes scored less. The expenses were calculated to be 8 pct. of the production costs. Figure 1 show the top-five initiators of the failures.

Activity	**Number of failures**
Pre-cast concrete element assembly	21 failures
Design (architectural, engineering)	17 failures
Building site installations	13 failures
Operational management	12 failures
Pre-cast concrete element production	10 failures
Sum	73 failures
Share of the total 160 failures	46 pct.

Figure 1: The top-five activities involved in the initiation of failures.

Two examples

In the following two examples of failures is discusses. In the *first* the focus is on subsystem integration of workforce and components, but with disintegration of knowledge. The design of the core of the house was carried out in-house in the group, whereas the manufacturing and on-site assembly of the pre-cast concrete elements was contracted to an external partner. This is an unusual governance form for delivery of the core. The group would more often produce and assemble the concrete elements as an in-house operation. This configuration of the processes implies much interaction and coordination from architects to building physics to contractor to production management etc. When manufactured, the concrete elements where delivered to the site as components and assembled by the manufacturing company's own workforce. Production failures consisted mainly of non-conformance with the design e.g. misplaced recesses and operational failures were mainly delays and erroneous assembly resulting in e.g. skewed walls and windows sections. The quality of the product and the processes strongly impacted the operations that followed immediately after. The total costs of the failures from the production and the assembly of the elements were estimated to €75.000 where the cost of remedial action on skewed window sections alone was app. €27.000. The company was involved in 31 failures (19 pct.) in the total sample of 160 failures, which was the highest number that involved a single company. This in spite of the company's good past performance recognized by the ratings in the groups record which indicates that quality of the deliveries from project to project can vary from the same suppliers. Differences can also be expected from project to project within the group which implies that boundary surfaces between group and suppliers are continuously varying causing insecurities to the projects. In the *second* example, knowledge, workforce and materials are separated. In a staircase area a radiator is to be designed, delivered and assembled in a process where knowledge, workforce and materials are delivered by different suppliers. The following chain of events took place. The architect, being the first 'unit' in the knowledge stream, specified the radiator's location choosing a standard 80 cm. radiator due to aesthetic concerns. The building physics design engineer then used the architects design as basis for the design of the main structure, transferring this to the first 'unit' in the material chain, the pre-cast concrete elements manufacturer. At the same time the HVAC design engineer calculated the necessary heating for the staircase prescribing a 100 cm radiator. This design discrepancy was revealed at a review meeting between architect and HVAC engineer after which the building physics design engineer was informed. The 80 cm radiator was thus maintained and modelled into the precast concrete elements. The HVAC engineer however forgot to change his own project, so the 100 cm prescription was channelled to the HVAC-contractor, who ordered a 100 cm radiator from the supplier. Upon assembly of the radiator on the building site, the plumbers discovered that the holes in the pre-cast concrete element did not fit the radiator. To make up for this failure, project management decided to fill up the original holes and drill new holes fitting the 100 cm radiator - without notifying the architect. Later, the architect however insisted on the aesthetic dimension of the original design, and managed to re-change the radiator, which again involved both the sub-contractor and the supplier. In this example the failure was repeatedly sent back and forth between the separated knowledge, workforce and materials deliverers. Since there is conformance with the project of the architect the quality for the end-user is untouched by the process. For the involved actors however, the losses were calculated to €2826. It is in other words the loss of efficiency of the supply chain units, which carry the most important implications, and not directly the customer.

DISCUSSION

In the following the experiences with the governance forms is discussed. As described, the project exhibits a specific mix of deliveries and governance. First of all there was a, in principle, unusual high level of integration internally into the hierarchy of the group. The client, three engineering design units, the central unit of purchasing and the production unit thus all stem from the same company. This meant that partnering was not used. Secondly inter-organizationally there is a specific constellation of governance forms; SCM efforts, subsystem deliveries and contracting per project. The SCM efforts such as past performance monitoring, and long-term delivery contracts had a contradictory effect, occasionally creating a false sense of security. In terms of subsystems it was chosen to outsource the subsystem of the core. A kitchen and an elevator subsystem-delivery were used, but other possible subsystems, such as bathrooms were not. Finally, the more traditional project contracting with most suppliers also exhibit quality problems. The study shows that only 7-8 pct. of the failures affected the final conformance quality of the buildings. Most failures affected the operational quality. Moreover our downstream analyses showed very little congruence between the conformance quality failures and the experienced failures of end users. The *first* example, the pre-cast concrete element company, represents almost a fifth of the failures, half of the cost, and the most planning problems during production. It gave many additional operations and affected the operational quality of many actors in the supply network. This in spite of the received wisdom that (sub) system delivery would assure improvements of quality and moreover in spite of established SCM-governance, where the company's good past performance were recognized by the ratings in the main-contractors record. Azambuja and Formosa (2003) similarly finds that the installation process of the elevator subsystem has a high level of interference with other ongoing processes in the building site (structure, electrical services, finishes). The elevator subsystem-delivery in this case (see Larsen & Koch 2006), shows on the other hand just one minor design failure. There can thus be strong variations in deliveries from project to project from the same suppliers. Governance through SCM-initiatives is impaired by these large differences within each supplier. Differences can also be expected from project to project within the main-contractor. This implies that the boundary surfaces between the main-contractor and the suppliers are continuously varying, causing risks to the projects. The *second* example exhibits the three types of quality problems with interfaces between deliveries. The architectural designer makes an aesthetical decision on behalf of the customers, when choosing the radiator and thereby defining design quality. The conformance quality is maintained in the end when the radiator is replaced with the prescribed model and therefore meets the design specification. Already when the HVAC-engineer forgot to change his project material, as agreed in the audit meeting, the operational quality was affected. When the assembly of the radiator commenced, the many additional operations affected the operational quality of many actors in the supply network. In terms of governance the architectural design is done through a project contract within the SCM-framework of the company. It is paradoxically the external partner, which seems to be keen on assuring coordination, rather than the group internal. Using generic components proves just to open a new possible source of failure, mixing one generic component with another. The analyses of the failures demonstrates that strong integration of material, knowledge, workforce and management aspects does not necessarily prevent all failures, and echoes Sousa and Voss' (2004) emphasis on integration between channels as crucial for quality. This is an indirect weakness of the mobilised set of governance forms. Even though the elevator-sub system organisationally is integrated, a minor failure still occurs. Having the material suppliers involved as early as the design-phase is often emphasized as a way of improving quality in the projects, which does not seem to be the case in this example. This highlights the need for continuous focus on the quality control procedures, both as entrance and exit control, also when the designer and sub-contractor stems from the same company. The analysis of relations in the supply network both shows relations to materials, knowledge and workforce chains and their interaction. Most of the failures were generated in the knowledge stream and then occasionally transform into the material stream. Both cases shows that the knowledge and material were intertwined, since a failure generated in the knowledge network could transform into the material network and vice versa. Azambuja and Formosa (2003) finds most of the problems are in the interfaces between the actors in the supply chain, and the majority of problems are associated with managerial issues, such as ineffective information flows, lack of cooperation and poor coordination of the actors, which is also our main causes (Apelgren *et al*., 2005). The interfaces and contact surfaces between the actors in the knowledge network clearly becomes critical junctions in the process – in-between the exit and entrance controls. On the background of the present case study it still appears a very complicated and contradictory task indeed to configure the supply network for a specific project. It appears that strong relationship with some suppliers are not enough and that even within a hierarchical integration serious problem might be generated in the processes. To actively orchestrate governance forms seems to be but one important approach.

CONCLUSIONS

The analyses showed, that several governance types had to be mobilised in bundling deliveries. The vast majority of the failures occurred in the knowledge chain (in a broad sense) and some transferred into the material chain. The result in terms of compliance with customer requirement was that 7-8 pct. of the failures impacted on the end quality. It is thus mainly the participating companies, rather than the client that looses. It seems a prevalent result that quality auditing at interfaces between units in the supply chain, becomes critical junctions. Project review meeting and other types of quality checking decays into symbolic actions, were the meeting are held on a basis of poor preparation and follow up is poor as well. The results also indicated the necessity of initiatives to strengthen governance in supply chains, improve integration between channels and especially at mixed stable and project configured types to handle the complexity of the building projects. Initiatives could include alliances with fewer suppliers or introducing multi-skilled teams as a way to reduce the number of sub-contractors and further integrate knowledge types in delivery. Moreover the reorganisation of the site processes removing the responsibility of the supply network management from project management is a major contradiction to overcome. Traditionally the project management handles most of the purchasing direct with the supplier, thus obtaining lucrative prizes as a result of the close personal relationship, and believed to be hallmarks of project management. The reorganisation however removes these tasks from project management, centralizing purchasing in the permanent enterprise organisation, giving the group greater “purchasing-power” through greater quantities and enforcing cheaper prizes and quality improvements. Lastly, a major result of the present research is that a single enterprise can obtain considerable productivity improvements if project partnerships could be improved. Better handling of especially the knowledge chain has a considerable business potential, also in improving the product offered to the clients.

REFERENCES

Apelgren, S., Richter, A. & Koch, C. (2005) Snublesten i byggeriet. Lyngby: BYG·DTU, Technical University of Denmark.

Azambuja, M.M.B & Formosa, C.T. (2003) Guidelines for the Improvement of Design, Procurement and Installation of Elevators Using Supply Chain Management Concepts. In:International Group of Lean Construction 11th Annual Conference, 22-24 July 2003. Virginia Tech, Blacksburg.

Bhote, K.R. (1989). Strategic Supply Chain Management – A Blueprint for revitalising the manufacturing/Supplier partnership. New York: American Management Association.

Binder, M, & Clegg, B. (2005) The modular enterprise: A new governance architecture for inter-firm collaboration. In: Demeter, K. (Ed.) Papers of the 12th International EurOMA Conference on Operational and Global Competitiveness, Budapest, Hungary: 1385-1394.

Dale, B.G. (2003) Managing Quality. Malden: Blackwell Publishing.

Davies A. & Hobday, M. (2005) The Business of Projects Cambridge University Press.Cambridge.

Deming W.C. (1986) Out of the crisis. Massachusetts: MIT centre for advanced Engineer study.

Ellram, L.M. (1996) The Use of Case Study Method in Logistics Research. Journal of Business Logistics, 7 (2): 93-138.

Forrester, J. (1958) Industrial Dynamics. Harvard Business Review, July- August: 37-66.

Galloway, L. (1998) Principles of Operations Management. 2ed. London: Thomson.

Hyll, H. (2005) Logistical Principles in Construction Supply Chains, Thesis for the degree of Licentiate in Engineering, Lund University.

Holweg, M. & Pil, F.K. (2004) The Second Century: Reconnecting Customer and Value Chain through Build-to-Order. London: MIT Press.

Jain K. & Dubey A. (2005) Supply Chain Collaboration: A Governance Perspective, Supply Chain Forum 6 (2).

Josephson, P.E. and Hammarlund, Y. (1996) Kvalitetsfelkostnader på 90 talet – en studie av sju byggprojekt. Göteborg: Institutionen for Byggnadsekonomi, Chalmers.

Koch, C., Gottlieb, S.C. & Thuesen, C. (2005) The Process of Partnering; Gluing Contracts, Organising and Financing together. In: Ahmed, S.M., Ahmad, I., Pantouvakis, J., Azhar, S. and Zheng, J. (Eds.) Proceedings of the Third International Conference on Construction in the 21st Century (CITC-III), Advancing Engineering, Management and Technology, Athens.

Larsen, C.S. & Schultz, M. (2005) Interaktion på tværs af niveauer i en større dansk entreprenørvirksomhed. Master Thesis BYG·DTU: Technical University of Denmark.

Larsen, C.S. & Koch C. (2006) Quality issues in project configured supply chains - Can a fragmented network learn from its failures? Paper prepared for the 3rd European Forum on Market-Driven Supply Chains, 7-8 March 2006, EIASM, Brussels.

London, K.A. & Kenley, R. (2001) An industrial organization economic supply chain approach for the construction industry: a review. Construction Management & Economics, 19 (8): 777-788.

Love, P.E.D., Li, H. & Mandal, P. (1999) Rework: A Symptom of a Dysfunctional Supply-Chain. European Journal of Purchasing & Supply Management, 5: 1-11.

Love, P.E.D & Li, H. (2000) Quantifying the causes and costs of rework in construction. Construction Management and Economics, 18(4): 479-490.

Mentzer, J.T. (2004) Essentials of Supply Chain Management. Sage publications.

Miller, R. & Hobb, B. (2005) Governance Regimes for Large Complex Projects. Project Management Journal, 36(3): 42-50.

New, S. & Westbrook, R. (2004) Understanding Supply Chains. Concepts, Critiques and Futures. Oxford: Oxford University Press.

Nicolini, D., Holti, R. & Smalley, M. (2000) The Handbook of Supply Chain Management. London: CIRIA Publications.

OECD (2004) Principles of Corporate Governance .Paris: OECD.

Peters, B.G. and Pierre, J. (2000) *Governance, Politics and the State*, Basingstoke: Macmillan.

Pietroforte, R. (1997) Communication and Governance in the building process. Construction Management and Economics, 15: 71-82.

Pryke, S.D. (2004) Analysing construction project coalitions: exploring the application of social network analysis. Construction Management and Economics, 22: 787-797.

Slack, N., Chambers, S. & Johnston R. (2004) Operations Management. 4ed. London: Pearson.

Sousa, R. & Voss, C. (2004) Service Quality in Multi Channel Services, employing virtual channels. Operations and Technology Management papers, OTM 04-023. London: London Business School.

Tangpong, C., Michalisin, M. D., & Melcher, A. J. (2005) Performance Effects of Relationalism with Dominant and Non-Dominant Suppliers: A Case Study. Operations Management Division Best Paper Proceedings. The Academy of Management Annual Conference. Honolulu.

Thomassen, M.A. (2004) The economic organization of building processes. On specialization and coordination in interfirm relations. Department of Civil Engineering. Techn. Univ. of Denmark.

Turnbull, S. (1997) Corporate Governance. Its Scope, Concerns and Theories. Corporate Governance –An International Review, 5(4)

Wathne, K.H. & Heide, J.B. (2004) Relationship Governance in a Supply Chain Network. Journal of Marketing, 68(1): 73-89.

Williamson, O.E. (1975) Market and Hierarchies: Analysis and Antitrust Implications. New York: The Free Press.

Williamson O.E. (ed.) (1990) Organization Theory. New York: Oxford University Press.

Winch, G. (2001) Governing the project process: a conceptual framework. Construction Management and Economics, 19: 799-808.

PROJECT CONTROL AND PLANNING INNOVATION – HOW IT CAN IMPROVE PROJECT DELIVERY.

Ian MacKenzie
Faithful & Gould, ATKINS, Stockton on Tees, UK
Ian.Mackenzie@atkinsglobal.com

Nashwan Dawood,
University of Teesside
n.n.dawood@tees.ac.uk

Delivery of projects on time and within budget with the required quality and safety is paramount in all businesses. However, there is still a high frequency of projects that are late and over budget. Recent examples of these include the new Wembley stadium and the Scottish Parliament building in Edinburgh.

The aim of the research work is review the current techniques that are used to plan and control projects with the objectives of identifying innovation and project control processes that improve control and delivery of projects.

This paper presents the approach establishing current practice in a variety of industries e.g. Oil and Gas, Nuclear, Pharmaceutical, Building Construction, Transport and Petro-Chemical. In order to establish the current practice for control, a questionnaire was developed identifying 50 key questions of how project controls are carried out and > 20 companies were interviewed with regard to their processes. The results were analysed to establish how each element of project controls was utilised in each of the different industries. Tacit knowledge gained in particular from Oil & Gas and Pharmaceutical industry is also being recorded to determine for example best practice and transfer of best practice and –processes between industries.

The final outcome of the research will be to develop and test road-maps that would identify preferred project control appropriate for different industries/projects or portfolio's of work.

KEYWORDS: Project management, Oil & Gas, Planning,

OVERVIEW

The Project Management Institute (PMI, 1996) defines a Project as any undertaking with a defined starting point and objectives by which completion is identified. (A Guide to the Project Management Body of Knowledge, 1996 P4). The primary objectives of Project control are to deliver a project within budget and on schedule, with the level of quality and workmanship as stated by the client in the contract. To achieve these objectives teams need to have systems, processes and procedures which reduce or eliminate those functions that increase costs and duration of projects. The design of a project control is an important part of the project management effort Shtub, Bard and Globerson (2005).

Many articles have supported the importance of control in the achievement of the project aims. Project performance can be improved if more detail is given to the issue of Control (Avison, Baskerville and Myers 2001).

Although delivery of projects on time and within budget and with the required quality and safety is paramount to all businesses, there are still a high frequency of projects that are late and over-budget. Recent examples in the UK include the New Wembley Football Stadium and the Scottish Parliament building in Edinburgh, Scotland.

Also, the paper's authors had many examples of cost and time over-runs in a variety of industries including Oil & Gas, Nuclear, Chemicals, Roads & Transport and Petrochemicals. This tacit knowledge and experience identifies many positives and shortcomings in the control of projects that resulted in cost and time errors.

In this context, the aim of this research project is to investigate current processes, systems and procedures that affect the delivery of projects in the heavy civil engineering which include Oil & Gas and Pharmaceutical construction and installation. The ultimate objective is to develop roadmaps that would assist project managers to identify preferred project control appropriate for different industries/projects or portfolio's of work.

The Research Project had four phases :-

- Literature Review – this will establishe areas of best practice and areas of concern.
- Development of Questionnaire and Collection of Data from various sectors of Business.
- Analysing, comparing and contrasting Project Control Practices.
- Development and Testing of Tools towards Roadmap Guidelines. The data that is collected during the research will be used to develop "roadmaps" which will provide guidelines to improve the Project Controls and avoid project delays.

This paper provides a summary from the research investigation that examined Project Controls. In detail it reviewed the following activities:-

- Cost Control/Work Breakdown Structure
- Estimating
- Cost Control
- Schedule Control
- Critical Path Planning/Completion date
- Change Control
- Reporting

The above reflect the core requirements of a robust Project Control system.

Research Objectives

The objectives of Project Controls research were to :-

- Carry out a detailed literature review, review considered best practice, what others are doing and common causes of failure.

- Collect data from a variety of industries on how Project Controls was utilised and which systems, processes and procedures were utilised.

- Examine and analyse the data to establish trends, common problems and issues, also to determine if there was any co-relation between the various aspects of control failings.

- Develop a road map based on best practice and innovation in order to demonstrate improved systems, processes and procedures to enhance delivery of projects.

Purpose of the Research

For this research an investigation and evaluation of current industry practices related to Project Controls was carried out. The purpose of the research was to investigate Project Control processes in a variety of industries, compare against "best practices" and develop a "road map" which, if followed, could help improve the Project Control process. This would help to improve Project delivery and improve cost and schedule over-runs.

Methodology

The methodology used for completing the first objective of project controls research included studying information on project controls to determine the types of issues which were arising in industry. Also to determine best practice and ascertain what worked well in different industries.

A questionnaire containing 55 questions was developed to collect data on project controls. It was discussed in detail with 24 companies at a Project Control, Planning Engineer, cost Engineer and Project Manager level. The industries covered Nuclear, Pharmaceutical, Oil & Gas, Petrochemical, Buildings and Transportation. The value of work covered in the survey was in the order of £4 – 5 billion. The survey participants were also requested to provide recommendations on how systems, processes and procedures could be improved. The questionnaire structure is given in appendix A of this paper.

Results and Analysis

Survey participants comprised the following industries :-

Oil & Gas	4 responses
Pharmaceutical	3 responses
Nuclear	4 responses
Buildings and Construction	4 responses
Transport and Roads	3 responses
Chemical/Petrochemical	6 responses

The following section discusses the responses and analyse the results. and appendix A shows the questionnaire list and the question that were asked in each section.

Cost Control and Estimating

Figure 1 shows responses of the cost control and appendix A shows the type of questions that were asked. The key observations from the cost control responses were :-

- Changes not monitored, therefore surprises at the end of the Project.

- The need for increased updating of the budget.
- Cost control to be managed by cost engineers.
- Wrong resource managing cost control.

It is interesting to note that the wrong resource was quite often seen as a potential problem when controlling costs. Yates and Eskonder 2002 advised that “assigning the project to the wrong person” was a major factor in lack of control.

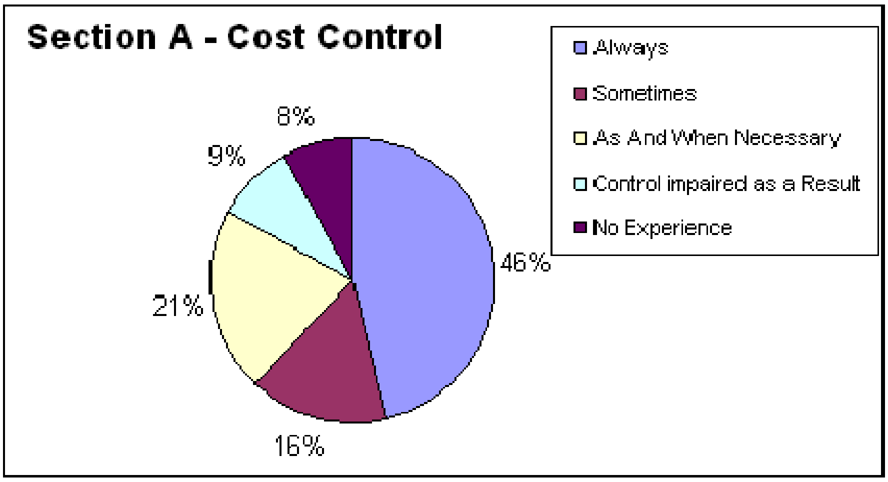


Fig 1: Responses from cost control and estimation questionnaire.

Key observations and recommendations for improvement for the estimation processes were :-

- Benchmarking previous projects and using the data for new project estimates.
- Improve quality of estimating personnel.
- Have a formal estimating system in place including norm values.

Schedule Control

Figure 2 shows results from schedule control questions. It is interesting to note that 14% of the personnel who completed the questionnaire advised that control of the project was impaired as a result of poor planning.

Key points derived from the research are as follows :-

- Inexperienced Project Managers who do not see the benefits of good planning.
- Planning training required for Project Managers and Engineers.
- Robust procedures in place.
- Baseline of the Project Plan.
- Buy in to the plan from management.
- Culture of industry is not conducive to best practice planning.

- Contractors to be aligned to client's needs and best practice.
- Client to have more involvement with contractor's planning.
- Use of standard planning software appropriate to the project requirements.
- Inexperienced Planning Engineers.
- Change control process to be implemented.
- Better integration between design and construction teams.
- Consider the use of visualisation 4D planning systems.

The need for a standard planning process was addressed in the paper – Effective Project Planning Techniques in the following statement "By adopting consistent procedures before a project begins, all parties can help eliminate costly assumptions and assure greater consistency and integrity in the use of the project schedule", Jensen, 1994 p. 66).

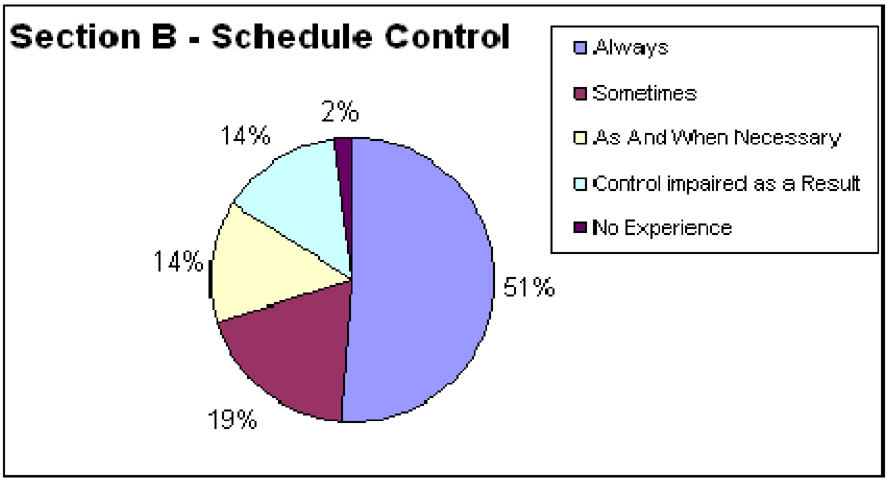


Fig 2 Schedule control

Change Control

Figure 3 shows schedule control summary analysis. The research indicated that almost 80% companies were using some form of change control process.

The major observation was that several organisations tracked changes from a cost management perspective but took no account of the impact of change to the schedule.

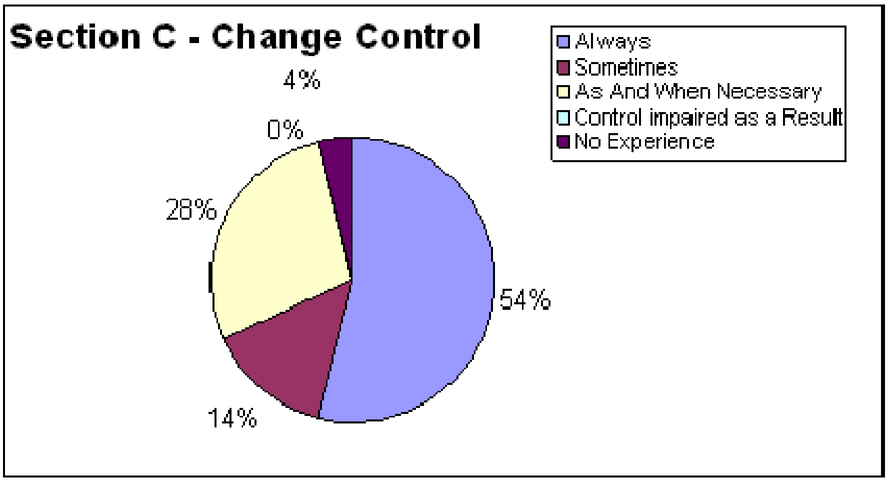


Fig. 3, Change control

Reporting of Projects

The research indicated the following key issues, with regard to Project Reporting and Reports :-

- Contractor's reporting needed to be in a standard format.
- Reports needed to be automated using planning and cost management tools.
- Planning and cost engineers using different cut off dates for reporting.
- Progress information not interrogated to establish trends and corrective actions.

KPI's and Earned Value Calculations

The use of KPI's and Earned Value calculations where discussed with clients and the following observations and recommendations were made :-

- 75% of clients were using EVA.
- 15% of clients' Project Control Specialists wanted client managers to implement EVA measurement.
- 10% of clients regarded EVA as "not required".

The use of the EVA principals to examine work performed cost versus budgeted cost is described in many text books, e.g. Sipper and Buffin, Raby 2000, Fleming & Koppleman 2000. EVA is recognised as a very common methodology for Project Control.

Industry/Cultural Effects on Project Controls

The research indicated that in keeping with Tacit Knowledge the North Sea Oil & Gas Industry was a "mature" Project Control model. The model developed and honed by North Sea operators and their major contractors in the 1980's was developed to ensure effective cost and schedule control of the £ billion investments to ensure timely completion within budget.

The culture of effective control was driven by a number of factors :-

- Return on Investment driven by the need to achieve oil and gas sales within a specified timeframe.

- Gas and Oil sales agreement established in advance with severe penalty payments.
- Heavy lift cranes booked 2 years in advance to install Jackets and Topsides in the North Sea. The need therefore to have construction completed on a specific date.
- £1 billion investments with several partners all of whom are themselves tied into finance agreements.
- The oil and gas industry also attracted top class practice specialists who were driven to provide good project controls. Hire the best people Cooper & Els (1997) studied one programme that cut off 25% off the schedule and 39% of the manhours from this one factor.

The culture developed as a result of the above factors was responsible for the introduction of many enhancements in Project Controls. The enhancements in project controls developed in the 1980's have since spread into many construction companies and other industries. The systems included :-

- Procedures for Cost, Planning and Estimating
- Effective schedule development
- Procurement schedules
- Design interface schedules
- Look ahead schedules
- Progress measurement innovation
- Productivity calculations
- Reporting techniques and corrective action techniques
- Change Control Procedures developed
- Improved Cost Management Processes
- Estimating techniques aligned to scope definition and cost control
- Integration of contractor's procedures, systems and processes

"Differing cultural factors in businesses can also influence how development and implementation of systems can be carried out. Cultural factors may include company history and tradition, lender influence, technology, industry competition, legislation and company environment, missions, visions, value and beliefs, organisation and resources". (Goodman 1997).

Also missing from Goodman's list is Commercial Drivers, i.e. sales agreements and rate of return on investments.

The collection of data via the survey indicated that some industry's project controls approach was influenced by different cultures from that shown in the oil industry for example.

Conclusion and future research

Analysis of the data has identified methods and processes that work and those that do not within the various sectors of business. Armed with this information coupled with tacit knowledge and many years' experience within projects and project controls we can then develop a model/toolkit/road map to demonstrate how to improve Controls and Project delivery. We need to be mindful, however, that not all projects/businesses are the same and that no single set of techniques can be universally applied.

These tools will be based on, for example :-

- Process flow sheets
- Improved procedures/guidelines
- Software recommendations
- 4/5 D planning software
- Training considerations
- Knowledge management
- Industry needs (which may be different for each sector of Industry)
- How we can transfer knowledge and processes between industry sectors
- Best practice considerations from experience and literature review
- Theory of PMBOK
- Organisational cultures

Following the development of models/toolkits/road maps it is then possible to review processes with live programmes and projects.

References

Cooper Kenneth Co & ELS Sharon (1997 Oct) Failing to Learn – Learning to Fail OLCA/TIMS Conference, Dallas, TX.

Globerson, S & Zwikael, O (2002) The impact of the Project Manager on project management planning processes. Project Management Journal 33(3) 58-65.

Aulson, D, Baskerville, R & Myers, M (2001) Controlling Research Projects. Information Technology & People 14 (1), 28.45.

Slitub, A, Bard, J & Globerson, S (2005) Project Management, Processes, Methodologies and Economies, 2nd ed. New York, Prentice Hall.

Sipper D and Buffin R Production Planning, Control and Integration, New York, McGraw Hill.

Raby, M (2000), Project Management Versus Earned Value, Work Study 49 (1) 6-9.

Fleming, Q.W, 4 Koppleman, JM (2000) Earned Value Management Project Management, Newtown Square, P.A. Project Management Institute.

Yates Janet K and Eskander A, Project Management Journal Volume 33, No. 1 37-48 (March 2002)

Jenson CA (1994 February) Effective project planning techniques. Civil Engineering Magazine, 9(2) 66-67.

APPENDIX: PROJECT CONTROLS QUESTIONAIRE

A = STRONGLY AGREE, B = AGREE , C = NEUTRAL, *D = DISAGREE*

General information

		A	B	C	D
1.	HAVE PROJECT GUIDELINES, PROCEDURES AND TOOLS BEEN PRODUCED , REVIEWED AND IMPLEMENTED FOR PROJECT CONTROLS.				
2.	HAS APPROPRIATE TRAINING TAKEN PLACE PRIOR TO IMPLEMENTATION.				
3.	ARE THE DISCIPLINES OF COST CONTROL, PLANNING AND ESTIMATING ALIGNED AND INTEGRATED VIA A OBS ,WBS, CBS				
Additional comments					

A COST CONTROL
WORK BREAKDOWN STRUCTURE

		A	B	C	D
4.	HAS A WBS BEEN ESTABLISHED AND ALL BUDGET COSTS CODED?				
5.	DOES THE CODING SYSTEM PROPERLY INTEGRATE WITH THE PROJECT ACCOUNTS CODES?				
6.	DO YOU CONSIDER THE WBS /CODING STRUCTURE IMPORTANT TO YOUR PROJECT(S)				
Additional comments					

ESTIMATING

		A	B	C	D
7.	Is there a build-up to each element of the original budget?				
8.	Has the estimate been checked and reconciled?				
9.	Has the estimate made provision for risk via QRA and has this been used to set contingency levels?				
10.	Has the estimate been updated at regular intervals to reflect changes in data and circumstances?				
11.	How could estimating be improved				
Can you elaborate on the software tools that can be used and the value of such tools. *Additional comments*					

B. SCHEDULE CONTROL
SCHEDULE DEVELOPMENT

		A	B	C	D
25.	HAVE SCOPE OF WORK AND DELIVERABLES BEEN ESTABLISHED WITH PROJECT TEAM?				
26.	HAVE RESOURCE REQUIREMENTS BEEN ESTABLISHED FOR EACH AREA OF WORK WITH THE PROJECT TEAM?				
27.	HAVE LOGIC CONSTRAINTS, MILESTONES AND KPIS BEEN SET?				
28.	HAVE PROJECT BASELINES BEEN SET AND RETAINED AS COMPARATORS? IS THE BASELINE USED TO MONITOR PLANNED V ACTUAL PROGRESS.				
29.	HOW COULD WE IMPROVE SCHEDULE DEVELOPMENT , TO OBTAIN A BETTER MODEL OF THE CONSTRUCTION SEQUENCE/PLAN				
Can you elaborate on the software tools that can be used and the value of such tools. *Additional comments*					

C. CHANGE CONTROL

CHANGE ORDER SYSTEM

		A	B	C	D
44.	HAS A CHANGE ORDER FORM/REGISTER BEEN FORMULATED AND IMPLEMENTED ACROSS THE PROJECT?				
45.	HAVE ALL COS BEEN APPROVED BY THE PM(S)?				
46.	ARE CHECKS MADE OF THE COST/SCHEDULE EFFECT OF ALL COS?				
47.	DOES THE CO SYSTEM WORK IS IT OF BENEFIT TO THE PROJECT, COULD IT BE IMPROVED IF SO, HOW				
Can you elaborate on the software tools that can be used and the value of such tools. *Additional comments*					

D. REPORTING
REPORTING

		A	B	C	D
48.	HAS AN INTEGRATED PROJECT REPORTING SYSTEM BEEN ESTABLISHED?ARE REPORTS ISSUED MONTHLY FOR EXAMPLE				
49.	HAVE REPORTS BEEN ISSUED FOR, OR INCLUDE A SECTION ON, COSTS, PLANNING, CHANGE AND A PROJECT NARRATIVE?				
50.	HAVE COMMITMENTS AND EXPENDITURE BEEN MONITORED?				
51.	HAVE PROGRESS AND PERFORMANCE BEEN MEASURED AND REPORTED?				
52.	HAVE RISKS BEEN IDENTIFIED, ASSESSED AND QUANTIFIED IN THE REPORTS?				
53.	HAVE TRENDS BEEN IDENTIFIED?				
54.	HAVE CORRECTIVE ACTIONS BEEN UNDERTAKEN AND THE RESULTS CHECKED AND REPORTED?				
55.	CAN YOU DETERMINE THE BENEFITS OF THE REPORTING PROCESS, COULD IT BE IMPROVED ?				

Can you elaborate on the software tools that can be used and the value of such tools.
Additional comments

UNDERSTANDING THE SOFTER SIDE OF COLLABORATIVE WORKING

Mark Shelbourn
Nottingham Trent University, Nottingham, UK
mark.shelbourn@ntu.ac.uk

Dino Bouchlaghem
Loughborough University, Loughborough, UK
n.m.bouchlaghem@lboro.ac.uk

David Kerr
Taylor Woodrow, Leighton Buzzard, UK
david.kerr@taylorwoodrow.com

Project collaborations and collaborative working are commonly used in construction projects; however, it has been argued that they are not being used to their full potential and in the correct context. The issues of where, how, and why should one work collaboratively are continuously being asked by construction professionals who are unfamiliar with collaborative working. Much of the recent work on collaborative working has focused on the delivery of technological solutions. However, it is now recognised by many researchers and leading industrialists that good collaboration does not result from the implementation of technological systems alone. The implementers of collaborative technology and procedures also need to address the impacts on the organisation and its people. This paper reports on the planning and implementation of collaborative working into real construction projects using a framework developed by research conducted at Loughborough University and a number of key industrial partners. It describes the issues concerning the more 'softer' aspects, i.e. the business process and people, as being more of a challenge. Using information captured in agreement with Taylor Woodrow, the paper shows the skills needed by project managers to fully embrace collaborative working into their projects requires further development.

KEYWORDS: collaborative working, information and communication technologies (ICT), people, skills

INTRODUCTION

Collaboration is not a natural way-of-working for everybody! Despite the enormous groundswell of interest in partnering and alliancing in recent years, there has been comparatively little research that has set out to investigate systematically the nature, feasibility, benefits and limitations of forms of project stakeholder collaboration (Bresnen and Marshall, 2000).

Since the 1980s many organizations and individuals have considered electronic collaboration of distributed teams as a means of achieving higher productivity and competitiveness, thereby improving the quality of their work products (COCONET, 2003). Research has observed that the current collaboration tool landscape is improving but at the same time is fragmented and lacking comprehensive solutions (COCONET, 2003). Many of the recent developments of collaborative working tools have focused on the delivery of technological solutions with a focus on the web, i.e. extranets, CAD (modelling and visualization), and knowledge management technologies and systems (Shelbourn *et al*., 2005; 2007). However, technology by itself is unable to provide a comprehensive answer to working collaboratively (Alvarez, 2001; Vakola and Wilson, 2002; Barthelmess, 2003; Ferneley *et al*., 2003). This may be because cooperative tasks in teams are increasing, and as a consequence the use of collaborative systems is becoming more pervasive (Dustdar and Gall, 2003). Approaches to collaborative working that purely focus on information technology have been seen to be less than successful, unless the organisational and people issues are considered as part of the implementation process (Grudin, 1994; Koschmann *et al*., 1996; Loosemore, 1998; Winograd, 1998; Eseryel *et al*., 2002; Baldwin, 2004). Implementing ICT into construction organisations also requires the bridging of many cultural boundaries (Crede, 1997; Proctor and Brown, 1997; Cheng *et al*., 2001). Managers of ICT implementations have to consider the barriers within the workplace that affect such introductions (e.g. the apprehensive nature of individuals to change) with a more strategic approach (Norton, 1995; Boddy and Macbeth, 2000; Maguire, 2002, Manthou *et al*., 2004; Erdogan *et al*., 2005).

This need was considered in research at Loughborough University in the UK. A project entitled: "Planning and Implementation of Effective Collaboration in Construction (PIECC)" aided project managers in construction organisations, throughout the supply chain, to introduce more balanced collaborative working into their projects. The remainder of this paper will demonstrate how implementing the results of the research into the Construction arm of Taylor Wimpey's processes and procedures have affected the needs of its employees in terms of their skills development.

THE PIECC PROJECT

The PIECC project had a focus on supporting strategic decision-making by highlighting areas where collaborative working could be improved incorporating the organisational (business), project and end users' needs. When carefully planned, and if based on informed decisions, it was believed that policies and protocols could help organisations improve their collaborative working, achieve better benefits from it, and maximize the use of tools and techniques that are currently commercially available.

The aims included a review of the current state-of-the-art in collaborative working – see Erdogan *et al*., (2005); Koseoglu *et al*., (2005); Shelbourn *et al*., (2005) and a requirements capture survey that gained the following requirements:

- **MODEL** – "*…a recognizable model for collaborative working does not exist at this time – it needs developing to enable a move forward…*"
- **MODEL** – "*…must build upon work being done in other aspects of collaborative working – the AVANTI programme for example…*"
- **PROCESS** – "*…processes that enable participants to agree a common vision & priorities for the collaboration – a route map for how the project is going to proceed, and must include suitable time for review of progress against vision & priorities…*"
- **PROCESS** – "*…procedures to promote trust in the collaboration – a key person needs to be in charge, they provide leadership, leading (hopefully) to better performance of the team, to build trust within the team…*"

- **PROCESS** – "…*a set of communication procedures that all stakeholders should use in the collaboration*…"
- **STANDARDS** – "…*standards that facilitate interoperability between different software and systems – we are fed up with learning a new system for every new project!!*"
- **STANDARDS** – "…*suitable (and appropriate) help templates/screens for users to familiarize themselves with the software tools. They are removed when a level of competence is reached*…"
- **GOOD PRACTICE** – "…*examples of good practice/case study material that shows tangible business benefits of collaborative working*…"
- **GOOD PRACTICE** – "…*evidence of good practice of collaborative working to be published to alleviate frustration of the industry*…"
- **DESIGN** – "…*intuitive interface design of software to reduce the requirement for training of new members of a collaborative project/environment*…"
- **LEGAL ASPECTS** – "…*clarification of professional liability of information generated. Who is responsible for the information generated and its trustworthiness? A right balance between the technology and professional liability is the issue to building trust*…" (Shelbourn *et al*., 2005).

Effective collaboration is only achievable through the innovative design and development of a more balanced 'collaboration strategy', that does not rely solely on ICTs. As yet there is little evidence (Shelbourn *et al*. 2007; 2007a) of such a 'strategy' existing that prescribes to project managers effective ways of implementing and managing collaborative projects. To develop a strategy the PIECC project produced a questionnaire and conducted a number of interviews with key industrial representatives. The next section summarizes the results of these questionnaires and interviews.

Using these requirements the research team set up a development group that consisted of industrial partners and senior researchers in the project. Over a twelve month period and numerous iterations a framework for effectively planning and implementing collaborative working was ready for testing – see figure 1.

The framework was built around the premise that there should be harmonization of three key strategies: business, people, and technology, split on a 40/40/20% basis. Six key areas must be represented in the three strategies. They are:

- **Vision** – all members of the collaboration agree on the aims and objectives;
- (Stakeholder) **Engagement** – managers need to ensure that all key participants are consulted as to the practices to be employed during the collaboration;
- **Trust** – time and resources are needed to enable stakeholders to build trusting relationships;
- **Communication** – a common means of communication is decided by all key participants in the collaboration;
- **Processes** – both business and project, that describe to all key participants how the collaboration is to work on a day-to-day basis;
- **Technologies** – an agreement on those to be used to ensure the collaboration is easily implemented and maintained.

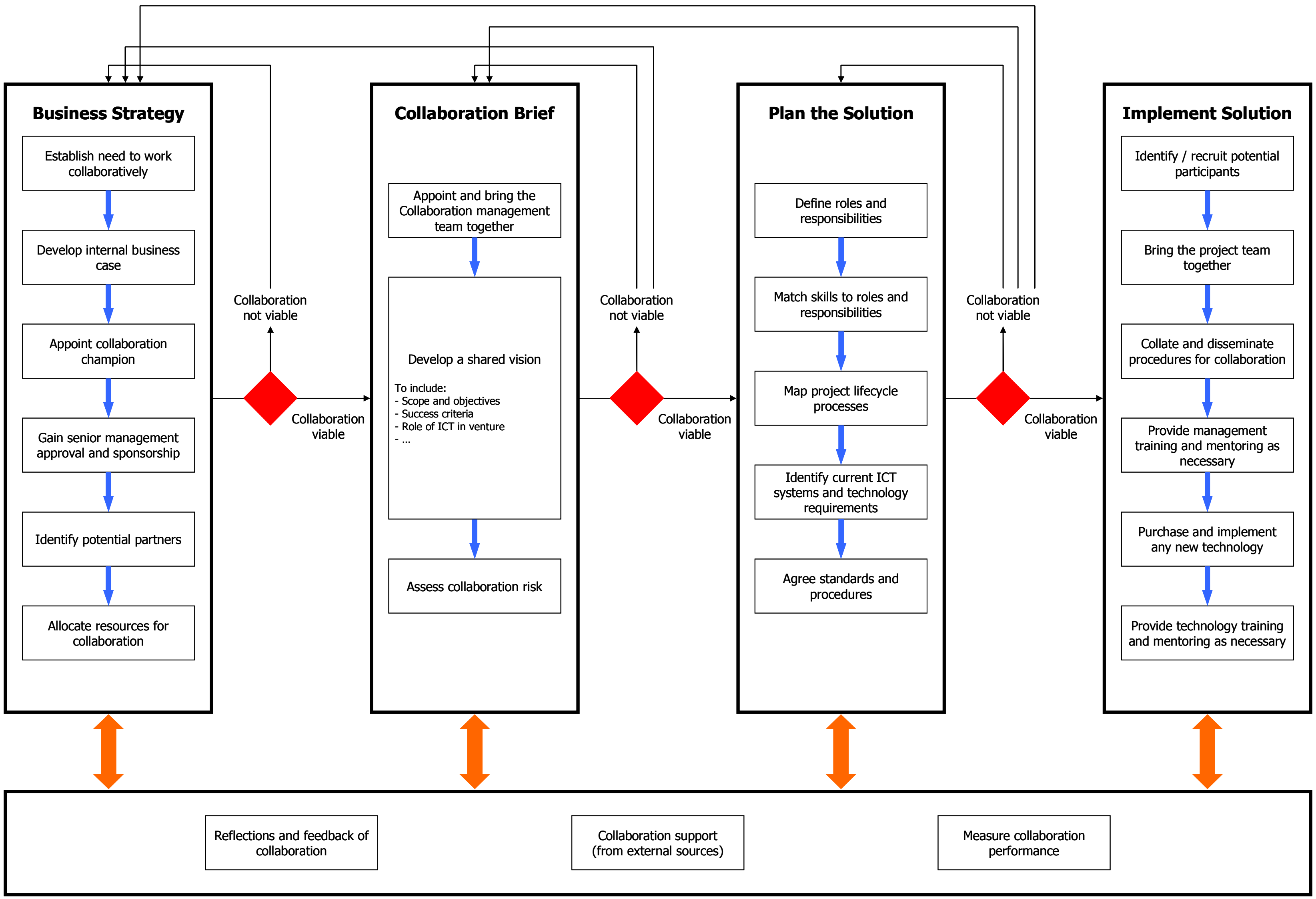

Business Strategy
Establish need to work collaboratively
Develop internal business case
Appoint collaboration champion
Gain senior management approval and sponsorship
Identify potential partners
Allocate resources for collaboration
Collaboration not viable
Collaboration viable
Collaboration Brief
Appoint and bring the Collaboration management team together
Develop a shared vision
To include:
- Scope and objectives
- Success criteria
- Role of ICT in venture
- ...
Assess collaboration risk
Collaboration not viable
Collaboration viable
Plan the Solution
Define roles and responsibilities
Match skills to roles and responsibilities
Map project lifecycle processes
Identify current ICT systems and technology requirements
Agree standards and procedures
Collaboration not viable
Collaboration viable
Implement Solution
Identify / recruit potential participants
Bring the project team together
Collate and disseminate procedures for collaboration
Provide management training and mentoring as necessary
Purchase and implement any new technology
Provide technology training and mentoring as necessary
Reflections and feedback of collaboration
Collaboration support (from external sources)
Measure collaboration performance

Figure 1: The PIECC decision making framework

The testing and evaluation exercise consisted of interviews with key industrial specialists in collaborative working and two workshops. Forty members from industry attended each of the one-day workshops where the PIECC framework was put under close scrutiny. To provide an overall summary of the testing and evaluation exercise of the PIECC framework it was prudent to bring the interviews and workshop results together. Shelbourn *et al*. (2007) summarised which of the PIECC framework's processes are the most important to effective collaborative working in projects. It was deemed that the most important processes in the PIECC framework were: 'appoint a collaboration champion', 'develop a shared vision', 'define roles and responsibilities' and 'agree standards and procedures'. It should be stressed that all the processes of the PIECC framework are considered important to the success of collaborative working.

From the concluding discussions of the industrial workshop it was seen that the PIECC project could improve team performance, thus enabling effective collaborative working. Using Bruce Tuckman's model for building successful teams (Smith, 2005) it was felt that if the PIECC framework was used it would probably reduce the distance between the teams' 'enthusiasm' and 'performance' during the 'forming' and 'storming' phases of the teams development. Tuckman's model would look significantly different as a result; see Shelbourn *et al*. (2007a).

TAYLOR WOODROW PROJECT IMPLEMENTATION

The PIECC project developed a framework to enable construction (or other project based industries) to agree procedures for new ways of working in a collaborative venture. Taylor Woodrow (TW), in particular their "Collaborative Working Group", was interested in furthering the research and using the framework in the projects where they were leading. The work with TW endeavoured to engage with their stakeholders in the early stages of projects and agree on the practices and procedures to work collaboratively. The framework was to be used to generate these agreements.

Before the framework went live with projects it was decided that all project managers within TW be assessed to see whether they have the appropriate skills to embrace collaborative working into their daily activities.

Self-Assessment of TW Project Managers

As part of their continuous development all project manages within TW have appraisals with their line managers. As part of this appraisal process the project managers fill in a questionnaire. This questionnaire forms the basis of the performance appraisal. The questionnaire has five sections, they are:

1. **Leadership** – this has questions on: (a) visions and values; (b) integrity and respect; (c) develops employees and delegates effectively; and (d) role model;
2. **Valuing our Customers** (demonstrating the competence of Customer Focus) – this has questions on: (e) personal commitment; (f) right first time; and (g) process focus;
3. **Getting things done** (demonstrating the competencies of personal drive and business and commercial acumen) has questions on: (h) inspires by example; (i) resilience and self confidence; (j) external effectiveness; (k) commercial focus; (l) opportunity – risk evaluation; and (m) decision making;

4. **Improving things** (demonstrating the competencies of Strategic Vision and Innovation) has questions on: (n) seeks and applies new ideas; (o) strategic implementation; (p) inputs to TW strategic vision; and (q) represents wider TW business;
5. **Working together** (demonstrating the competencies of communication and teamwork) includes questions on: (r) team working; (s) manages high performance teams; (t) builds effective teams; (u) sharing information; (v) credibility and trust; and (w) presence and influence.

TW provided the research with one hundred and twenty-three completed questionnaires from their managers. The total represented fifty percent of the total number of project managers that were active within TW at the time. For each of the questions the project managers gave a competency score between six and zero, six being the best. Table 1 shows the analysis of results in areas where the PM's felt they were 'best'. TW deemed that a score of five or above was said to be competent in that area. Only two areas of the questionnaire: Leadership – integrity and respect; and Valuing our customers – personal commitment, show a score of five or above, leaving twenty-one areas for improvement if the TW threshold is upheld.

The results from the individual project manager's scores were then totalled across each of the twenty-three questions and an average obtained. The scores ranged from 5.83 at the top of the range to 3.00 at the bottom of the range. The results showed that around a quarter of the project managers have an average score of five or above, suggesting that significant improvements maybe needed for PM's to be competent in a number of areas.

Collaborative working aspects of Project Manager's results

From the questionnaire, a number of questions can be linked directly to the requirements of being able to provide collaborative working effectively in projects. The research with TW showed that there was a single section from the questionnaire that directly relates to the skills needed to embrace collaborative working, i.e. working together. In this section TW build their project managers skills in areas including: team working; managing high performance teams; building effective teams; sharing information; credibility and trust; and presence and influence. Although these aspects are towards the bottom half of the results if matched against the results from the project manager's answers, it was felt by the team at TW that as all projects are built around teams, a short training course would enable more effective teams to be 'built' by collaborative project managers within TW.

After discussions with senior personnel in TW it was felt that the research should define a new role that encompasses collaborative working into the current project manager's profile. The new profile determined that a "Collaborative Project Manager" (CPM) should be responsible for the resourcing, development and implementation of collaborative working into a project. This is achieved through developing a common vision for the project; responsible leadership of a team; defining and communicating the objectives and constraints of roles and responsibilities of team members to deliver the end product on time, within budget and to the agreed quality. CPMs should provide expertise in ensuring project outcomes that maximises profit for TW and endeavours to exceed client expectations regarding quality, programme and budget thus portraying a positive image of TW to the client.

Table 1: Results of project managers self assessment questionnaires

Leadership – integrity and respect	1	5.15	Treats all relationships with integrity and respect. Trustworthy and reliable in dealings with staff. Respected by all employees
Valuing our customers – personal commitment	2	5.05	Takes an active lead in promoting the importance of long-term relationships with customers. Sets an example by intervening personally in problems which are escalating
Getting things done – resilience and self confidence	3	4.92	Goal oriented and confident but can be thrown or deflected by setbacks, obstacles or unexpected difficulties
Leadership – role model	4	4.89	Sets an example in several areas but may ignore or underplay some key aspects of role as leader
Getting things done – decision making	5	4.71	Generally decisive but displays limitations outside of immediate area of responsibility
Improving things – seeks and applies new ideas	5	4.71	Supportive of ideas for improvement at a local level. Listens and cautiously embraces change
Working together – credibility and trust	5	4.71	Credible communicator within area of expertise. Shares facts with clarity and makes time for preparation
Valuing our customers – process focus	8	4.66	Needs to demonstrate greater proactivity and commitment to the management of customer care processes
Getting things done – inspires by example	8	4.66	Results focused and sets challenging goals for self and team
Valuing our customers – right first time	10	4.59	A degree of commitment has been achieved but this must be extended to deliver more evidence of a right first time culture
Getting things done – commercial focus	11	4.55	Understands commercial fundamentals but does not manage these to optimum margin/profitability
Working together – builds effective teams	12	4.53	Partial success, team has recognisable strengths and weaknesses but has clear action plans for addressing weakness areas
Leadership – develops employees and delegates effectively	13	4.50	Seeks to delegate but is not wholly effective because of specific weaknesses in approach or in the development of capabilities in reports
Working together – team working	14	4.49	Effective within team context but less able to demonstrate team working with respect to other areas of the business
Working together – sharing information	14	4.49	Flexes style to meet the needs of any situation. Less competent when outside of ‘comfort zone’
Working together – manages high performance teams	16	4.45	Copes with tension in team situations. Addresses conflict areas but at times can be indirect and slow to do so
Leadership – vision and values	17	4.34	Transmits a team vision but does not link this effectively to the wider Taylor Woodrow picture
Working together – presence and influence	18	4.19	Can make a contribution to senior team level but lacks impact. Effective in certain types of influencing but limited range
Getting things done – opportunity – risk evaluation	19	4.17	Partial or patchy success in pursuing commercial opportunities – room for improvement
Getting things done – external effectiveness	20	4.04	Sees values in the role of other work groups as a driver of change in the business. Responds co-operatively to opportunities to work with or utilise resources outside team
Improving things – strategic implementation	21	3.91	Business plans do not entirely fit with Company Strategic Vision. Make efforts to ensure company wide initiatives are delivered locally but these are not always successful
Improving things – represents wider TW business	22	3.75	Selective or partial representation of wider Taylor Woodrow activities
Improving things – inputs to TW strategic vision	23	3.41	Seeks to engage with high level strategic forums but needs to develop ways to make more effective contributions

CPMs should have the following requisite skills to be able to fulfil this role: adaptability; shared situational awareness; leadership ability; interpersonal relations; co-ordinating; communication; and decision-making abilities. There are a number of key competencies that a CPM should have, they include:

- Teamwork – they act as a model in demonstrating very effective collaborative team working both within immediate team and wider TW team. They play an effective role as a member of the TW team;
- Communication – they should possess the ability to communicate effectively both verbally and in writing, demonstrate effective listening and questioning to check understanding, and persuade / influence others to gain agreement to and acceptance of ideas;
- Customer focus – they should work to understand customer needs, that meet and exceed expectations and establish and maintain longer term customer relationships;
- Business / Commercial Acumen – CPMs contribute to maximising TW's profitability by controlling cost. They try new ways of doing a job to gain efficiencies and consider the financial implications when making decisions;
- Personal drive – they inspire others through enthusiasm and commitment, with positive behaviour reinforcing their message. They set and achieve challenging goals and standards for self and others, and act as a role model;
- Innovation – they consistently produce imaginative ideas and solutions to problems. They help encourage innovation in others, are prepared to experiment, and are comfortable with managing risk; and
- Leadership – they shape vision and are a credible role model with the ability to inspire and develop others. They have the adaptability to manage and lead diverse groups adapting their style to suit any situation. They put themselves on the line to deal with difficult problems.

As collaborative working is seen as a means of improving the business activities of TW, the skills required to ensure that these key competencies are met take on more significance. An ability to display these skills in CPM's in TW should ensure that collaborative working becomes an every-day way of working in the future.

CONCLUSIONS

This paper has described research undertaken with Taylor Woodrow and their collaborative working team. It has shown the importance that collaborative working now plays in construction projects, and that the key research area is now focused on the 'softer' side – the people and business process aspects. The paper has demonstrated the skills areas where PM's within TW are strong and areas where improvements are needed if collaborative working is to be an every-day way of working in TW.

The importance of collaborative working to TW was summarised in a report by Tony Mrowicki (Head of Design Management at TW), where he stated in discussions with the research team that: "*in the delivery of design information there was no difference in the 4 of the 20 projects where the use of the collaborative working and TW's Standard Method and Procedure was used…*", however "*…the quality of the design information in these 4 projects* *was significantly improved, i.e. 90% in one project, 80% in another. The TW average is 74%, with some projects being as low as 50% - a half of all information needs to be reworked*."

REFERENCES

Alvarez, R. (2001) "It was a great system" Face work and discursive construction of technology during information systems development. Information, Technology & People. 14(4), pp. 385-405. MCB University Press;

Baldwin, A. (2004) Overcoming the Barriers to the Successful Introduction of Collaborative Technologies in Construction, Proceedings of the INCITE 2004 Conference Designing, Managing and Supporting Construction Projects through Innovation and IT Solutions. Langkawi, Malaysia, 18-21 February 2004, pp. 319-326;

Barthelmess, P. (2003) Collaboration and coordination in process-centred software development environments: a review of the literature. Information and Software Technology. 45, pp. 911–928;

Boddy, D. and Macbeth, D. (2000) Prescriptions for managing change: a survey of their effects in projects to implement collaborative working between organisations. International Journal of Project Management, 18(5), pp. 297-306. Elsevier Science;

Bresnen, M. and Marshall, N. (2000) Building partnerships: case studies of client-contractor collaboration in the UK construction industry. Construction Management & Economics. 18, pp.819-832;

Cheng, E.W.L., Li, H., Love, P.E.D. and Irani, Z. (2001) An e-business model to support supply chain activities in construction. Logistics Information Management, 14(1/2) pp. 68-77. MCB University Press;

COCONET (2003) Research Agenda and Roadmap. Context-Aware Collaborative Environments for Next-Generation Business Networks (COCONET IST-2001-37460). See http:www.europa.net;

Credé, A. (1997) Social, cultural, economic and legal barriers to the development of technology-based information systems, Industrial Management & Data Systems, 97(1), pp. 58-62. MCB University Press. ISSN 0263-5577;

Dustdar, S. and Gall, H. (2003) Architectural concerns in distributed and mobile collaborative systems. Journal of Systems Architecture. 49, pp. 457-473. Elsevier Science;

Erdogan, B., Anumba, C.J., Bouchlaghem, N.M., and Nielsen, Y. (2005) Change Management in Construction: The Current Context, Association of Researchers in Construction Management (ARCOM 2005), Ed. by. Farzad Khosrawshahi, 2, pp. 1085-1095, London, UK, 7-9 September 2005;

Eseryel, D., Ganesan, R. and Edmonds, G. (2002) Review of Computer-Supported Collaborative Work Systems. Educational Technology and Society, 5(2), 2002;

Ferneley, E., Lima, C., Fies, B., Rezgui, Y. and Wetherill, M. (2003) Inter-organisational semantic webs to enable knowledge discovery and dissemination: technical support for the social process, Proceedings of the 10th ISPE International Conference on Concurrent Engineering (CE 2003), Madeira (Spain), pp. 779-785;

Grudin, J. (1994) Computer-Supported cooperative work: its history and participation. IEEE Computer, 27(5), pp. 19-26;

Koschmann, T., Kelson, A.C., Feltovich, P.J. and Barrows, H.S. (1996) Computer-supported problem based learning: a principled approach to the use of computers in collaborative learning. In T. Koschmann (Ed.), CSCL: Theory and Practice pp. 83-124. Mahwah, NJ: Lawrence Erlbaum Associates;

Koseoglu, O.O., Erdogan, B., Nielsen, Y., Anumba, C.J. and Bouchlaghem, N.M. (2005) Visual Information Transfer using Mobile IT Solutions, Proceedings of the Tenth International Conference on Civil, Structural and Environmental Engineering Computing, Topping, B.H.V.(Editor), Civil-Comp Press, Stirling, Scotland, pp. 29-30;

Loosemore, M. (1998) Organisational behaviour during a construction crisis. International Journal of Project Management. 16(2), pp. 115-121. Elsevier Science;

Maguire, S. (2002) Identifying risks during information system development: managing the process. Information Management & Computer Society. 10(3), pp. 126-134. Emerald, MCB University Press;

Manthou, V., Vlachopoulou, and Folinas, D. (2004) Virtual e-Chain (VeC) model for supply chain collaboration. International Journal of Production Economics. 87, pp. 241-250. Elsevier Science Limited;

Norton, D.P. (1995) Managing benefits from information technology. Information Management & Computer Society. 3(5), pp. 29-35. MCB University Press Limited;

Proctor, S. and Brown, A.D. (1997) Computer-integrated operations: the introduction of a hospital information support system. International Journal of Operations & Production Management. 17(8), pp. 746-756. MCB University Press;

Shelbourn, M., Bouchlaghem, D., Koseoglu, O.O., and Erdogan, B. (2005) Collaborative Working and its effect on the AEC organisation. Proceedings of the International Conference on Computing in Civil Engineering, Cancun, Mexico, July 11^{th} – 15^{th};

Shelbourn, M.A., Bouchlaghem, N.M., Anumba, C.J. and Carrillo, P. (2007) Planning and implementation of effective collaboration in construction projects. Construction Innovation, 7(4), 357-377. MCB University Press Limited;

Shelbourn, M.A., Bouchlaghem, N.M., Anumba, C.J. and Carrillo, P. (2007a) Framework for effective collaborative working in construction. Management, Procurement and Law, 160(MP4), 149-157. Proceedings of the Institution of Civil Engineers;

Smith, M. K. (2005) “Bruce W. Tuckman – forming, storming, norming and performing in groups”, available at: www.infed.org/thinkers/tuckman.htm;

Vakola, M., and Wilson, I.E. (2002) The Challenge of Virtual Organisation: Critical success factors in dealing with constant change, Proceedings of the European Conference on ICT Advances and Innovation in the Knowledge Society (eSM@RT 2002 in Collaboration with CISEMIC 2002), Rezgui Y., Ingirige B., Aouad G. (ed.), Salford (UK), 18-21 November, Part B, pp. 264-275;

Winograd, T. (1998) A Language/Action Approach on the design of cooperative work. Human Computer Interaction, 3(1), pp. 3-30;

A governance framework for sustainable development in the built environment

Authors:

Alan Gilham
Director, Sustainability Works Limited,
93 Chatterton Road, Bromley Kent,
UK

AND

PO Box KD 223,
Kanda, Accra,
Ghana.
Email: alangilham@Sustainability-works.com

Obas John Ebohon BA (Hon) MA PhD LLM MIE
Reader in Energy, Sustainability, and Development
Director, Developing World Built and Natural Environment Research Unit
De Montfort University
Leicester, LE1 9BH
Email: ebohon@dmu.ac.uk

ABSTRACT

This paper describes the outcomes of a research project seeking to develop and test a governance framework suitable for use in the built environment sector of developed and developing countries. The research was inspired by the need identified by construction professionals at the WSSD for a 'common framework of understanding' which would encourage sustainable development in the built environment sector.

The governance framework was developed from critical analysis of global literature, exploring the interaction between governance, sustainable development, and the built environment sector.

The critical analysis identified the components of the governance framework which were validated through a comparative analysis of the current state of governance arrangements in the built environment sectors of the UK and Ghana and further validated with policy makers and practitioners of Ghana's built environment sector.

The paper describes the governance framework, its significance in analyzing performance, and how it can enhance decision and policy making in the built environment.

1.0 Background and objectives of the research project

This project started with an idea that, in the context of achieving sustainable development in the built environment sector, a new approach was needed. At the World Summit for Sustainable Development, built environment policy makers and practitioners had expressed a need for a 'common framework of understanding' (GABS, 2002). Having previously worked on the challenges of decision making for urban sustainability with CIB Task Group 38 and explored the need for a 'framework of understanding' for business (Gilham, 2000) the author prepared this project to identify a suitable framework that would improve decision making for sustainable development in the built environment sector as a whole.

Priori theorising indicated the suitability of governance as a topic of consideration and the possibility that a governance framework offered a potential solution. The research question was therefore cast as: *"would a governance framework for the built environment sector provide a framework in which decision making for sustainable development can be improved for all built environment stakeholders?"* With an added dimension of testing for developed and developing countries, the case study method was used with the focus being the built environment sectors of the UK and Ghana.

The project aimed to:

- Construct a functional governance framework for sustainable development in the built environment sector
- Test the developed framework to ensure its global functionality and practical application in developed and developing countries
- Demonstrate the centrality of a governance framework as a mechanism for effective analysis and decision making between diverse stakeholders in which performance for sustainable development can be improved.
- Establish through the framework universal policy guidance on how to improve sustainable development performance in the built environment sector of the economy in developed and developing countries

2.0 What is a Governance Framework?

Governance, considered part of the political sciences and differentiated from Government as a system for decision making and social order, has through demands for globalisation and sustainable development, emerged as a topic in its own right. Mainstreamed through a process of policy formulation, research and practice, governance has emerged as two agendas, ie:

- Global governance – dealing with the relationships between and behaviour of governmental, intergovernmental, non-governmental and private sector organisations;
-
- Corporate governance – dealing with the relationships between and behaviour of companies, their Directors and critical stakeholders.

Agenda 21 (UNSD 1992 and 2002) set out a comprehensive programme of measures for sustainable development including institutional reform and capacity building that aimed to create the 'social organisation' originally identified by Brundtland (WCED, 1987) as a limitation on achieving sustainable development. It is through the gradual implementation of the sustainable development agenda (UN General Assembly, 2000, 2001; and WSSD, 2002) that both: Global governance - seeking to reform and build capacity at intergovernmental and national levels; and Corporate governance - seeking an extension of the corporate governance framework to include social, environmental and economic factors, have merged to become an essential enabler for sustainable development.

However, whilst governance lies at the heart of sustainable development and whilst sustainable development is a critical and well established area of research and knowledge development for the built environment sector, governance and other socio-cultural issues have largely remained unexplored in the built environment sector. The need for new decision-making tools in the sector has been evident since Vanegas et al (1996) showed us in Bourdeau et al (1998), that sustainable development in the built environment sector extended decision making from predominantly project-based time, cost and quality considerations, to the wider impacts of resource consumption, emissions and biodiversity and subsequently include wider ranging issues such as social equity, economic constraints and environmental quality. Thus decision making for sustainable development is challenging, extending traditional spatial and temporal boundaries and, when analysed from a governance perspective, it challenges stakeholder sovereignty, institutional capacity, established systems and hierarchies as well as exposing core values of stakeholder groups to comparative scrutiny.

Through analysis of governance literature, a Governance Framework has been determined to comprise four key components:

1. A shared vision or purpose statement (GoG, 1999) and (CACG, 1999 and 2004)
2. Key stakeholders including directors and policy makers (OECD, 2004), (Adei and Gilham, 2003), (CACG, 1999 and 2004), and (IIA/KPMG, 2003)
3. Key drivers – ie Legal, regulatory, fiscal requirements, 'market-forces' and voluntary standards (GoG, 1999; Iskander and Chamlou, 1999; OECD, 2004)
4. Capacity of organisations and governance structures (IIA/KPMG, 2003; Adei and Gilham, 2003; Iskander and Chamlou, 1999)

Within these components internal and external features come together in different ways to create a range of governance requirements that reflect specific market structures, traditions, regulations and cultural and societal values. Once determined, the main function of a governance framework is to inform the development of all corporate (governmental and non-governmental) strategies ensuring that effective measures are taken to satisfy the standards required of it. A governance framework is a strategic management tool for organizational leaders and policy makers enabling them to develop effective strategies for the management and development of their organizations which satisfy their corporate objectives and comply with good governance principles (King 2002).

3.0 The Method of validation for the built environment sector

3.1 Sustainable development in the built environment sector

Having determined a Governance Framework, it was necessary to validate the framework for achieving sustainable development in the built environment sector. This was achieved through a thorough analysis of CIB's Agenda 21 documents (CIB, 1999 and CIB/UNEP 2002), selected because of their global applicability and comprehensive attention to 'process' issues as much as technical issues.

There was a systematic analysis of the CIB reference documents to identify and analyse references that fit into each of the (i) Vision or Purpose component; (ii) Stakeholder component; (iii) Key Drivers component; and (iv) Capacity component. A review of the issues affecting developed and developing countries completed this part of the validation process.

The analysis showed that the Governance Framework was applicable to the requirements for achieving sustainable development as set out in the CIB Agenda 21 documents.

3.2 Validation for a developed (UK) and developing (Ghana) country

In order to provide a consistent framework for comparison and to make use of significant studies in which the author was involved (WSP 2006 & Nathan 2006), the analysis was structured to review the current policy and legal frameworks for sustainable development affecting the sector and analyse also the functionality of the sector looking at 'how things work' in three functional areas of: (i) sustainable development policy formulation and coordination; (ii) developing and enforcing laws and regulations; and (iii) implementing policies, programmes and projects aimed at achieving sustainable development.

In seeking clarification of the key governance components from the perspective of satisfying policy and functional requirements it was possible to explore the governance measures in place in the countries studied and subsequently identify the gaps and potential relevance and uses for the Governance Framework.

The findings identified four key components of the Governance Framework essential to decision making. Not only where many governance issues common to both case studies but also identified some stark differences in the completeness of the governance frameworks for the UK and Ghanaian built environment sectors. For example, the almost total lack of policies, regulations, institutional and enforcement capacity in Ghana illustrated how gaps in the governance framework had a significant impact on basic performance standards let alone performance standards expected for sustainable development.

3.3 Contingent valuation of the governance framework with policy makers and practitioners in Ghana

Ghana's built environment sector was used as a case study in which a contingent valuation method was used to identify and compare the preferences of local policy makers and practitioners with the theoretical framework. Data was collected in the controlled environment of a national workshop from 4 focus group sessions and 11 keynote speakers. Analytical techniques were applied to the qualitative data, to compare the outcomes with the theoretical framework.

Whilst there was widespread correlation between the preferences of participants for the four key components of the Governance Framework, the findings have prompted the introduction of new groups, sub-groups and issues which reflect the experiences of policy makers and practitioners in Ghana.

4.0 Key Findings of the Research

4.1 Governance as an indicator of Sustainable Development

As was determined in the early stages of this study, Sustainable Development is both an output and a process. The process is concerned with decision making involving multi stakeholder interests to identify the most appropriate economic, environmental and social development solutions. Whilst not the primary concern of this Study, the literature and case studies has revealed fundamental differences in what sustainable development solutions are in practice in developed and developing countries. The literature and case studies have consistently demonstrated how the lack, or failure, of key governance components affects performance.

The stark differences exposed in this study suggest that a weak or inadequately developed governance framework could be THE single most important differentiator in performance of developed and developing countries' built environment sector and therefore a clear indicator of a country's ability to achieve a sustainable built environment.

The comparison between the two case studies provides a perfect example in that:

- The lack and failure of key components such as policy, regulation, enforcement, management, supervision and logistical support means that the Ghanaian built environment sector cannot be relied upon to achieve even the most basic construction standards let alone sustainable development, which is more demanding.
- The comprehensive framework of policies, laws and regulations either force or enable key stakeholders in the UK's built environment sector to address complex sustainable development issues.

It became evident in the analysis that some Components of the Governance Framework may be more critical important than others.

4.2 The Vision/Purpose Component:

A clearly stated vision, as expressed in policies and strategies, was shown in the literature to demonstrate leadership and intent, mainly on behalf of Government but, some corporations demonstrated leadership by their early declaration of sustainability strategies, etc, In the case of the UK Government's declaration of intent in their Sustainable Development strategies (1999 and 2005) and subsequent Sustainable Construction Strategy (2000), sector stakeholders were able to combine and coordinate their efforts which, over a period of 8 years have gradually influenced demand and supply-side stakeholders to integrate sustainability into built environment performance targets.

A Vision which demonstrates leadership by a government or corporation appears to be critical in both developed and developing countries, and the different approach of Governments in Ghana and the UK towards sustainable development in the built environment sector provide us with a clear indicator of likely performance.

4.3 The Stakeholder Component:

Good governance requires the involvement of stakeholders from Government, the private sector and civil society. The UK case study demonstrated how wide ranging stakeholders are involved in the various functions of policy formulation, regulation and implementation (SDC 2006, SBTG 2004). In the case of Ghana, there is less stakeholders' active engagement in Ghana for several reasons. Firstly, government ministries, agencies and departments tend to carry out all of the major functions of policy, regulation and implementation; although in recent years some construction works are now contracted to the private sector. Secondly, civil society and private sector organizations are relatively less well established and organised, and often poorly resourced, thereby limiting their impact and effectiveness. Thirdly, there are few formal mechanisms for involving non-governmental organizations in the functions of policy formulation and regulatory development.

Perhaps the most critical factor for stakeholder engagement is the availability of mechanisms that allow and enable stakeholders to be engaged constructively in consultation. Once again the case studies provide a stark comparison, not only in the number of stakeholders involved in the various policy development and implementation processes, but in the formal mechanisms by which involvement is possible. For example, the UK has a wide range of consultative mechanisms in which built environment stakeholders are involved at various levels of policy formulation and regulatory developments. Until recently there were no formal mechanisms established for stakeholders in Ghana's built environment sector to consult with Government on polices that affect the sector. The Government has recently introduced a requirement that Strategic Environmental Assessment is carried out on all new policies and this gives stakeholders a new opportunity to participate in the process. Structured consultations, including regional and national workshops, have also been held for the recently completed National Transport Policy (Nathan 2006).

Therefore, in order that stakeholders get the opportunity to participate in policy formulation and implementation, it is essential that formal consultation mechanisms are created by governments.

4.4 The Key Drivers component:

A range of Drivers have been identified in the Governance Framework. Whilst all of them contribute to a comprehensive approach to sustainable development some appear to be more critical than others. For example, Government policy, national laws and enabling measures.

In the UK, Government and its agencies (EA, 2002) have been the promoters sustainable development by their insistence on improved performance in the built environment projects it has commissioned. In Ghana, Government projects are known for their failure to include environmental standards and, through poor management and supervision of the works, consistently reward poor contractor performance (Gilham et al, 2007, MOT 2008). Furthermore, the failure to enforce even basic standards of planning, building regulations, and infrastructure provisions has lead to consistent infrastructure failures exemplified by collapsing buildings and premature rehabilitation costs. The formula used for prioritizing investment in Ghana's infrastructure shows little concern for environmental and social sustainability whilst leading to investment choices that are not economically unsustainable (WSP, 2006).

The lack of well trained and resourced private sector affects the performance of Ghana's built environment sector in several ways. One of which is to limit the effectiveness of competitive bidding as there are a limited number of competent contractors available for major projects. Another is the lack of appreciation of 'market forces' and therefore Ghana lacks the driving force of a 'market' demanding higher performance standards.

The absence of effective market forces means that government regulation becomes increasingly important as a key driver for sustainable development. Therefore, Government policies, national laws, market regulations and their enforcement are critical sub-groups of the Key Drivers component.

4.5 The Capacity Component:

In the analysis of interdependent policy, governance and institutional frameworks, capacity is a critical component of both governance and institutional frameworks.

Evidence shows how the lack of capacity can lead to poor performance and failures even where institutions and regulations are in place. Often treated as the last piece in the jigsaw, the analysis shows how there is a need for capacity in five groups:

- Cultural capacity – to apply core values and bring about change
- Performance management – ability to strategise and formulate policies and regulations
- Performance management – ability to implement and enforce
- Technology – including hardware, software and know-how
- Personal knowledge and skills - for leadership and management

5.0 Practical applications

There are two practical applications on which to report so far. Both are a result of the experiment in Ghana.

5.1 The National Workshop on Governance and the built environment sector:

The Governance Framework was used as a basis for exploring governance issues associated with Ghana's built environment sector. The event provided the platform on which Ghanaian built environment stakeholders came together to build a vision and develop a strategy for development in the sector. There was representation from Ministers, Ministries, various departments and agencies of Government and Local Government, all built environment professions, and contractors. It demonstrated that, when given such a platform, built environment stakeholders were willing to develop joint strategies and plans for performance improvement in the sector. A communiqué was issued to Government at the end of the workshop and the Architects Registration Council plans to publish the output report as soon as funds are available. Collaboration between the professional bodies has continued since the event.

5.2 National Transport Policy and Institutional Reform:

In January 2005, the (then) Ministry of Road Transport commenced two closely related projects to review the policy and institutional arrangements for the road sub-sector in the context of national development and the transport sector as a whole. During 2005 and 2006, both projects progressed through a comprehensive programme of review, analysis and consultation with wide ranging stakeholders including Politicians, Government, Civil Society and Development Partners.

The projects have resulted in Ghana's first National Transport Policy, currently in Draft White Paper format, awaiting submission to Cabinet and a Government-owned strategy and implementation plan for institutional reform in the roads sub-sector. (IRWG 2007) They provide a good example of how a 'governance-led' approach provides an objective method for evaluating performance and reform options and also shows how the Governance Framework has been embedded in National Transport Policy.

This extract from the Policy document illustrates the centrality of good governance to the sector and how the policy document is a key driver of good governance.

> *Good Governance requires increased transparency and accountability from policy makers and providers. By setting out the strategic objectives for the Transport Sector against which the performance of policy makers, practitioners and providers of transport infrastructure and services can be measured and by which they can be held to account; this Transport Policy becomes a key driver for good governance in Ghana (MOT, (2007).*

The Policy sets out a range of 'Policy principles' making reference to a wide range of governance issues identified in the Governance Framework as well as the overall importance of the Governance Framework in achieving performance improvement in the roads sector. For example, Principle 2.2 Integrated Policy, Governance and Institutional Frameworks, is based on the principle that Ghana's policy framework is changing due to the need for sustainable development and good governance. This requires that the objectives for the Transport sector, as with other sectors, are changing and therefore the governance framework needs to change. With changes in the governance framework comes the need for new institutional capacity to fulfil the new functionality, roles and responsibilities. Furthermore, the structured governance-led analysis has enabled critical governance measures to be integrated into strategies aimed at improving performance for national development.

6.0 Conclusions

The Governance Framework as developed and tested in this project is widely applicable. As was determined in the literature, all sectors and all organizations have a governance framework in which they operate. Therefore, whilst the Framework has been developed with the Built Environment Sector in mind, it can be adapted and applied to other sectors of the economy.

However, the most important 'replicability' considered for the Governance Framework is the possibility of global application of the Framework to the built environment sectors of the developed and developing countries. The conclusion from the findings is that, whilst the relative importance of each component of governance framework varies, and this depends on the prevailing economic, environmental and social conditions in each country. Factors such as different constitutions and legal frameworks, country cultures, philosophies and language may hinder the use of governance framework in some countries. However, on the basis that the case studies were carried out in the UK and Ghana it is most likely that replicability is possible both the developed and developing countries provided the necessary institutional prerequisites are in place to underpin sustainability initiatives.

The general conclusion is that the research project has achieved its main aim of developing a Governance Framework suitable for achieving sustainable development in the built environment sectors of developed and developing countries. It has been demonstrated how a governance-led approach provides an objective decision-making framework to underpin the drive for sustainable built environment.

7.0 REFERENCES

- Adei, S., Gilham, A., (2003) *Introduction to Corporate Governance*, Accra: Ghana Institute of Management and Public Administration (GIMPA)
- CACG (1999) Corporate Governance Principles – Guidelines. London: Commonwealth Association on Corporate Governance and on www.cacg-inc.com site last visited November 2004
- CACG (2004) *Guidelines for selection of Boards for Government Owned Enterprises in Commonwealth Countries* – draft for consultation. Commonwealth Association of Corporate Governance (CACG) posted on http://www.cacg-inc.com/documents/draft-director-selection-guideline-govt-boards.doc
- CIB (1999) Agenda 21 on Sustainable Construction, CIB Report 237, Rotterdam, The International Council for Research and Innovation in Building and Construction (CIB)
- CIB & UNEP-IETC(2002) *Agenda21 for Sustainable Construction in Developing Countries a discussion document*, Boutek Report no BOU/E0204 Pretoria, The International Council for Research and Innovation in Building and Construction (CIB) & United Nations Environment Programme International Environmental Technology Centre (UNEP-IETC)
- DETR, (2000) *Building a Better Quality of Life – A Strategy for more Sustainable Construction*, London: Department of Environment, Transport and the Regions
- EA (2002) Sustainable Construction policy published by Environment Agency
- GABS (2002) Global Alliance for Building Sustainability: Aspirations and Reality, Parallel session to WSSD held on 29th – 30th August 2002, Johannesburg
- Gilham, A., (2000) *Sustainability: understanding the business perspective*, British Institute of Architectural Technicians (BIAT) conference Dublin
- Gilham A, Abbey Sam, K (2007) *Road Maintenance and Funding Management* a final report for the Ministry of Transportation, Ghana
- GoG (1999) Common Development Framework – Governance plan. Accra: Government of Ghana (GoG)
- IIA/KPMG (2003) *The Corporate Governance Framework*. London: Institute of Internal Auditors (IIA)
- IRWG (2007) Final Report from the Ministry's Institutional Reform Working Group
- Iskander M, Chamlou N, (1999) *Corporate Governance: A framework for implementation*, Washington DC. The World Bank Group
- King M (2002) *King Report on Corporate Governance for South Africa*, Executive Summary, Parklands, Institute of Directors South Africa
- MOT (2008) Report of the Ministry's Special Monitoring Team
- Nathan (2006) National Transport Policy, Draft Green Paper for the Ministry of Transportation, Ghana (September 2006)
- OECD (2004) *OECD Principles of Corporate Governance*. Paris: OECD
- SBTG (2004) Better Buildings – Better Lives: the Sustainable Building Task Group Report
- SDC (2006) Review of sustainable development in the English Regions; Sustainable Development Commission (SDC).

- TI (2003) *Transparency International Corruption Perceptions Index 2003*, www.transparency.org
- TI (2005) *Global Corruption Report 2005* special focus: Corruption in Construction and post-conflict reconstruction
- UK GOV (1999) A Better Quality of Life
- UKGOV (2005) Sustainable Development Strategy
- UN General Assembly, (2000) *Millennium Declaration*, UN Report of the Secretary General A/55/L.2 on www.un.org/millennium/declaration/ares552e.htm site visited February 2004
- UN General Assembly, (2001) *Road Map towards the implementation of the United Nations Millennium Declaration*, UN Report of the Secretary General A/56/326 para 6
- UNSD, (1992 and 2002) *Agenda 21 Issues*, UN: also on http://www.un.org/esa/sustdev/issueslist.htm (ch 27,28,29,30,31, 34,36,37,38,39,40) site visited November 2003
- Vanegas, DuBose & Pearce (1996) in Bourdeau L, Huovila P, Lanting R, Gilham A (1999) *Agenda 21 for Sustainable Construction.* Rotterdam: CIB
- WB (2003) '*Governance indicators'* based on governance indicators identified by D. Kaufmann, A. Kraay, and M. Mastruzzi (2003): Governance Matters III: Governance Indicators for 1996-2002 on World Bank web site Governance and anti-corruption data by country at a glance at http://info.worldbank.org/governance/kkz2002/sc_chart.asp?Country_ID=
- WCED, (1987) *Our Common Future*, Oxford: Oxford University Press
- WSP (2006) Institutional Study of the Transport Sector – for the Ministry of Transportation, Ghana, FINAL REPORT (September 2006)
- WSSD, (2002) *Johannesburg Declaration on Sustainable Development*, Johannesburg: UN and on http://www.un.org/esa/sustdev/documents/WSSD_POI_PD/English/POI_PD.htm site visited December 2003

APPLICATION OF PUBLIC PRIVATE PARTNERSHIP (PPP) MODEL IN PROCURING INFRASTRUCTURE PROJECTS IN HONG KONG

Albert P.C. Chan, Patrick T.I. Lam, Daniel W.M. Chan, Esther Cheung*
The Hong Kong Polytechnic University
*Corresponding author: bsesther@polyu.edu.hk

Hong Kong has been one of the early jurisdictions to adopt Public Private Partnership (PPP) model for delivering large public infrastructure projects. The development of this procurement approach in Hong Kong has followed an intricate path. As such, it is believed that there are a number of areas which are interesting to unveil. As part of a comprehensive research study looking at implementing PPPs in Hong Kong, interviews with experienced local industrial practitioners were conducted. Amongst these interviews, seven were launched with past and present Government officials from different relevant local Works and Administrative Departments. This paper presents the analysis of these interviews which helps to answer some of the queries that both academics and the private sector are keen to follow up with. The interview findings show that the retarded adoption of this approach has been due to the public sector being able to afford public infrastructure projects comfortably using taxpayers' monies, since recent budgets have recorded surplus. To bring in private sector finance may not always be the best value for money. Instead observing the success of PPP projects in other jurisdictions has triggered the Government's interest to introduce innovation and efficiency. Therefore it was found that in general, the public sector welcomed this form of procurement. In addition, the Hong Kong SAR Government has been keen to learn from the good experience of other jurisdictions by seeking advice from various consultants and experts. It can be observed that the interviewees exhibited a positive outlook for PPPs and are keen to explore its benefits for the right projects. The findings from this paper are expected to provide a clearer insight into how government officials perceive PPPs; as a result the private sector can gain a clearer understanding of what is expected from them.

KEYWORDS: Public Private Partnerships (PPP), Procurement, Infrastructure Projects, Hong Kong.

INTRODUCTION

Public Private Partnership (PPP) is a procurement approach where the public and private sector join forces to deliver a public service or facility. In this arrangement normally both the public and private sector will contribute their expertise and resources to the project and share the risks involved. The definition of PPP may differ slightly between different jurisdictions, depending on which part of the arrangement the importance is focused on. But in general PPPs can be any agreement where the public and private sectors work together to deliver a public project. PPP is a relatively modern term for this arrangement used only more commonly in the last decade. Previously different variations of the arrangement included Private Finance Initiative (PFI), which is a more familiar term to many people due to its successful development in the United Kingdom (U.K.) during the early nineties (Tieman, 1992). It would not be incorrect to say that the PFI practice developed in the U.K. raised the world's attention to this alternative option for delivering public infrastructure and services. The extent to which PFI could be used and the advantages created were the main drivers attracting other countries to start adopting or improve their practice in PPP. A more specific term used more commonly a decade ago is Build Operate and Transfer (BOT). This arrangement was commonly adopted for transportation projects. This is because transportation projects tend to be larger in size and also because their long physical lives fit well into the procurement mode. Earlier this century, concession was a common form of PPP. These early concessions mainly occurred in Europe (particularly in France) for water projects (Grimsey and Lewis, 2004). Although water projects tend not to be particularly large in project sum, it was noticed early on the advantages of introducing private expertise to deal with tasks that the public sector was probably not as efficient or experienced in carrying out the works. Although a long history if PPPs has been recorded, many jurisdictions are still unclear of how to maximize the benefits and avoid the risks which could occur.

HONG KONG'S PPP EXPERIENCE

Hong Kong is not completely new to the idea of PPP. In actual fact the city was probably one of the first to utilize resources from the private sector. The term PPP may sound revolutionary to Hong Kong, whereas a more familiar term is BOT. The concept of BOT has been used since the late sixties. In September 1969 the construction for the first BOT project in Hong Kong commenced (Mak and Mo, 2005). The Cross Harbour Tunnel (CHT) is a two lane tunnel in each direction. It took only 36 months to complete and was eleven months ahead of schedule. The CHT was an instant success when it came into operation in August 1972. Within three and a half years of operation the Tunnel had collected enough tolls to pay back its construction cost. The Tunnel is probably the most successful BOT project in Hong Kong, and is still one of the most important and profitable pieces of infrastructure locally.

Although Hong Kong has had experience in adopting quite a number of BOT projects, the approach of PPP has never really been studied extensively on a local scale. The traditional practice of these projects was for the government to directly award a concession to the potential bidder. This practice of awarding concessions is common in Hong Kong, but the gestation period spent in formulating the enabling legislation is lengthy.

In recent years the Efficiency Unit of the Hong Kong Special Administrative Region Government has been heavily involved in PPP research. The Government's interest in utilizing PPP is obvious. The approaches that they have taken mainly involve gaining international experience from particularly Europe and Australia. One of the early documents produced by the Efficiency Unit on private sector involvement was a guideline to help governmental bureaux and departments to familiarize with private sector engagement (Efficiency Unit, 2001). These guidelines were published in 2001 and showed the government's interest in adopting the idea of PPP. Only two years later they also produced a comprehensive introductory guide to PPP (Efficiency Unit, 2003). This guide was aimed for the use of the civil service but is also made available for the public's interest to understand the government's approach. After the publication of this report much interest was drawn from the public due to the possibility of the increased business opportunities available. More recently, the Efficiency Unit published two more guidelines on PPP (Efficiency Unit, 2007; 2008). The first edition shows how more knowledge on the issues of PPP have been learnt, it also identifies areas of concern to local practitioners as well as civil servants, and it tries to provide some insights into these areas. The second edition is much more specific on how to establish a PPP project. The guideline is aimed at coaching civil servants on how to conduct a PPP project by looking at the business case, dealing with the private sector, managing the risks, funding and payment issues, managing performance etc.

THE RESEARCH FRAMEWORK

The findings presented in this paper are part of an on-going research project looking at developing a best practice framework for implementing PPPs in Hong Kong. As part of the data collection, interviews were conducted with PPP experts from the public sector in Hong Kong.

Design of Interview Questions

Utilizing in-depth literature findings, interview questions linking up to the project objectives were derived. The following questions were derived for the interviewees:

1. Have you conducted any research looking at local case studies? And if so, could you share your insights?
2. How would you compare PPP with traditional procurement methods?
3. Which type of project do you feel is best suited to use PPP?
4. What do you feel are the key performance indicators in a PPP project?
5. In general, what do you think are the critical success factors leading to successful PPP projects?
6. Does your organization have any in-house guidance/practice notes?

Selecting Respondents

The target respondents of the interviews were practitioners with experience in PPP of senior level and authority who have had experience acting for the government. Amongst the seven interviewees, two were from Administration Departments (one of the interviewees previously represented a Works Department), three were from Works Departments (one of which previously represented an Administration Department and the other also holds a position at a local institute), two of the interviewees were from Non Governmental Organizations (NGO) (both had previously acted for different Works Departments). The interviewees selected ranged from a variety of different roles within the Government. Table 1 shows details of these interviewees.

Table 1 List of Interviewees from the Public sector in Hong Kong

No.	Position of Interviewee	Organization of Interviewee
PU1	Assistant Director	Administration Department
PU2	Permanent Secretary	Administration Department (previously Works Department)
PU3	Director	Works Department (previously Administration Department)
PU4	Senior Director	Works Department
PU5	Senior Quantity Surveyor	Works Department / Local Professional Institute
PU6	Executive Board Member	NGO (previously Works Department)
PU7	Executive Director	NGO (previously Works Department)

THE PUBLIC SECTOR'S PERSPECTIVE ON PPP

1. Have you conducted any research looking at local case studies? And if so, could you share your insights?

Interviewee PU 1 is an Assistant Director of a public administrative department. His department has been incredibly active in conducting PPP research and hence he was interviewed for his expert knowledge in the area. Interviewee PU1 mentioned that the department had already produced a guideline back in 2003 and the second edition would be produced by the first quarter of 2007. He added that the new bilingual guideline would include information collected from overseas and will also look into the local problems and the success factors for PPP. In addition their department has also carried out internal case studies on local projects.

Interviewee PU2 had recently started his post at an administrative department, before this he had spent a long time working at a works department. Hence the discussion was heavily based on his experience at the works department. He did not go into detail on whether there have been any case studies conducted within his previous department, but instead he introduced how asset management can also be regarded as a form of PPP, and also how it has been implemented successfully in his previous department for maintenance works. He also added how this form of arrangement has been successfully carried out for asset management of buildings in Melbourne, Australia.

On the contrary to Interviewee PU2, Interviewee PU3 had previously worked in an administrative department but only recently changed to a position in a works department.

He suggested that most countries new to adopting PPPs try to learn from the experience and practice in Australia and the United Kingdom. Instead it may be useful to also consider the practice in developing countries such as South Africa and the Philippines. The extent and use of PPPs may not be as extensive in these countries but there are many new practices which can be learnt. Whereas experiences adopted in the United Kingdom and Australia maybe more dated in comparison. Interviewee PU2 has been actively involved with PPP research, one publication that he had heavily participated in was a technical circular for the local government.

Interviewee PU4 is a Senior Director of a local works department. He explained that the PPP model they adopt is in the form of Design Build and Operate (DBO). DBO has also been utilized by another works department in Hong Kong. He shared that his department had previously employed consultants to advise on the DBO method. In order to investigate the appropriateness of using DBO for their department’s projects, they have hired consultants to conduct studies on the DBO strategy.

Interviewee PU5 is a Senior Quantity Surveyor working for a local works department (responsible for project management of public building projects) and also an office bearer of a local professional body. Referring to the department he works for, he explained that no studies have been carried out within their department and that they have not taken the most active role in PPP projects. Instead he suggested that the client’s departments who are the people involved with operation, and also the finance bureau who are the people with cash, would be in a far better positions to initiate PPP projects.

Referring to the work conducted at the professional body, Interviewee PU5 explained that they focused very much on the financial structure and risk management of PPP projects. Similar to other researchers he believed that there should be clear risk allocation and risks should be assigned to the party best able to manage them. Also a clear timeframe for the project milestones should be setout. Other common aspects of PPP internationally but not mentioned as frequently in Hong Kong include Public Sector Comparator and Special Purpose Vehicle.

Interviewee PU6 is an Executive Board Member of a NGO. He explained how it would be inconvenient to comment on the works department he had previously worked for, but he was willing to share some insights into the topic of PPP from a personal level.

Interviewee PU7 is currently the Executive Director of the same NGO as Interviewee PU6. Previously he had worked in a governmental works department for many years before his retirement. In the interview conducted with him he shared his knowledge and experience on PPP from his previous position. Interviewee PU7 explained that he had personally not conducted any research studies in the area of PPP, but suggests that the home ownership scheme Private Sector Participation Scheme (PSPS) could also be considered as a form of PPP. Through PSPS, good quality residential apartments were financed, designed and built by private developers by allocating land to them on a subsidized basis. The completed apartments were marketed to medium-income buyers as a form of affordable housing.

2. How would you compare PPP with traditional procurement methods?

Interviewee PU 1 explained that PPP projects take longer to lift off. Normally this is due to the more complex design and scale of PPP projects. Also the longer bidding period compared to projects that are procured traditionally. He added that a Public Sector Comparator ought to be constructed to decide which method is the best for the project. Interviewee PU1 further explained that Hong Kong has tended to procure PPP projects traditionally rather than by PPP as there has been no drive from the top or the treasury to do so. Unlike other jurisdictions that have adopted PPP, the Hong Kong government has not been short of money therefore the incentives have not been the same.

Interviewee PU2 described for his department that under the traditional practice, a works order would be needed for any works required, whatever the cost. This created a large amount of documentation which has now been replaced by PDAs, under the new arrangement the works department now acts as a supervisor’s role. For a more accurate analysis of which procurement method should be adopted he added that a Public Sector Comparator should be utilized.

Interviewee PU3 believed that it would be more appropriate to consider which method the project requires rather than procure projects by PPP for the sake of it. Whether a procurement approach is appropriate for a particular project would depend on the nature and characteristic of the project itself. He also added that unfortunately his colleagues would rarely consider the PPP option as they tend to prefer the usual practice for which standard forms of contract are available. This behavior is understandable for bureaucratics in general, as they are not awarded for achievements but instead would be criticized if problems arise as a result of changing procurement methods. Therefore staying with methods that have been practiced numerous of times would be less risky to them. The private sector on the other hand are willing risk takers if they can foresee commercial benefits.

Interviewee PU4 described that for each PPP project the concession period and the payment arrangements would be identified, normally depending on the major activities and milestones; whereas in a traditional approach, the contractor would be paid on a monthly basis during the construction stage. Also, for PPP projects the contractor would submit the price for construction and operation in their tenders. The nature of a PPP or DBO project is to allow more flexibility at all angles for tenderers so that they can maximize their expertise whether it is in terms of financial, technical or managerial. These projects tend to involve rigorous procedures.

Interviewee PU5 explained that for cases where the Government has an observation but not a solid project idea the PPP approach can add value. Also, as the private sector is more motivated than the public sector, PPP projects tend to develop faster than those procured by the traditional approach.

Interviewee PU6 believes that the suitability of adopting PPP depends on the project itself. The project must be financially stable as the private sector enters the partnership for commercial benefits. A project with an uneconomic case would therefore not be able to attract any private partners. Also, in cases where the project may make a loss the government should also be responsible for the project themselves or help to subsidize the private sector; for example, in the cases of hospital and school projects which have been incredibly successful in the United Kingdom. These projects alone are not economical but with a regular fixed service fee from the government, the private sector is willing to enter the partnership. The arrangement has been a role model to other countries and opened up new opportunities in conducting social infrastructure projects by PPP as well.

When asked whether the PPP arrangement is best when the government is the end user, Interviewee PU6 agreed. He also added that in a traditional procurement method the government will most likely finance the facility or services themselves. He added that governments procure projects by PPP because of two main reasons. Firstly they may not have the money or want to borrow money for public facilities or services. And even if the government does have money they may want to spend it on other more demanded things. Secondly PPP projects are known to be more efficient due to the highly motivated private sector. Efficiency is also related to finance. He added that PPP is a lot more complex compared to traditional procurement methods hence the cost is also much larger.

Interviewee PU7 explained that all projects are unique. Therefore if a project involves the public and private sector, and also PPP is believed to be the most suitable to achieve success for that project then this procurement method should be used. The public sector ought to consider what the end product will be before deciding on the procurement method to be used.

3. Which type of project do you feel is best suited to use PPP?

Interviewee PU 1 believes that for PPP projects to work. It does not matter whether the income comes direct from the end-user, paid by the government, or a combination of both. As long as there is a link between payment and performance the project will be suited to use PPP.

Interviewee PU2 believes that each project is unique so no type of project is best suited for the PPP option.

Interviewee PU3 believes that the Shatin Water Treatment Works project in Hong Kong is a project with prospect of being a PPP. Other suitable projects will depend on whether they can be financially viable taking into account the risks associated with the project. To deliver PPP projects in Hong Kong, the value for money aspect should also be considered.

Interviewee PU4 feels that in order for projects to be procured by PPP they ought to involve a large operating element and also the project performance should be measured easily as payment is often related.

Interviewee PU5 described that unsuitable PPP projects are those that have no economic case for the private sector to benefit. In these cases the private sector would also not be willing to participate.

Interviewee PU6 believes that the projects most suitable to use PPP are those that involve a high operation cost, and are economically attractive to the private sector. Although some projects may not be economically feasible alone, the government could help to subsidize. For example, the MTR Corporation Limited has been granted the development rights to construct property above their stations, as a means of subsidizing the railway construction. This has proved to be a successful case and an effective arrangement of the public and private sectors working together to deliver public infrastructure in Hong Kong. Therefore projects with similar arrangements could also be considered.

Interviewee PU7 suggested that housing projects have also been shown to be successful in Hong Kong. For PPP projects to work there must be mutual benefits for both the public and private sector.

4. What do you feel are the key performance indicators in a PPP project?

For the key performance indicators, again Interviewee PU 1 believed that it would be down to the link between performance and payment.

Interviewee PU2 described that success of PPP projects could be measured in terms of the resources reduced in terms of money and labour.

The interview with Interviewee PU3 did not touch on the key performance indicators.

Interviewee PU4 believes that a Public Sector Comparator (PSC) could be used to confirm whether the arrangement would be cost effective if procured by PPP. Also the KPIs used to measure the contractor’s performance should be project specific.”

Interviewee PU5 believes that the traditional KPIs (cost, time and quality) are also applicable to PPP projects. He also feels that a Due Diligence Audit can be used to measure the consortium’s performance.

The key performance indicators according to Interviewee PU6 include time, cost and risk management.

And Interviewee PU7 added that projects could be measured by the profits of the private sector, time savings and general public acceptance level.

5. In general, what do you think are the critical success factors leading to successful PPP projects?

Interviewee PU 1 suggested that there should be a champion in Hong Kong to lead the development of PPP projects. For example, in the United Kingdom and some states in Australia it has been the Treasurer or someone of high authority in the government who has taken on this role. As the public sector is often reluctant to change, without a champion there will be little development in PPP projects. He also added that PPP projects in Hong Kong ought to be above at least HK$300 million for it to worthwhile. Again other jurisdiction governments have also a similar guideline where projects that are too low in value should not be procured by PPP. Sometimes there are exceptions such as water projects, these although are low in project value are still procured by PPP as there is a large operating element involved, also the private sector's expertise in these works are advantageous.

Interviewee PU2 described that there are three key ingredients for PPP projects to succeed: 1) Supervisory level should have the correct mindset for adopting PPP; 2) The organizational papers and contract are prepared correctly; and 3) The roles of each party need to be well defined with a partnership arrangement. Some other factors include: the procurement method must be a transparent process; the projects must be well defined and the objectives identified; and public consultations conducted to achieve social acceptance.

Interviewee PU3 mentioned that for a PPP project to succeed, the risk assessment must be conducted well. Risk has become a very popular topic for PPP research in recent years. Although there have been numerous successful PPP cases, there have also been those unsuccessful cases leading to the increasing interest to study this area.

Interviewee PU4 suggested that the critical success factor for PPP was the same as what he mentioned before for the suitability of PPP. Projects ought to involve a large operating element in order to fully benefit the advantages of private participation.

Interviewee PU5 named three critical success factors for PPP: 1) There must be development potential; 2) Ability to clearly specify requirements of the Government; and 3) Appropriate risk allocation which is dependent on the contract conditions. He also added that the key was to inform the general public what PPP actually was and how these facilities procured by PPP would be looked after. Apart from the risks, political problems are also important to consider. Political problems are often experienced in developing countries where the political environment is more unstable. In these places even guarantees from the government may not be enough to convince the private sector to participate.

Interviewee PU6 believes that PPP projects must be economically viable. The risk must also be manageable for the investor. Risk is often related to cost. Social factors are important to affect the success of a project hence the support from the general public is vital.

Interviewee PU7 described that both parties must share the same goal, there should be mutual benefits perceived, the arrangement must be fair, responsibilities should be clear, and also the mechanism must be easy to implement.

In addition Interviewee PU7 added that the process must be transparent enough for the general public to understand and accept.

6. Does your organization have any in-house guidance/practice notes?

As mentioned earlier in the interview the department of interviewee PU1 has several guidelines on PPP accessible from their website for public viewing. During the interview, interviewee PU1 also raised a few other areas of concern that should be considered for PPP projects. He mentioned that staffing is an issue particularly if there is an existing facility or service that is thinking of moving into the private sector. The main problem is that there is currently not a standard staff transfer mechanism or scheme. Therefore the lack of a standard mechanism discourages departments from considering a PPP proposal if the staff transfer arrangement is required. Also, traditionally departments do not need to handle the sole responsibility of a large project but using the PPP method they would have to; therefore it is understandable that departments are reluctant to change their normal practice of procurement.

In other countries that first started to adopt PPP, the financial drive has often been a large motivator. In Hong Kong Interviewee PU2 explained that PPPs are used to increase efficiency in projects rather than to draw private financing. He added there is too much respect given to minorities in the society and the media often report inaccurately.

Interviewee PU3 shared similar views as Interviewee PU2 on Hong Kong's financial situation. He explained that there is no need for external capital finance so for the Government to bring in the private sector they must demonstrate that efficiency and productivity could lower the cost by approximately 30%. Reference materials that their department uses include Hong Kong governmental guidance notes on the design and build method, and also PPP guidelines published in Australia, Philippines and South Africa.

On the other hand Interviewee PU4 tended to refer to the Efficiency Unit's PPP guidelines, the Environmental Protection Department practice and other international practices.

Interviewee PU5's institute had produced several related publications including a PPP booklet and proceedings from a PPP conference organized their institute. He added that for the Western Kowloon Cultural District project the Hong Kong Government had been heavily criticized, as the public believed that the development right had been handed over to a single developer resulting in immense commercial benefits for them.

Interviewee PU6 shared some of the problems related to PPP projects. For existing facilities there are often problems due to staffing issues resulting in opposition from the existing employees and unions, causing political and social problems. In the case of the Western Kowloon Cultural District project, the general public believes that it is an excuse for property development. Also the need for specific PPP legislation should be considered, especially for facilities that are receiving payment from the general public.

Interviewee PU7's organization has not produced any in-house materials but he raised that there has been argumentation about whether the Western Kowloon Cultural District project resulted in too much profit for the private party. Several of the interviewees mentioned the problems arising from this case. Their common view is that the government has handled projects unwell resulting in huge benefits for the private sector. Therefore a correct balance of the benefits should be analyzed.

CONCLUSIONS

This paper has presented the findings of seven interviews conducted with past and present government officials with experience in PPP projects and research. It was found that the project itself was important in determining which procurement method should be adopted. A public sector comparator could also be used to determine the method most appropriate for the project. The procurement process of PPP projects tend to take a lot longer but there is the advantage of incorporating the private sector's expertise. Projects that are suitable for the PPP method include those that have a high operating element and cost. Also suitable PPP projects are those that have a good economic case. The key performance indicators of a PPP project are mainly related to the cost, time and risk. There are a number of critical success factors for PPP projects: there must be an appropriate risk allocation, adequate information to the general public, clear specifications defined, the project must not be too complicated, there must be a partnering spirit between the parties, and the project must have an economic case. Some of the interviewees felt that the Hong Kong government is more than capable to fund public work projects, but instead they would like to adopt PPP for the added advantages of bringing in the private sector such as increasing efficiency. Finally, the Hong Kong government should ensure that PPPs are not conducted for the private sector to make large profits.

A follow-up empirical questionnaire survey to solicit various opinions on the key issues regarding the application of PPP model from those project team members who had gained hands-on experience in participating in PPP projects had also been launched between October and December of 2007 in both Hong Kong and Mainland China. The major survey findings including the perceived benefits, potential obstacles, critical success factors, key risk factors and their treatment of adopting PPP models will be collated and disseminated towards the research community and construction industry through subsequent refereed publications in the form of journal articles and conference presentations.

ACKNOWLEDGEMENTS

The work described in this paper was fully supported by a grant from the Research Grants Council of the Hong Kong Special Administrative Region, China (RGC Project No. PolyU 5114/05E). Sincere thanks goes to those industrial practitioners, who have kindly participated in the interviews reported in this paper.

REFERENCES

Efficiency_Unit. (2001). *Serving the Community by Using the Private Sector*. June 2001, Hong Kong Special Administrative Region Government.

Efficiency_Unit. (2003). *Serving the Community By Using the Private Sector - An Introductory Guide to Public Private Partnerships (PPPs)*. August 2003, Hong Kong Special Administrative Region Government.

Efficiency_Unit. (2007). *Serving the Community By Using the Private Sector Policy and Practice (Second Edition)*, January 2007.

Efficiency Unit (2008). *Serving the Community By Using the Private Sector - An Introductory Guide to Public Private Partnerships (PPPs) (Second Edition)*, March 2008, The Hong Kong Special Administrative Region Government.

Grimsey, D. and Lewis, M. K. (2004). *Public Private Partnerships: The Worldwide Revolution in Infrastructure Provision and Project Finance* (First ed.). Cheltenham, U.K.

Mak, C. K., & Mo, S. (2005, 22 February). *Some Aspects of the PPP Approach to Transport Infrastructure Development in Hong Kong.* Paper presented at the Public Private Partnerships - Opportunities and Challenges, Hong Kong.

Tieman, R. (2003, 24th November). A Revolution in Public Procurement:UK's Private Finance Initiative. *Finance Times,* 4.

ENACTING DIGITAL COORDINATION: DEVELOPING AND IMPLEMENTING DATA MANAGEMENT PRACTICES IN CONSTRUCTION WORK

Chris Harty
School of Construction Management and Engineering, University of Reading, UK
c.f.harty@reading.ac.uk

Building Information Modelling (BIM) tools have made significant progress in recent years. But although they promise to integrate the production, sharing and representation of information in construction projects, there is often a gap between the possibilities they offer and the ways they are currently utilised. The position adopted here is that it is not solely the technologies themselves, but the socio-technical practices of which they are a part that will realise the potential benefits such technologies offer. Some developing applications of such technologies on a large project - a £1 billion hospital project in London - are described. For each case, a practice-based approach is taken, revealing the ways that multiple actors and technologies are being assembled together in novel ways to produce new practices of data management and collaboration. These practices extend beyond the expected ways of using and functionalities inscribed in the technologies by their developers.

KEYWORDS: Information management, Practice, Implementation, Building Information Modelling (BIM)

INTRODUCTION

A perennial problem within construction is the management of the vast amounts of data that even routine projects generate. This, coupled with construction activity's displacement across numerous disciplines and organisations, means that ensuring data is robust and accessible to relevant actors is a paramount consideration. When the potential to re-use design and construction information for the purposes of facility maintenance and operations management is also considered, especially in the context of PFI and PPP projects, the efficacy of integrated solutions for the production, management and manipulation of construction information becomes all the more apparent.

Because of this, there is currently an increasing interest within the construction sector in finding ways to produce, share and utilise various data in more integrated and consistent ways. One solution to this problem of managing data is to use a variety of computer based information management and modelling tools. Such tools can potentially fulfil a number of functions; becoming the medium through which design and engineering work gets done (for instance using CAD, calculation or fabrication tools), being the central hub for the production, storing and dissemination of information, (using document management systems) and acting as the conduit through which different parts of the construction process interact (through electronic communication tools such as e-mail or, more formally, collaboration systems and extranets). But the challenge is to incorporate these diverse technologies into a robust and interoperable system which encompasses the technological artefacts, the actors who utilise them and coherent underlying processes and practices.

In response to this challenge, increasingly these tools are being positioned as part of BIM (Building Information Modelling) systems. The term BIM represents an integrated and interoperable collection of various information production, modelling and management tools. By using BIM technology, the various aspects of design, construction and operation are digitally coordinated, with information exchange mediated through shared technology platforms across projects. However, the effective utilisation of BIMs across complex construction activities requires a significant shift away from current practices, especially with regard to the multiple ways various technologies are currently utilised (Harty, 2005; 2007a). In practice, the translation of activities from being based around paper, printouts and informal communication as well as information technologies to wholly digital mediation and coordination is a significant undertaking. Crucially, it is being increasingly acknowledged by practitioners that for BIM technologies to realise their potential it is not technological solutions which are required, but the development of new data management and business processes and practices to support these technologies' utilisation across design, construction and operation activities. Without being embedded into robust practices and processes, the potential of these technological artefacts cannot be realised.

In order to better understand and to address these challenges, this paper discusses early outcomes from on-going research examining the application, implementation and use of various information management technologies on a large hospital new build / refurbishment project. To begin, some of the broad characteristics of BIM technologies are outlined, and some of the challenges of implementation delineated. Following this, the theoretical and methodological approach adopted to investigate these challenges is discussed, oriented around the 'practice turn' and with an emphasis on unpacking the socio-technical (rather than solely social) interactions through which new practices are constituted and performed. Then, after a brief description of the project itself, a number of emerging applications of BIM technologies currently being implemented on the project are outlined. Each of these applications is centrally concerned with using existing technological tools to develop and support new data management and collaborative practices and processes. The conclusions argue that it is only through developing robust socio-technical practices that the full advantages of BIM solutions can be realised, and that the practice-based approach advocated is highly suitable for both understanding and supporting the dynamic processes of implementing BIMs.

BUILDING INFORMATION MODELS (BIMS)

Although the idea of integrated BIMs are currently the subject of increasing interest within construction circles, the sector has for a number of years been utilising various information and visualisation technologies to support construction activity[1] (Whyte, 2002). Computer Aided Design (CAD) is standard practice, and this is increasingly undertaken in three dimensions, especially when designing and representing complex areas (such as plant rooms) or complex elements (such as building services or intricate architectural designs). Various 3D representation tools are regularly used to communicate design ideas to clients. Similarly, electronic communication, extranets, collaboration software and document management systems can all be seen in use, especially on large or complex projects.

[1] The term BIM is relatively new; during previous research on implementing coordinated technologies and practices the term 'single model environment' (or SME) was used.

Although these tools promise the integration of the production, sharing and representation of information in construction projects, in practice there seems to be a gap between their possibilities and the ways they are actually utilised. The concept of the BIM represents more than just the use of these various tools. Also required is a high level of integration and inter-operability between these applications, to effectively join up the design and construction processes, to re-use the same information down the supply chain and to digitally mediate construction activities. This integration requires the development of coherent practices and processes, as well as the actual BIM tools.

As one might expect, different and contested definitions of BIMs co-exist. Jernigan (2007) offers the following:

> "BIM is the management of information and the complex relationships between the social and the technical resources that represent the complexity, collaboration and interrelationships of today's organizations and environment. The focus is on managing projects to get the right information to the right place at the right time" (Jernigan, 2007: 23)

This is a useful definition in that it draws attention to the inter-relations between social and technical (or technological) constituents, to the BIM as a tool for management, as well as for representing information, and to the complexity of the contexts in which BIM technologies and practices must operate. Eastman *et al*'s (2007) recent BIM handbook provides a more specific and substantive definition; a BIM is

> "a modelling technology and associated set of processes to produce, communicate and analyse building models" [2] (Eastman *et* al, 2007: 13).

The fundamental idea is that all of the information produced and required for the design and construction process is produced in a consistent way, using inter-operable tools and accessed through a shared repository (such as a database or document management system). The key advantage is that the same coordinated information is used as the basis of different representations or views (whether as a database, CAD drawing or model, a bill of quantities, an excel spreadsheet, set of calculations etc). Changes to information occur at the level of the repository, and are therefore reflected across any particular view of the information. To enable this, the building models that constitute the BIM must have specific characteristics (again from Eastman *et al*);

- 'Intelligent' building components (or objects) represented digitally with intelligence about what they are and can be associated with data attributes and parametric rules
- Components that include data describing how they behave as required for analysis and work processes (i.e. to produce material take-offs, specifications and performance analysis)
- Consistent and non-redundant data, where changes to components are represented across all views
- Coordinated data so all views are represented in a coherent way.

[2] I use this particular source and definition here, as during a recent conversation with industry partners, it was felt that this best captured what they felt the key characteristics of a BIM should be.

Projects in the past have taken significant steps towards achieving this, but have fell short of generating a durable, co-ordinated system of BIM tools and set of shared practices to utilise them. There are a number of possible reasons for this; the significant resource requirements and re-configurations of existing practices they demand; the challenge of capturing new practices developed through project work for subsequent re-use; the lack of a clear market leader or of robust integrated technological solutions to guide technology choices. These problems have been revealed both through attempts to develop and implement such technologies in practice, and through research which has followed and traced these efforts (Harty, 2005; 2007a b; forthcoming). But at their core is the problem that although various BIM solutions are technologically well developed, what is lacking in the sector is a robust set of working practices which mobilise and effectively utilise these artefacts, and which can be disseminated across projects and through and across construction activities.

In sum, implementing BIM tools and, crucially, developing the practices and processes to support them is a significant undertaking. It has implications throughout the design and construction process, and that go beyond a simple adoption of new technologies, requiring considerable change to current ways of working. The empirical material described below captures some of the scope of these changes, and delineates the novel ways of working emerging from efforts to situate BIM tools within robust practices of information management. But before moving onto a discussion of the case study project, the next section addresses the conceptual approach developed to investigate the implementation and use of these technologies. It is oriented towards a practice-based approach, and emphasises the active role of the technological artefacts themselves, as well as the human actors who implement and utilise them.

THE ‘PRACTICE TURN’

The practice turn in organisational studies is perhaps better described as a diverse collection of theoretical accounts which share a common proposition – that the proper field of inquiry for understanding what organisations and individuals do is the field of practice. Moreover, the social world is broadly considered

> “a field of embodied, materially interwoven practices centrally organised around shared, practical understandings” (Schatzki *et al*, 2001: 3).

There are two aspects illustrated in this definition which can serve to differentiate practice based approaches from others. The first is the embodied nature of practice. Although the individual and individual cognition are important, practices are extra-individual; they emerge from the efforts of multiple actors to develop shared understandings and activities through interaction. Practices are not developed by individuals in isolation, but through largely tacit, rather than explicit or codifiable, collaborative engagements. A strong emphasis is therefore placed on seeing organisational learning and knowledge as emerging from the on-going (re)production of practices (e.g. Orlikowski 2002, Nicolini et al, 2003) within specific contexts.

The second aspect is an acknowledgement of the role of material artefacts in mediating and enacting practices. This intuitively makes sense, as practices rarely involve only human actors, but rather incorporate a plethora of material artefacts. However, within practice-based approaches there is no consensus over precisely how much importance, influence and agency is attributed to such artefacts, and the endowment of some sort of agential capacity to the material can lead towards some complex ontological and epistemological debates.

MATERIAL ARTEFACTS, AGENCY AND PRACTICE

Adopting a practice-oriented approach and situating the material as a central part of practice acts as a useful counter or supplement to accounts which focus only on social and/or structural aspects of interaction. Within such approaches, objects or material artefacts are sometimes incorporated, but arguably only in an passive sense; they are seen as mirroring or reflecting social distinctions (e.g. Bourdieu, 1984), as a backdrop or stage proving part of the contexts in which social interactions are played out (e.g. Goffman, 1971), or as 'material levers' or resources which are manipulated by knowing individuals (e.g. Giddens, 1984). However, there are alternative approaches which position material artefacts as a more active constituent within the field of practice such as the area of science and technology studies (STS). Within this literature, actor-network theory (ANT) in particular has positioned the material artefact on an equal footing with human actors.

ANT places the actor-network at the centre of understanding. Actor-networks are characterised by continual transformations and (re)configurations of actors and artefacts occurring through interaction. Practices can be seen as the performance of these actor-networks over time. The co-production of non-human artefacts, actors and practices are framed as sets of associations being formed and held together or pulled apart and reconfigured. This process has been called 'heterogeneous engineering' to denote the involvement of a variety material as well as human actors (Law, 1986; 1992). This emphasis on the (re)production of actors and objects through interaction has led to ANT being positioned by some as part of the broader 'practice turn' (Bresnen, 2007).

When thinking about how new technologies become incorporated into practices, the concept of actor-networks provides a useful analytical tool. Tracing the associations and configurations of actor-networks directs the researcher to the social aspects of interaction – the ways that people interact and the expectations, ideas and conventions which inform them. But the actor-network also emphasises rather than excludes the active role of material artefacts in the performance of practice. This role is more difficult to emphasise when purely *social* accounts of practice are mobilised. But by positioning practices as networks or systems of human and material agents, consisting of more or less stable sets of associations, more inclusive *socio-technical* accounts of practice can be developed, which consider their hybrid (human and nonhuman) constitution. It allows the active roles of both people and technological artefacts to be considered.

EMPIRICAL CONTEXT AND METHOD

The project from which the empirical material below is taken involves a combination of refurbishment and new build work across two London hospitals, with a total value of approximately £1 billion. The project is currently moving from detailed design into construction phases with detailed design scheduled to be fully complete by the end of 2008. Final completion of the construction work is due for 2014. There are a number of issues of note with this particular project, in addition to its size and complexity. As a hospital project, it must satisfy the plethora of different users of the finished facility; patients, doctors, nurses, admin staff and visitors, as well as the NHS trust acting as client. Also, facility management is a challenge given both the high levels of use of medical facilities, and the complex services and equipment which will be installed. In addition, the sites being located in central London impose various constraints for the construction process itself, in terms of site access, delivery of materials and minimising disturbance of neighbours. Finally, a condition of the contract being awarded was the generation of savings on the total project cost in the order of 10%. It is the meeting of these challenges that has resulted in a significant attempt to develop new ways of working which effectively utilise BIM information coordination and management tools.

The central aim of this research is to understand how these technologies are used, shaped through use and embedded into new activities; hence the methodological focus is the constitution of new socio-technical practices emerging through engagement with these BIM technologies. Qualitative methods have been utilised, including observation of working practices, informal discussion and (largely unstructured) interviews. The research techniques being employed were selected to resonate with a practice-based approach. Together, these methods have in the past proved highly successful in building up detailed accounts of emerging practice and on-going technology development (e.g. Harty, 2005). The research is on-going, and was started in early 2008.

EMERGING PRACTICES AROUND BIM TECHNOLOGIES

To date, the research has concentrated on investigating specific areas where the project's main contractor has implemented BIM technologies, focussing on the development of new ways of working which utilise these artefacts (see also Huberman and Throssell, 2008). The approach taken by the contractor has been to look for particular areas where realising the potential of BIM oriented practices could generate visible advantages, respond to specific challenges experienced on the project, or align with a particular business case. Three specific applications of BIM technologies and the socio-technical practices which are emerging through their implementation are therefore sketched out below. They each involve integrative activity across different actors within the project, ranging from design through to facility management and new ways of sharing and utilising construction information.

But these applications all depend on production of consistent shared information across the project, enabled through a central repository and on the development and use of inter-operable tools. These are more generic, project wide requirements upon which these specific applications hinge. Although BIMs are often associated with CAD modelling, in order to enable the coordination of building information, a detailed repository or database is a fundamental technological requirement. It is from the database that multiple representations of the data are drawn, whether as, for example, CAD models or schematics, bills of quantities, spreadsheets of calculations, or schedules of work. Through utilising information from the database, each of these representations contains up-to-date information from the same coordinated source.

Populating the database with the relevant information is therefore crucial; if information is incomplete or out of date, representations and coordination will be inaccurate, and the efficacy of BIM technologies is greatly reduced. This is just one example where it is the practices around these technologies and which manage the information in the repository, and not the technologies themselves, which are vital. One such practice developed on the project is the delivery of all design work as 3D models, rather than 2D schematics[3]. These are combined into a single, coordinated 3D model, with various 'intelligent' attributes added to specific components. This model can then be interrogated to provide a huge range of information, such as whether elements of the design are spatially coordinated, where specific components are located across the facilities, component part numbers, specifications or servicing schedules, and so on. Having a coordinated central store of project information requires significant effort – the cost of setting up such a system is estimated at around 0.5% to 1.5% of the total project value. However, doing so enables a number of new ways of managing and using project information, with the promise of significant cost savings, and reduction of risk. It is to some of these new emerging practices that we now turn. Each of the following vignettes describe the ways various actors and BIM technologies are being assembled and shaped, and the new ways of managing information and collaborating across the project emerging from these interactions.

Virtual snagging

Clash detection – combining models from different disciplines and checking their spatial coordination – is now a well established technique. But the navigation of a fully coordinated model of the facility offers further benefits. The process of constructing complex facilities can present unique and unforeseen problems. These often emerge on site, as problems of access, undocumented changes in completed work, or the need to go back to engineers to verify possible solutions to inconsistent information can lead to considerable and costly delays. Reducing these problems is therefore a significant factor in reducing overall project costs. This particular project also involves a significant amount of refurbishment, as well as new building work, which can present further problems of installing new components within existing, often constricted, spaces. To address these issues, the project's central model is being used to perform a virtual troubleshooting or virtual snagging of the designs before on-site installation or fabrication of components begins. Weekly CDM (Construction and Design Management) reviews are held to check across various parts of the on-going design for a range construction problems. These include ensuring there is adequate access to install new services, and to perform health and safety assessments – looking for trip hazards, inaccessible components, room to erect ladders and platforms and so on. Any particular problems are 'red-lined' – marked up on the model - and then go back to the designers for amendment. There is a growing list of several hundred of these issues which have been discovered and resolved so far.

Without the CDM process such problems would not be discovered until actual on-site installation, causing potential delays through having to re-route, reposition or even re-fabricate components. The meetings, focussed on the virtual model, enable project managers, designers and engineers, data managers and, increasing, facility managers to interact with the model, and to input into the design review process; effectively developing a set of practices through which actors across the construction supply chain are involved much earlier than is usual. The long-term operation and maintenance commitments in PFI projects (35 years on this particular project) means that the contractors take on responsibilities which extend beyond construction and hand-over. By integrating facility managers into design reviews,

[3] Interestingly, a number of very small consultancies have sprung up to convert 2D schematics to 3D models, where organisations are unwilling or unable to provide 3D models directly to the contractor. This is especially the case in the area of building services design.

they are developing designing and building practices which can lead to facilitates which are easier, and hence cheaper, to operate and maintain. It has also been noted that by being able to navigate through the virtual model 'live' on a large screen has encouraged a more interactive process with more collaborative discussion and input into the review.

Interestingly, as well as avoiding a plethora of costly problems, performing this level of checking can also be seen as revealing a fundamental problem in existing processes and practices of producing and coordinating project information elsewhere. If robust coordination was occurring at the level of design information *creation*, - i.e. if practices were robust enough to ensure information was produced in a coordinated manner - this reviewing process would not discover such a large number of inconsistencies and problems. So as well as developing new practices of checking and reviewing design information, through these efforts a more detailed understanding of where problems and inefficiencies are located within the overall construction process is being gained.

Construction Monitoring and Planning

An important aspect of monitoring complex projects is in providing robust comparisons between planned activity and actual work completed. This is essential to keep track of progress, and to flag up and mitigate for any delays, but is often complicated to coordinate as a paper based activity distributed between building sites and project offices. However, on this projects the BIM repository already contains the planned sequences of work. These are then used to produce an animation of the facility being constructed over time, therefore showing how the on-site work should be undertaken, according to plans of work and contractual obligations. Alongside this, actual work started and completed on site is recorded weekly via hand-held devices. This is fed back into the BIM, and is used to produce a comparative animated model showing actual activity on the site over time. These two models are then run side-by-side to check actual against planned activity. This allows progress against plan to be easily monitored, rather than having to laboriously cross reference planned sequences of work with progress reports.

Monitoring and recording handovers from design to construction is also a significant activity. For each room, 83 separate handovers are required, and each has to be recorded and signed off. A paper-based process involves 12 A3 printouts per room, which have to reflect the latest design changes – so if amendments occur these papers have to be reprinted. Bearing in mind that there are 6225 rooms across the two hospitals, this is both a very resource intensive task, and one that is very difficult to keep track of. An alternative set of practices is being developed on the project, again using hand-held devices linked to the BIM repository, rather than paper. As for the monitoring and planning application, the BIM contains details of expected and current work. The hand held device allows managers on site to access this information live from the repository (so hence it is up-to-date) and a customised menu on the model viewing application is used to input dates of completion and handover, or current state of work and expected completion. This information is automatically transferred back into the repository. Not only has this vastly reduced the effort required for checking status, but also solves the problem of managing what would have been vast amounts of paper based information. It is also another example where site based activity and actors are being incorporated into these new practices around the BIM tools.

Working with medical planners

A key challenge in hospital construction is the installation of large pieces of medical equipment, such as MRI scanners. These are generally supplied complete, and cannot be broken down and reassembled wherever they are to be located. Furthermore, on this project they have to be installed less than six weeks before the opening of the hospital. In the past, as large equipment has arrived on site various access problems have been experienced, leading to removing partition walls or suspended ceilings, or even having to grind concrete floors down to give enough room to get the equipment *in situ*. This deconstruction of course must then be put back.

To avoid these problems, virtual models of the facilities as they will be at time of delivery are extracted from the BIM repository, again using updated planned and actual models of work completed. Working with the medical planning team, a virtual scanner of the correct dimensions can then be 'pushed' through the hospital model, and any clashes or areas with less than the required access can be identified. In doing this, a large number of such issues have emerged, which are then red-lined and go back to the relevant designers to amend either design or planning sequences to ensure that the equipment can be installed without any rework of the facility. Not only will this avoid costly problems, but again represents the development of the BIM new practices which involve parties who are not usually engaged with until much later in a project.

CONCLUSIONS

These brief descriptions do not do justice to the complexities, negotiations and compromises which have characterised the development of these new practices, which are also still emerging and evolving. But they do provide a flavour of the ways that users on this project are developing coordinated BIM practices which are realising significant benefits. Importantly, none of the applications describe 'cutting edge' technologies, or purely technological solutions. Neither do they describe the simple adoption of existing functions of these artefacts. What they do describe are the socio-technical practices which have emerged as these tools have been implemented to support specific business cases, help solve particular problems, or generate new ways of coordinating across the project and of managing information. These applications go some way beyond both the functionalities inscribed in the software by developers, and narrowly defined mobilisation of BIM tools restricted to design processes. Importantly, these technologies are not enabling new ways of working merely through their implementation. Rather, they are being appropriated into and shaped as part of new ways of working, managing and collaboration across the project. These practices incorporate designers and engineers, drafters, project managers, site-based actors, facility managers and equipment manufacturers. But even more importantly, they demonstrate that realising the potential of BIM technologies involves not just implementation, but their incorporation into specific and robust ways of working, as components of new socio-technical practices and systems.

These reflections and conclusions are in no small way generated through the practice-based approach mobilised on this research. By positioning emerging practices as constituted through embodied and materially-inclusive interactions, the importance, indeed the inseparability of the technological and the social is revealed. Both are mutually constituted and shaped as they interact, and from this new ways of working emerge. This focuses research away from adopting a priori assumptions about technological change, and onto following in detail what actors and artefacts actually do. This can then contribute both to better understanding and to supporting the processes through which new practices are developed.

REFERENCES

Bourdieu, P. (1984). Distinction: a social critique of the judgement of taste. London: Routledge & Kegan Paul.

Bresnen, M. (2007). The practice turn in organizational studies and construction management research. Construction Management and Economics Past Present and future, Reading, UK, University of Reading.

Eastman, C., P. Teicholz, et al. (2008). BIM handbook: A guide to building information modeling. Hoboken, Ney Jersey: John Wiley & Sons.

Giddens, A. (1984). The constitution of society: outline of the theory of structuration. Cambridge: Polity Press.

Goffman, E. (1971). The presentation of self in everyday life. Harmondsworth: Penguin.

Harty, C. (Forthcoming) "Implementing innovation in construction: contexts, relative boundedness and actor-network theory" Construction Management and Economics

Harty, C. (2007a) "The social and the technological: The role of technology in the production of construction practice", Copenhagen: Copenhagen Business School

Harty, C. (2007b) "Implementing innovation: Transforming practices and technologies in construction work" CIB Capetown SA.

Harty, C. (2005) "Innovation in Construction: A Sociology of Technology Approach" Building Research and Information, vol 33(6), pp512-522

Huberman, M. and D. Throssell (2008). Collaboration through building information modelling. Space craft: Developments in architectural computing. D. Littlefield. London: RIBA.

Jernigan, F. (2007). Big BIM little bim. Salisbury, MD: 4Site Press.

Law, J. (1986). On methods of long distance control: Vessels, navigation and the Portuguese route to India. Power, action and belief: A new sociology of knowledge. J. Law. London: Routledge Kegan Paul.

Nicolini, D., S. Gherardi, et al. (2003). Knowing in organizations: a practice-based approach. London: M E Sharpe.

Orlikowski, W. (2002). "Knowing in practice: enacting a collective capability in distributed organizing." Organization Science 13(3): 249-273.

Schatzki, T. R., K. Knorr-Cetina, et al. (2001). The practice turn in contemporary theory. London: Routledge.

Whyte, J. K. (2002). Virtual Reality and the built environment. Oxford: Architectural Press.

EFECTIVE PROJECT RISK KNOWLEDGE MANAGEMENT

Prof. Mladen Radujkovic, Ph.D.
University of Zagreb, Faculty of Construction Engineering, Department for Construction Management, Zagreb, Croatia
mladenr@grad.hr

Ivana Burcar Dunovic, M.Sc.C.E.
University of Zagreb, Faculty of Construction Engineering, Department for Construction Management, Zagreb, Croatia
iburcar@grad.hr

Maja-Marija Nahod, M.C.E.
University of Zagreb, Faculty of Construction Engineering, Department for Construction Management, Zagreb, Croatia
majan@grad.hr

Knowledge management and organisational learning are both important and complex in projects, especially knowledge about management of projects. Management knowledge is much more tacit than explicit there for is even more problematic. Earlier the main focus of risk management was quantitative risk analysis while today, risk management research and practise is more focused on risk identification and response which knowledge are more complicated to manage. The paper discusses type and structure of data to effectively capture and disseminate knowledge on risks and risk management in construction projects to improve risk management itself and project performance. These have been implemented in a database management system to act as a knowledge repository. A prototype system being developed to support the risk management framework is briefly discussed. It provides the guidelines for establishing procedures to support risk knowledge management in construction project based organisation with purpose to integrate risk and knowledge management practices and systems in a comprehensive manner that will accomplish more with less bureaucracy. The research is conducted in Croatia.

KEYWORDS: knowledge management, risk management, projects, risk register.

INTRODUCTION

Knowledge is now considered the most strategically important resource, and learning the most strategically important capability for business organizations (Zack 1999). There are two types of knowledge: tacit knowledge and explicit knowledge (Nonaka, 1991; Nonaka & Takeuchi, 1995). Tacit knowledge is highly personal, developed from experience, and hard to formalize; therefore, it is difficult to communicate. The need to share tacit knowledge and disseminate best practice represents the need to leverage the knowledge gained by key employees within the organization to make it an organizational asset, rather than retain the knowledge as individual assets. Explicit knowledge, on the other hand, is formal and systematic. It is, therefore, easy to communicate and share, for example, in product specifications or codes of practice.

The relationship between the size of an organization and the existence of a KM strategy is also significant and strong. There is a growing awareness of the potential benefits of KM within the construction community, especially in large organizations. It is because they belong to industry networks where KM is being actively promoted as a mechanism for improving project, company, and industry performance.

Recognizing the importance of KM and developing a KM strategy is not a guarantee that it will bring business benefit. KM programs and initiatives must be adequate resourced if the objectives of the strategy are to be realized. Furthermore, it has to be integrated with general project processes. The same problem is recognized in risk management, where one of the main problems in current approaches is that the Risk Management Process is dealt with as a stand-alone process, and not as integrated part of the general project process.

Projects and project organizations require exceptionally efficient knowledge management, if they are to learn from their experiences. The project-based, fragmented and unstable nature of the industry has led to chronic knowledge loss compared with other industries (Orange et al. 2003).

PROJECT RISK MANAGEMENT AND KNOWLEDGE MANAGEMENT

It is recognized that most organizations now need a more structured, coherent approach to KM than ever before – within projects, across temporary, multi-discipline project organizations and within individual firms. Modern construction industry is being highly competitive, high risk with low margins. To success in this environment, a business has to be sharper, more efficient, and consistently using the knowledge assets to «get it right first time» and avoid repeating mistakes.

KM can enhance innovation, knowledge sharing, and performance in business, and its greatest value may lie in *risk management*. (McElroy 2003). Neef (2003) wrote that *"a company can't manage its risk today without managing its knowledge."* Two of the main disciplines that have embraced the KM discourse are information systems and human resource management, and integration of these having the greatest potential for advances in the field.

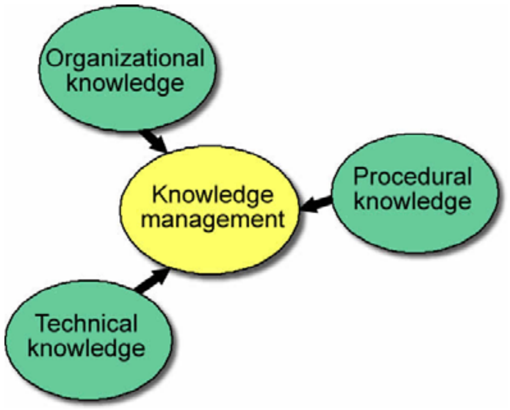


Figure 1: Project knowledge related to the product

Researchers agreed that there are three project knowledge areas related to the product, its production and use (see Fig. 1.)

Knowledge management include: committed leadership to learning, collecting knowledge, creating knowledge, storing knowledge, transferring knowledge, sharing knowledge, utilization of knowledge, rewarding knowledge and shared vision in knowledge needs of company. Many companies recognize that KM needs to be delivered through a number of complementary tools.

Procedural, technical and organizational knowledge as well as their quantity seems to be essential for Risk management. It turns out that organizational knowledge is the most important factor for the success of risk management. Significant quantity of organizational knowledge needs to be implemented in the initial phases of Risk management. By development of Risk management organizational knowledge needs to be increased. (see fig. 1.)

Project risk management is dealing with unknown and uncertain aspects of projects. The risk management should be contemplated through the prism, which integrates three aspects: tools and methods, creative thinking and knowledge and quality information (Fig. 2).

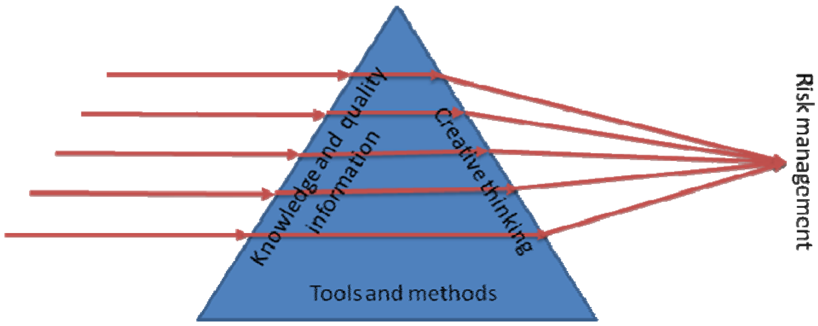


Figure 2: Risk management prism

During the long period of research the risk management in construction projects we perceived that the main focus, especially practitioner's, was on methods for risk identification, analysis and risk management plan development. Everybody urge to come up with the some results but the main problem with these results is reliability. In line with these thoughts the idea on risk register as knowledge management tool emerged.

AIM OF RESEARCH AND RISK REGISTER MODEL

It is understood that the first obstacle in risk management implementation in construction companies is knowledge of risks per se. Just as humans learn and gain experience from their mistakes and the mistakes of others, so companies must be enabled to do so by the provision of a "permanent brain" of the company. Among other things, the risk register is considered as a repository of knowledge on risks, therefore our aim was to come up with directions for a risk register structure design for use in construction companies.

Although the risk register frequently emerges in works on risk management and often appears in risk management methodologies, there are few writings about its construction and development. However, many organisations do store their risks in undisclosed forms of paper or computer-based risk registers (Patterson and Neailey 2002), which was confirmed by a research conducted by the Design Information Group at Bristol University (Crossland and McMhahon 1998). Moreover, there is limited information on their structure.

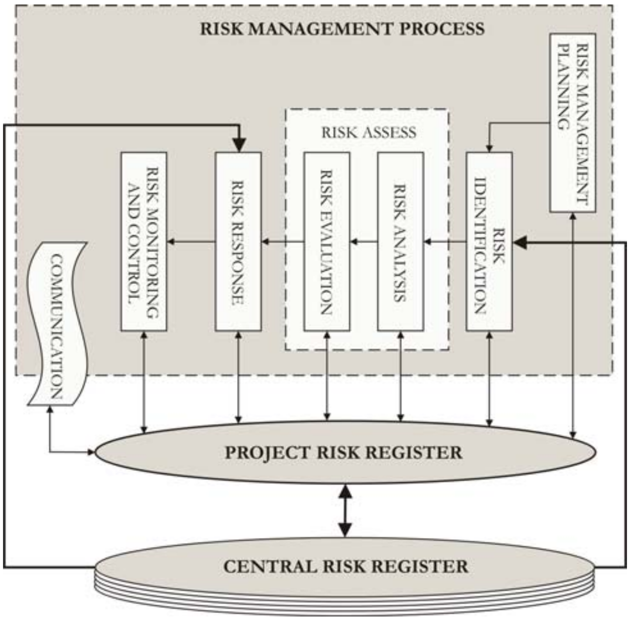
A review of available literature resulted in different definitions for risk register and views on its role in project risk management. Therefore, only some of them will be presented in this paper.

In the questionnaire on risk register conducted in Croatian construction companies respondents were asked to choose two statements defining risk registers (taken from different authors). Three different statements by Williams, Barry, Patterson and Neailey, cited above, were the most frequently selected.

Williams (1994) points out that project risk register should play a key role in risk management process and emphasizes its role as "a repository of a corpus of knowledge"…which has bigger importance for large firms and project teams where all members do not have good project overview. Barry (1995) defines the risk register as a comprehensive risk assessment system, used as a formal method of identifying, quantifying and categorising risks and providing the means of developing a cost-effective method of controlling them (Patterson and Neailey 2002). (Patterson and Neailey 2002) Patterson and Neailey (2002) define risk register as a tool for recording and documenting information generated through risk management process, and to enable consciously evaluate and manage the risks as the part of the decision making process. It also provides a platform for mitigation actions and future decisions while enabling better understanding and acceptance of the visible risks, and documenting project reduction and mitigation plans. (Patterson and Neailey 2002)

The questionnaire also resulted in giving the most important possibilities that the risk register has to enable:

- documenting risk source, response and its classification;
- saving information on all risks identified at the beginning and through the project life cycle;
- prioritizing risks regarding likelihood of occurrence and impact;
- systematic data storing to establish repository of knowledge for future projects.

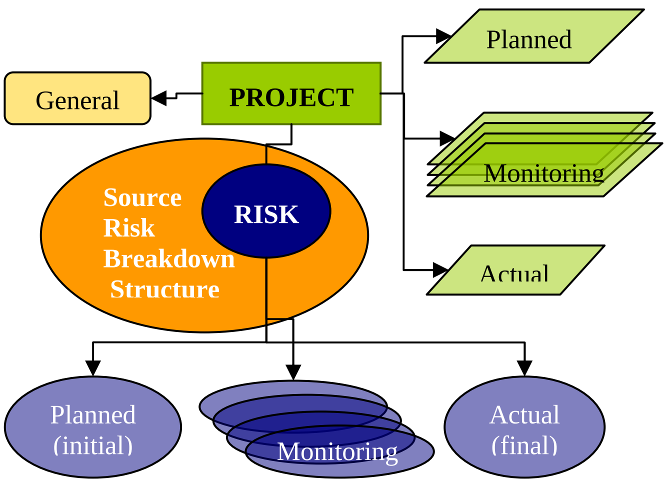


An important role of Risk Register System as a repository of knowledge, i.e. source of data and information on risks, will be accomplished through risk register application as a platform for construction project risk management on every project and conscious, systematic storage of generated data. The model of the Risk Register System (RRS) consists of two parts, Project Risk Register (PRR) and Central Risk Register (CRR) (Fig. 3.). **Project Risk Register** enables recording and saving risk data throughout the whole risk management process in order to collect data for each construction project.

Figure 3: Model of Risk Register System

Data entry and structure follow risk management process to meet the demand for data record and documentation generated throughout the whole risk management process, which means recording and documentation of needed input and output data from each phase. Furthermore, this part has the role of a platform and tool for project risk management and communication. Providing continuous risk tracking it can become a medium for communication between project stakeholders. Risk data from all projects are stored in the **Central Risk Register**. This part of RRS has a function of "repository of knowledge". During long term utilisation it becomes a source for quantitative and qualitative risk data. It is especially valuable as risk identification tool and as a source of data on risk response, tracking and controlling, it enables particular response efficiency evaluation as well as undertaking a consequence-based action. For the CRR to fulfil all its functions it is necessary that the planned and actual data are compared and summarized in relation to risk "behaviour and reaction". The more data on changes causing modification of a risk component or characteristic exist, more reliable information and conclusion on sources and drivers can be obtained. A comparison of initial response plans and actual actions and consequences will enable risk management quality assessment and improvement.

Data and structure of PRR (Fig. 4.) arise from the model of RRS and risk management process; therefore, they need to involve all risk components and characteristics through all the stages of risk management process. From recording and structuring aspect there are two major groups of data: **project level data** describing project characteristics directly or indirectly related to risks, and **risk level data** describing risk characteristics and components necessary for generating information and needed for risk management process. Risk and project data are grouped according to phases through which they are generated.



Planned (initial) data for risk level data are a result of initial risk identification, assessment and response, while for the project level data these are planned data on project duration and budget.

Monitoring data are logs on planned data during risk monitoring stage, while **actual (final) data** are the data on actual project outcomes at the project close-out including risk closing data.

Figure 4: Risk Register data structure

There is one more group of data on the project level not subjected to changes during the project, but describing project characteristics, introducing stakeholders and setting out success factors. All data at the project level are required, whereas data on the risk level are depending on the risk register application level which differs related to the level of defining risk and application of risk management. All risks identified for each project are grouped according to their sources into three level risk source RBS (risk breakdown structure).

DATABASE STRUCTURE FOR CONSTRUCTION RISK REGISTER

Analysis of preliminary list of attributes and whole process of recording and searching the database resulted with relational database structure with eight basic tables, five containing project data and other three risk data. Tables and their attributes are shown in Figure 5. The first risk table contains planned risk data, the second monitoring data and the third actual (close-up) data. These data are the reflection of risk model and methodology which are result of research initiated for this purpose. Attribute values calculated based on other attributes are marked “italic” and value attributes with “bold” letters. Primary key for each table and type of relationships are shown in Table 2. Tables Project characteristics, Project actual and i Project success factors priority are linked to Project planned with *one-to-one* link because for each projects can have only one record, while table Project stakeholders is linked *one-to-many* link because on each project we have more than one stakeholder. Every project has more than one risk, therefore tables Projects planned and Risk Planned are linked with *one-to-many*, as well as tables Risk planned and Risk monitoring to enable recording more than one monitoring record. For each risk in project must be only one record for risk close-up, therefore Risk planned and Risk Actual must be linked *one-to-one* link (Fig. 6).

These links which are result of nature and type of data and functionality of database ensures the reliability and compactness of database.

Tables described in this paragraph make the structure of database and contain data to be recorded. For actual usage work with database and getting the information out of it different *views* need to be used giving the high flexibility in work with data. Types of views and implementation depend on RDBMS used. For purpose of this research a prototype of Risk Register for construction was made using *MS Access 2000.* The prototype of RR for construction was successfully applied on several projects and now is in developing phase to software application.

Risk data are grouped into 3 groups therefore application of the risk register can be performed in 3 stages which differ according to the extensiveness level of risk data and analysis application in risk management. Required data – are including general data necessary for database functioning, basic, mostly qualitative data on risk components and response and all project level data; Additional data – are determining closely risk components and their characteristics; Advanced data – are including quantitative data for assessment and prioritizing risks, cost benefit analysis of responses and connection with monitoring data.

Risk Register application can start with Required data, and then continued by including Additional and Advanced data. An Application level from the lower level, which includes only Required data, can rise through two possible options, by including Additional or Advanced data, while the highest level includes all 3 groups of data (Fig. 7).

Figure 5: List of basic tables with their atibutes for risk register database

PROJECT CHARACTERISTICS
ProjectCode
ConstructionType
ConstructionSize
Location
Population
SiteTopography
TypeOfWorks
Technology
TypeOfContract
InvestmentType

PROJECT PLANNED
ProjectCode
ProjectName
Project ManagerName
Project ManagerSurame
ContractedValue
StartDate
Project Duration
Duration/unit

PROJECT ACTUAL
ProjectCode
ActualContractedValue
AcualStartDate
ActualProject Duration

PROJECT STAKEHOLDERS
ProjectCode
Stakeholder
Role
Representative

PROJECT SUCCESS FACTORS PRIORITY
ProjectCode
Priority 1
Priority 2
Priority 3
Priority 4
Priority 5

RISK ACTUAL
RiskID
Project Code
RiskDescription
CloseupDate
RiskClosedupBy
RiskActivated (Y/N)
Source
SourceOwner
Driver
Correlation
Consequence
ConsequenceOwner
ImpactType
ImpactTime
ImpactLocation
ResponseType
ResponseDescription
ResponsiblePerson
ResponseCost
AdditionalRiskCost
SecundaryRisk / Consequence

RISK PLANNED
RiskID
ProjectCode
RiskName
Event/Risk
IdentificationDate
RiskIdentifiedBy
SourceGroup
SourceCategory
Source
SourceOwner
Driver
Correlation
Consequence
ConsequenceOwner
ImpactType
ImpactTime
ImpactLocation
CostEstimate
OccurenceProbability
ImpactValue
RiskImpact
Acceptability
Rank
ResponseType
ResponseDescription
ResponsiblePerson
ResponseCost
ResidualProbability
Residual ImpactValue
ResidualCost
Cost-benefit
ResidualRiskImpact
SecundaryRisk

RISK MONITORING
RiskID
MonitoringID
ProjectCode
MonitoringDate
RiskMonitoredBy
RiskStatus
SourceGroup
SourceCategory
Source
SourceOwner
Driver
Correlation
Consequence
ConsequenceOwner
ImpactType
ImpactTime
ImpactLocation
CostEstimate
OccurenceProbability
ImpactValue
RiskImpact
Acceptability
Rank
ResponseType
ResponseDescription
ResponsiblePerson
ResponseCost
ResidualProbability
Residual ImpactValue
ResidualCost
Cost-benefit
ResidualRiskImpact
SecundaryRisk

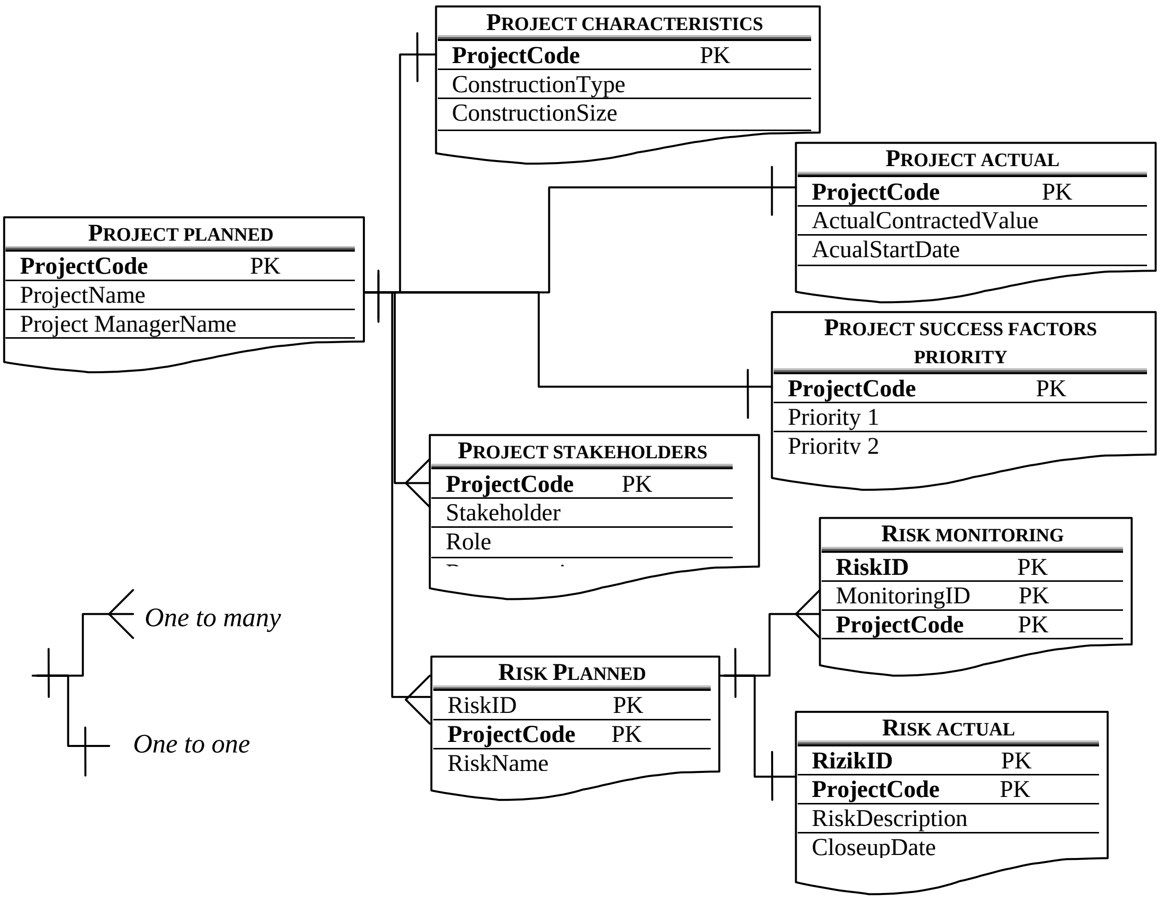


Figure 6: Primary keys and relationships

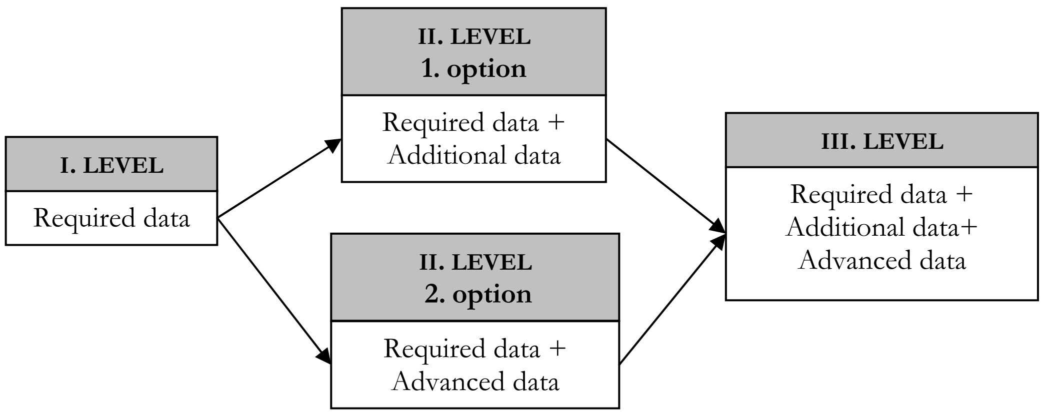


Figure 7: Application levels of RRS

CONCLUSIONS

There are some crucial barriers that can adversely affect the outcome of KM implementation like organizational culture, lack of standard work processes, not enough time - many construction organizations believe their organizational structure is too lean to exploit knowledge (lack of detailed post project reviews and the subsequent dissemination of lessons learned), not enough money, employee resistance and poor IT infrastructure. Risk Register System is designed to overcome most of these barriers. Its implementation is directly linked with implementation of risk management process and procedures because of the mutual dependences of risk and knowledge. Therefore, the whole knowledge management procedures are integrated in risk management process and that can save time and money. If organisation culture does not encourages KM it can be implemented only as risk management platform and later introduce CRR. One of primary requests on RRS is the quality of collected data; therefore risk register has to accommodate risk management level applied in the company. Proposed Risk Register System has major advantage because of its flexible structure which enables its application regardless of risk management level. It can be used in firms with advanced as well as in those with lower risk management practice and knowledge, supporting and directing progress in risk management practice towards complete application. An extension of application to CRR will result in creating a database of good and bad practice which will definitely contribute to the improvement of project management practice in construction.

Now, we can look again the risk management through the prism and see that this Risk Register System model with described structure integrates all three aspects of the prism. It is a tool for risk management, but not only that, it is the platform which supports the whole risk management process that encourages and supports creative thinking and in that way capture valuable qualitative data necessary for risk management process. Beyond that, with its CRR it is complete knowledge management tool for knowledge on project risks, its components and characteristics, management plans and actions and consequences. Knowledge management with RRS includes not only organisational knowledge necessary for risk management but procedural and technical as well.

REFERENCES

P. Carrillo, H. Robinson, A. Al-Ghassani, C. Anumba (2004) Knowledge Management in UK Construction; Strategies, resources and barriers. Project Management Journal, Vol. 35, No.1., ISSN 8756-9728/03, 46-56

P. Carrillo, H. Robinson, A. Al.Ghassani, C. Anumba (2004) Knowledge Management in UK Construction: Strategies, Resources and Barriers. Project Management Journal, Vol. 35, Issue 1, 46-56

Crossland R, McMhahon, CA, Simms Williams JH. (1998) Survey of current practices in managing design risk. Design Information Group, University of Bristol

Graham B., Thomas K. (2007) The development of an integrated knowledge management model for construction, In:Boyd, D(Ed) Procs 23rd Annual ARCOM Conference, 3-5 September 2007, Belfast, UK. Association of Researchers in Construction Management, 535-536

Hlupic V. (2003) Knowledge and Business Process Management. Hershey: Idea Group Publishing

Kasvi J. J. J., Vartiainen M., Hailikari M. (2003) Managing knowledge and knowledge competences in projects and project organizations. International Journal of Project Management (21), 571-582

Kukulanga G. K., McCaffer R. (2001) Measuring knowledge management for construction organizations. Engineering, Construction and Architectural Management (5/6), 346-354

Love P.E.D., E.-Fotwe F., Irani Z. (2003) Management of knowledge in project environments. International Journal of Project Management (21), 155-156

McElroy M. W. (2003), “Knowledge and Risk Management“, available at: http://www.macroinnovation.com/images/knowledge_and_risk_management.pdf

McElroy, M.W. (2003) The New Knowledge Management, Burlington, MA: KMCI Press/Butterworth-Heinemann

Neef D. (2003) Managing Corporate Reputation and Risk: Developing a Strategic Approach to Corporate Integrity Using Knowledge Management. Amsterdam; Boston: Elsevier/Butterworth-Heinemann

Nonaka, I., Takeuchi, H. (1995) The Knowledge- Creating Company: How Japanese Companies Create the Dynamics of Innovation. Oxford University Press.

Nonaka, I. (1991) The knowledge creating company. Harvard Business Review, 69, 96±104.

Orange, G., Onions, P., Burke, A., Colledge, B. (2003) ¨Knowledge Management: Facilitating Organizational Learning Within the Construction Industry¨, Leeds Metropolitan University, School of Information Management Discussion Paper Series, available at: www.lmu.ac.uk/ies/im/documents/RIP2003-14Orangeetal.pdf

Patterson F.D., Neailey, K. (2002) A Risk Register Database System to aid the management of project risk. International Journal of Project Management, Vol 19 , 139-145.

S. Pender (2001) Managing incomplete knowledge: Why risk management is not sufficient. International Journal of Project Management (19), 79-87

Williams, T.M. (1994) Using a Risk Register to Integrate Risk Management in Project Definition. International Journal of Project Management, Vol. 12, 17-22.

M. H. Zack (1999) Managing codified knowledge. Sloan management review (4), ISSN 0019-848X, Vol. 40, 45-58

EXPLORING THE ROLE OF MODELLING, SIMULATION, AND VISUALISATION (MSV) IN INNOVATING HEALTHCARE ENVIRONMENTAL DESIGN

Emeka Efe Osaji
Health and Care Infrastructure Research and Innovation Centre (HaCIRIC)
Civil and Building Engineering
Loughborough University, Leicestershire, UK
e.e.osaji@lboro.ac.uk

Andrew D.F. Price
Health and Care Infrastructure Research and Innovation Centre (HaCIRIC)
Civil and Building Engineering
Loughborough University, Leicestershire, UK
a.d.f.price@lboro.ac.uk

There exists a global and national need for improved understanding of how innovative solutions can be developed and applied to the therapeutic design of new hospitals. This necessity is growing as National Health Service (NHS) infrastructures face challenges of: overcrowding; thermal energy use and comfort; lighting; hygiene and Health Care Acquired Infection (HCAI); and ventilation. These issues emphasise considerable need for change in the way hospitals are designed in order to become built environments that promote health, and enhance patient wellbeing, staff performance, operational efficiency and medical outcomes. This paper reviewed current literature and tools relating to advances in MSV technology, particularly in: 3 Dimensional (3D) Computer Aided Design (CAD); Building Information Modelling (BIM); Parametric Modelling and Environmental Simulation; Construction Simulation; Virtual Reality (VR); and Facility Planning and Design Simulation. Their applicability to healthcare environmental design was reviewed to identify: examples of good practice; evidence based solutions and current trends; and conceptualise a Virtual Health Promoting Environment (VHE) that integrates MSV tools for optimised building performance. It was discovered that MSV has an important role to play in facilitating innovation and stimulating change from traditional healthcare design approaches to new approaches that support healthcare environmental design aimed at increase in the evidence base and optimisation of performance within multiple environmental parameters.

KEYWORDS: Innovation; Modelling; Simulation; Visualisation.

INTRODUCTION

One of the questions addressed by this paper is, "how can innovation stimulate change from a traditional healthcare design approach to a more evidence based healthcare promoting environmental design approach – one that incorporates consideration for multiple parameters and impacts - and what role can modelling, simulation, and visualisation (MSV) tools play in this much needed innovative change?"

Innovation Technology (IvT) has been defined by Gann and Dodgson (2007, pp.10-11) as comprising three main types of technology platform: eScience, or Grid technologies; Modelling, simulation and visualisation; and Virtual and rapid prototyping systems. "Modelling, simulation and visualisation technologies, … evolved from CAD systems and benefited significantly from developments in the computer games industry". However, opportunities and reasons abound for MSV technologies to gain prominence within the planning, design and construction of healthcare buildings. In comparison to traditional approaches, the advent of MSV provides design professionals and teams with the opportunity to investigate, demonstrate and validate various solutions within a virtual environment. The benefits inherent in such an approach were identified by Gann and Dodgson (2007) and these include, the reduction in the cost and time required for various aspects of the building design and development process. It also integrates several stakeholders, including end users, industry, practitioners and regulators – through 3D visualisation - to effectively collaborate even during the early stages of the building design process. In further describing IvT and its current prominent role, Dodgson et al. (2005, p.8) stated that "Computer-based simulation and modelling is replacing the traditional, laborious drafting, physical testing, and model building approach to many design tasks". These physical testing and model building approaches represent traditional methods such as the use of Physical Mock Ups (PMU) for addressing specific assessment and validation requirements, but which is subject to limitations in its ability to incorporate multiple parameters in its assessments and validations. Computer based models, according to Dodgson et al. (2005), assist design tasks with diagnosing, analysing, verifying and optimising design. Advances in MSV technology offer many opportunities for a more integrated approach to the planning, design, construction and operation of healthcare infrastructure. This is intended for improvement in operational efficiency in order to engender clinical recovery and medical outcomes. Considerable information and knowledge is available about innovative design and construction of healthcare infrastructure. However, most of this information is fragmented and not easily accessible. The study disseminated in this paper is intended to help reduce such fragmentation, improve access and provide an excellent foundation on which subsequent research can be built on. The main methods used to gather the information include the following:

- The use of Literature Reviews: for the presentation of current Construction IT application of modelling, simulation and visualisation to healthcare infrastructure planning, design and construction.
- The use of Case Study Research: for the investigation, identification and collation of evidence of good practice in modern design and construction. The resultant information will be used to develop an approach that facilitates good knowledge transfer.

MSV tools were reviewed, particularly those relating to Three-Dimensional (3D) Computer Aided Design (CAD), Building Information Modelling (BIM), Parametric Modelling and Environmental Simulation, Construction Simulation, Virtual Reality (VR), and Facility Planning and Design Simulation. Their application to healthcare design and construction were reviewed.

The Built Healing Environment (BHE) research project has identified a link between impacts and patient recovery. The traditional approach to designing solutions to these impacts involves the use of 2D documentation, 3D physical models and Physical Mock Ups (PMU) such as the full-scale mock-up of a patient room for the Sacred Heart Medical Center at RiverBend, Oregon, United States of America (USA). This traditional approach has its advantages but is limited in its flexibility to incorporate multiple varying evidence-based design solutions, and it can also be cost intensive in its implementation. An emphasis on the adoption of new approaches such as the use of MSV technology and Digital Mock Ups

(DMU) is timely since the United Kingdom (UK) Government's policy interest is currently geared towards evolving a more innovative National Health Service (NHS).

Current research work involves improving the therapeutic design of new, and the assessment of existing healthcare environments through the use of MSV technologies that optimise performance within multiple environmental parameters, thus enhancing evidence based approaches. It also explores the development of a Healthcare Infrastructure Digital Mock Up Facility (HIDMUF) that provides a multi-parameter long-term financially beneficial evidence based approach to the design against impacts in the Built Health Promoting Environment (BHE), including those in NHS Trusts.

Tools for MSV of Healthcare Promoting Environments

One of the work packages (WPs) of our current research, Improving the Therapeutic Design of Healthcare Environments through the use of MSV, involves the 'determination of the human aspects associated with MSV technology use and its impacts on decision making'. Part of the review presented in this paper represents a study undertaken to identify some of the MSV tools currently being applied to healthcare design and construction, as well as the role their use has played in the work of some stakeholders. Knowledge acquired from this study will be applied in future work. Current literature and tools relating to advances in MSV technology were reviewed, particularly in: Three-Dimensional (3D) Computer Aided Design (CAD); Building Information Modelling (BIM); Parametric Modelling and Environmental Simulation; Construction Simulation; Virtual Reality (VR); and Facility Planning and Design Simulation. Their applicability to healthcare environmental design was reviewed to identify: examples of good practice; evidence based solutions; current trends; and conceptualise a Virtual Health Promoting Environment (VHE) that integrates MSV tools for optimised building performance.

These MSV tools have been evaluated by the first author (an environmental designer and architect) based on a study of relevant literature and software, and case studies of MSV application to healthcare building design and construction. These MSV tools will be eventually mapped in relation to human aspects (planned for the latter phase of the current research) but are categorised in this paper into the following:

- 3D Computer Aided Design (CAD) Tools: these include MicroStation, ArchiCAD, Bentley Architecture, and AutoCAD Revit Architecture Suite 2008;
- Building Information Modelling (BIM) Tools: these include Bentley BIM Technology, and Bentley Speedikon Architectural;
- Parametric Modelling and Environmental Simulation Tools: these include ECOTECT, and IES Virtual Environment (VE);
- Construction Simulation Tools: these include Synchro, and Asta Powerproject;
- Virtual Reality (VR) Technology Tools: these include Urban Sim, MultiGen Creator, Vega Prime, and Immersive Environments (VR theatres, Caves, Domes, Immersive workbenches, and Hemispherical screens); and
- Facility Planning and Design Simulation Tools: these include ProModel, MedModel, ED, OR and Process Simulators, and DataAnalyzer.

3D Computer Aided Design (CAD) Tools

Widely used 3D CAD tools include: ArchiCAD 11; MicroStation version 8; Bentley Architecture 2008; and AutoCAD Revit Architecture Suite 2008. Based on the MSV tools review, these 3D CAD tools were discovered to support: integration of design and work between internal and external teams; accuracy and flexibility in design; about 10% reduction in construction time wastage; about 3% savings on the cost of projects; time resource optimisation; Building Information Modelling (BIM); compatibility with other systems; visualisation of design; effective communication; and evidence based design (Graphisoft, 2007; Bentley Systems, 2007; Autodesk, 2007).

Advances in 3D CAD and BIM have been applied by architects from Anshen and Allen for the creation, effective collaboration and integration of the mechanical, structural, electrical and plumbing systems for the Mills-Peninsula Medical Centre in California, USA. The ArchiCAD 3D BIM model was also used in collaboration with NavisWorks for preconstruction clash detection simulation tests. MSV tools were applied in the design of three USA healthcare facilities, Mills-Peninsula Medical Centre, Heart Hospital, and Santa Clara Medical Centre, and advantages were observed. For example, according to Graphisoft (2007), the use of ArchiCAD improved the integration of systems, quality of 3D visualisation, evidence based design, and avoidance of resource wastage in the delivery of the Mills-Peninsula Medical Centre scheme.

Building Information Modelling (BIM) Tools

According to Autodesk, and Laiserin (2002), BIM is a tool – based on Three-Dimensional (3D), object-oriented, Computer Aided Design (CAD) – that is used by the Architecture, Engineering and Construction (AEC) industry. It is offered by several technology providers including Graphisoft, Autodesk, and Bentley Systems, and provides a representation of the building process in order to facilitate exchange and interoperability of information in digital format. Further, the American Institute of Architects (AIA) – in its definition of BIM – states it is a technology that is model-based and linked with a project information database.

These BIM tools include Bentley Speedikon Architectural, Bentley BIM technology, and ArchiCAD. Based on the MSV tools review, and according to Bentley (2007), BIM tools were discovered to support: integration of systems; improved construction documentation coordination; accelerated decision making during the design phase; enhancement of details during other phases; improved workflow; reduction in production time; collaboration between design and development teams; minimisation of resource wastage; cost savings; time resource optimisation; compatibility with CAD platforms; 3D Visualisation; effective communication; evidence based design; and promotion of the patient healing process.

Advances in 3D CAD and 3D BIM were used by architects from Escade for the creation of a hospital design in the Netherlands through utilisation of the Bentley Speedikon Architectural. This is a single architectural integrated BIM application for MicroStation, and it supports building design and construction documentation of new and existing structures. NBBJ used Bentley BIM technology for the design, documentation and 3D visualisation of the Moscow Medical Centre. Bentley (2007) described the Centre's scheme objectives as involving the design of a hospital that promotes the process of patient healing through the creation of friendly and operationally efficient experiences. There are also inherent opportunities that were identified for BIM to gain greater prominence in the AEC industry. However, for this to be actualised, there has to be an emphasis shift from traditional design presentation and preparation approaches to more evidence based and performance optimisation oriented approaches.

Parametric Modelling and Environmental Simulation Tools

Parametric Modelling and Environmental Simulation can be described as the use of object oriented CAD for the modelling and simulation of components within multiple real-world behaviours and environmental attributes to assess, evaluate and validate design solutions.

In its description of the ECOTECT building design and analysis tool, Crawley et al. (2005, p. 232) identifies that “ECOTECT is a highly visual architectural design and analysis tool…”. It has the capability to link multiple performance analysis functions to a 3D editor and modeller, and its performance analysis functions include thermal, energy, lighting, shading, acoustics and cost aspects. Its 3D editing, modelling, and visualisation capabilities are advanced enough to incorporate varying degrees of volumetric and analytical complexities. Its volumetric and spatial analysis results can be visualised and real time animations can be created to reflect updates and changes to the building’s response to its location, climate, and operational hours’ characteristics. ECOTECT provides the opportunity for obtaining important performance feedback during the earliest stages of the building design process. It displays analytical results as standard graph and table based reports, however, such results can also be mapped over the building surfaces and within their spaces. During studies involving the use and review of ECOTECT by an environmental designer and architect, it was discovered to be a highly visual and interactive tool that supports:

- parametric modelling;
- performance analysis covering thermal, energy, lighting, shading, acoustics, resource use, and cost aspects within multiple environmental parameters;
- mapping of analysis results over building surfaces and within spaces;
- compatibility with EnergyPlus, Radiance, NIST FDS and ArchiCAD; and
- evidence based design improvements.

Construction Simulation Tools

According to Synchro, in iBIM-UK (2008), Construction Simulation is described as the 4D Planning and Visualisation of construction schedules. Firstly, it involves the importation of a created 3D model into a 4D Planning software such as Synchro. Secondly, a construction schedule created in software such as Asta, Priamvera or MS Project is imported into the 4D Planning software. Thirdly, the individual tasks on the construction schedule are linked to the corresponding geometry on the 3D model. Fourthly, a 4D view of the time line of the construction program over time can be played back or forward and watched as a visualisation. These Construction Simulation tools include Synchro, and Asta Powerproject as identified earlier. The review of these tools by an environmental designer and architect included participation at a National User Forum, interviews, meetings, a workshop, and demo trials, which were all informative on various aspects of the tools’ capabilities. These revealed that the construction simulation tools support: 4D simulation; 4D problem solving; 4D collaboration; project visualisation; bid visualisation; coordination and scheduling management; integration of design, procurement and delivery schedules; flexible management systems; cost savings; time resource optimisation; compatibility between systems; communication between clients and professionals; efficient planning; and avoidance of scheduling problems (Ormerod and Williams, 2008; Scurr and Williams, 2007).

Virtual Reality (VR) Technology Tools

Virtual Reality – otherwise known as VR – can be described as a computer simulated environment of a real or imagined system that permits users to immerse themselves and interact within the created VR environment in order to assess, evaluate and validate impacts and solutions to multiple scenarios in real time.

Virtual Reality (VR) Technology tools include Urban Sim, MultiGen Creator, Vega Prime, and Immersive Environments (VR theatres, Caves and Pseudo Caves, Domes, Immersive Workbenches, and Hemispherical Screens). Based on the review of the Antycip VR software – and work and facilities of the Advanced Virtual Reality Centre (AVRRC) – these VR tools and facilities were discovered to support: real-time interaction; optimised 3D Visualisation; collaboration between design and development teams; building performance measurement; and evidence based design (Kalawsky and O'Brien, 2008; Mould, 2007).

Facility Planning and Design Simulation Tools

Facility Planning and Design Simulation can be described as the creation and development of a computer representation of a system for the evaluation of several parameters related to its product characteristics, equipment capability, facility capacity, and operational and occupancy performance in order to support forecast scenarios.

These Facility Planning and Design Simulation tools include ProModel, MedModel, ED Simulator, OR Simulator, Process Simulator, and DataAnalyzer. A review of their capabilities revealed that they support: scenario testing; system behaviour analysis; parametric modelling; performance measurement; data analysis; accurate modelling of patient flow, staff scheduling and facility layout; conceptual planning and coding assistance; collaboration with other consultants; and evidence based design (ProModel, 2007).

The Virtual Health Promoting Environment (VHE): The Role of the Healthcare Infrastructure Digital Mock Up Facility (HIDMUF)

The Virtual Health Promoting Environment (VHE) is an emerging concept that applies the benefits inherent in the use of modelling, simulation and visualisation technology – in the form of MSV Inputs and MSV Outputs – towards solving healthcare infrastructure design and performance problems. It involves the integration of the capabilities and constituents of the virtual healthcare infrastructure to rectify the problems existent in the built healthcare infrastructure. The Built Health Promoting Environment (BHE) – and the non-digital and traditional methods usually employed in its design and assessment – are subject to physical limitations in terms of upgrade, adaptability and flexibility; they are indeed victim to the constraints of their physical surroundings. However, the VHE – and the Digital Mock Up methods employed in its design and assessment – do not have such limitations as the BHE, and they provide the opportunity for seamless assessment, evolution, demonstration, validation and documentation of healthcare building design and performance optimisation solutions.

The VHE will, through high-specification processors, process MSV Tools Input – consisting of 3D CAD, BIM, Parametric Modelling and Environmental Simulation, Construction Simulation, VR, and Facility Planning and Design Simulation tools – and develop MSV Tools Output that optimise design and performance. This system layout of high-specification processors, AEC related MSV Tools Input, MSV Tools Output, high-resolution projectors, ancillary hardware and software, and VR will constitute the Healthcare Infrastructure Digital Mock Up Facility (HIDMUF) currently being developed by the authors.

The HIDMUF (refer to figure 1) aims to enhance therapeutic design of healthcare environments – by facilitating the Virtual Health Promoting Environment (VHE) – based on multi-parameter assessment and performance optimisation. Its system layout will comprise of high-specification processors, AEC related MSV Tools Input – consisting of 3D CAD, BIM, Parametric Modelling and Environmental Simulation, Construction Simulation, VR, and Facility Planning and Design Simulation tools – and MSV Tools Output, high-resolution projectors, ancillary hardware and software, and VR display component. The VHE will involve exploring complementarities between these multiple parameters and establishing the feasibility of establishing an integrated approach. The developed integrated approach – incorporating parameters that include air quality, aesthetics, lighting, acoustics and thermal comfort – will be used for assessment, evaluation and validation of various healthcare environmental design impacts and solutions, as well as forecasting of future scenarios.

Also, current research at Purdue University's Regenstrief Center for Healthcare Engineering, Envision Center for Data Perceptualization, and Division of Construction Engineering and Management in the USA have focused on developing an immersive virtual reality mock up for the design review of hospital patient rooms. According to Dunston et al. (2007), a scarcity of evidence-based design principles and practices for patient-centred healthcare environments was identified. This necessity justified the objective of researchers at the Purdue University Regenstrief Center for Healthcare Engineering to develop a Virtual Reality (VR) mock up of a hospital patient room for the exploration of environmental design impacts on its behaviour, processes and safety, and the efficacy of its design solutions. Key to the importance of the VR patient room mock up is its high level of interactivity that facilitates the evaluation of its designed space as a therapeutic environment. Healthcare practitioners provided positive feedback on the mock up's performance and this has further justified the objective of the researchers at Purdue University to develop additional VR mock ups for other hospitals.

The current and proposed use of digital mock ups and virtual environments described in this paper demonstrate an emerging trend towards the adoption of new approaches. Since innovative solutions can be complex and involve several facets, the traditional use of physical mock ups to support these can be cost intensive. However, the emergence of MSV technologies provide a platform for cost effective visual alternatives that are flexible, upgradeable, performance optimisation driven, and equipped for evaluation and validation of multiple healthcare building design parameters, impacts, solutions and scenarios.

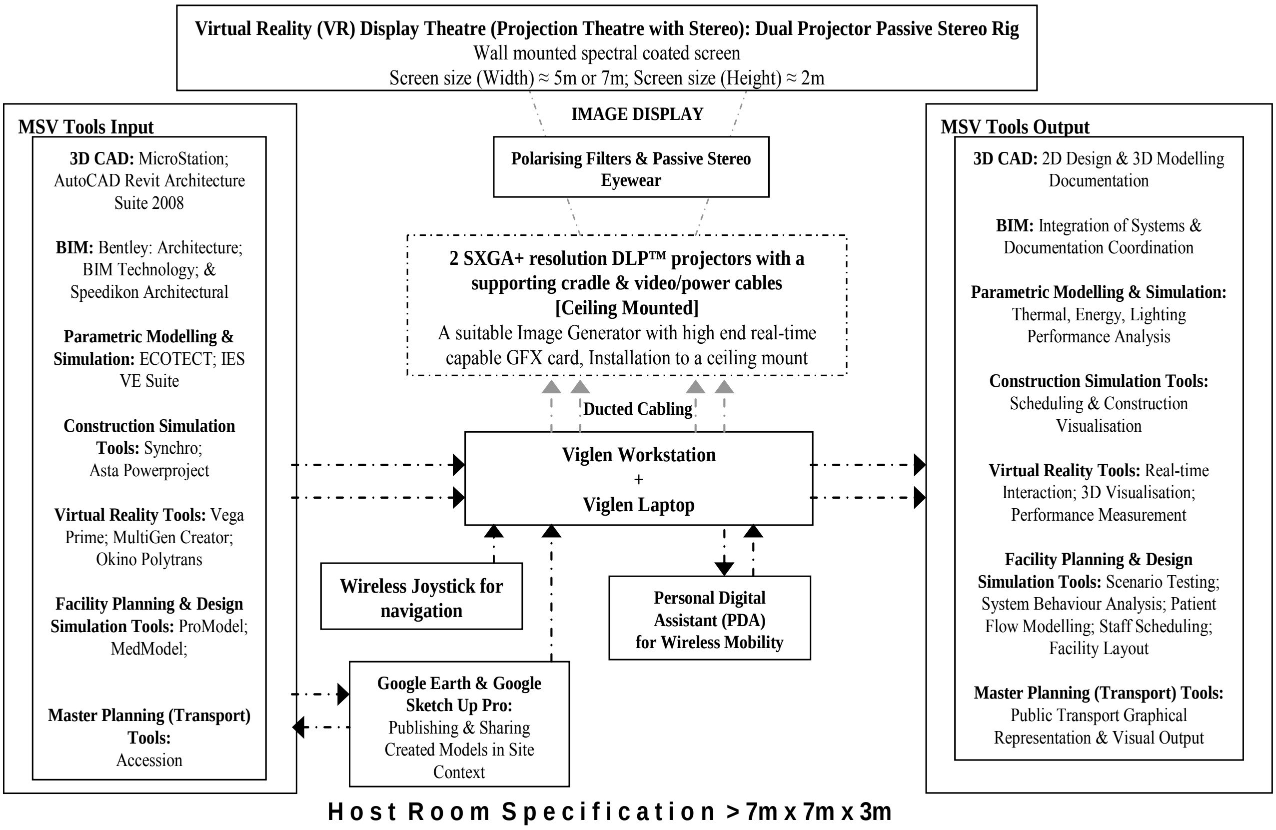


Figure 1: The Healthcare Infrastructure Digital Mock Up Facility (HIDMUF) that facilitates the VHE.

CONCLUSION: THE ROLE OF MSV TOOLS IN SUPPORTING INNOVATION IN HEALTHCARE ENVIRONMENTAL DESIGN

Based on the evidence presented in the studies reviewed, it was discovered that the application of MSV technology to the design of the healthcare environment facilitates the development of innovative methods, as well as solutions. It also offers opportunities for an integrated approach to the planning, design, construction and operation of healthcare built environments. Since the conceptualisation, development and operation of healthcare built environments involve complex and diverse processes, new approaches that integrate these processes offer opportunities for improvement in the planning, design, construction and operation of healthcare built environments. Although it is accepted that innovative solutions are complex and involve several facets of complexity, it is also important to appreciate that the traditional use of physical mock ups can be expensive. However, it has been discovered that the recent advances in MSV technology provide a cost effective, more visual and evidence based alternative when compared to the more cost intensive traditional approaches. Healthcare built environments that are designed with specific reference to the needs of patients, staff and visitors have been shown to deliver positive outcomes. MSV technology and its tools can effectively support the design of such healthcare built environments that cater to occupant needs and medical expectations within multiple environmental parameters.

These MSV tools were discovered – based on a review by an environmental designer and architect – to play a crucial role that supports innovation in healthcare built environments by:

- providing an evidence base that aids planning for designing integrated delivery and operation;
- facilitating effective decision making for multiple stakeholders through visualisation and simulation processes; and
- integrating processes and systems for effective collaboration and decision making.

As stated earlier, MSV technology provides an integrated approach to the planning, design, construction and operation of healthcare infrastructure, and it also offers opportunities for improvement in operational efficiency in order to engender clinical recovery and medical outcomes. MSV can support innovation and stimulate change from traditional healthcare design approaches to new approaches that support healthcare environmental design aimed at increase in the evidence base and optimisation of performance within multiple environmental parameters.

REFERENCES

American Institute of Architects (AIA), (2008)

Autodesk, (2007), "AutoCAD Revit Architecture Suite", available at: http://www.autodesk.co.uk/adsk/servlet/index?siteID=452932&id=8853628

BBC, (2007), "NHS 'hygiene standards struggle'", available at: http://www.bbc.co.uk

Bentley, (2007), "MicroStation", available at: http://www.bentley.com/en-US/Products/MicroStation/

CIFE, (2007), "Virtual Design and Construction", available at: http://cife.stanford.edu

Clague, J.E., Reed, P.G., Barlow, J., Rada, R., Clarke, M. and Edwards, R.H.T. (1997) Improving outpatient clinic efficiency using computer simulation. International journal of health care quality assurance, 10(5).

Crawley, D.B., Hand, J.W., Kummert, M. and Griffith, B.T. (2005) Contrasting the Capabilities of Building Energy Performance Simulation Programs Joint Report Version 1.0. Proceedings of the International Building Performance Simulation Association 2005 Montreal, August 15 – 18, p. 232.

Dodgson, M., Gann, D. and Salter, A. (2005) Think, Play, Do – Technology, Innovation, and Organization. Oxford: Oxford University Press, p. 8.

Douglas, C.H. and Douglas, M.R. (2005) Patient Centred Improvements in Healthcare Built Environments: Perspectives and Design Indicators, Health Expectations, Vol. 8, No. 3.

Dunston, P.S., Arns, L.L. and McGlothlin, J.D. (2007) An Immersive Virtual Reality Mock-Up for Design Review of Hospital Patient Rooms. Proceedings of the 7th International Conference on Construction Applications of Virtual Reality, Pennsylvania, October 22 – 23.

Gann, D. and Dodgson, M. (2007) Innovation Technology – How new technologies are changing the way we innovate. London: NESTA, pp. 10-11.

Graphisoft, (2007), "Value Proposition for ArchiCAD", available at: http://www.graphisoft.com/products/archicad/

Green, J.H., (2008), "A collaborative process ties safety and efficiency to create Sacred Heart Medical Center's new design", available at: http://www.healthcaredesignmagazine.com/ME2/dirmod.asp?sid=&nm=&type=Publishing&mod=Publications%3A%3AArticle&mid=8F3A7027421841978F18BE895F87F791&tier=4&id=C7C9D152C8AB46338F59D2099AF221DB

iBIM, (2008), "iBIM-UK Brochure", available at: www.iBIMGroup.com

Kalawsky, R.S. and O'Brien, J. (2008) Advanced Virtual Reality Research Centre

Laiserin, J. (2002) "Comparing Pommes and Naranjas", available at: http://www.laiserin.com/features/issue15/feature01.php

Marsh, A.J. (1996) "Integrating Performance Modelling into the Initial Stages of Design", in ANZAScA Conference Proceedings, Chinese University of Hong Kong, 1996

Marsh, A.J. (2006) "ECOTECT meets ArchiCAD", available at: http://www.squ1.co.uk/node/1585

Mould, J. (2007) Antycip Virtual Reality (VR) Technology

Ormerod, R. and Williams, R. (2008) Asta Powerproject

PeaceHealth, (2008), "Sacred Heart Medical Center at RiverBend", available at: http://www.peacehealth.org/Oregon/News/Facilities/RiverBend/SHMC_RiverBend.htm

ProModel, (2007), "ProModel Optimization Software Suite", available at: www.promodel.com

Rundell, R. (2007) "BIM and Visualisation, Part 2 (1-2-3 Revit Tutorial), Case Study: RTKL", available at: http://aec.cadalyst.com/aec/Column:+1-2-3+Revit/BIM-and-Visualization-Part-2-1-2-3-Revit-Tutorial/ArticleStandard/Article/detail/444294

Scurr, D. and Williams, S. (2007) Construction Simulation Technology: 4D and Beyond – Synchro.

Weaver, M. and Long, K. (2001) "'Problem' hospital up for design award", available at: http://www.societyguardian.co.uk

SUPPLYING PRODUCTION INSTRUCTION KNOWLEDGE TO THE CONSTRUCTION SITES

Mats H Persson
Division of Construction Management, Lund University, Sweden
mats.persson@bekon.lth.se

Bengt Hansson
Division of Construction Management, Lund University, Sweden
bengt.hansson@bekon.lth.se

A systems analysis of construction project management revealed inconsistencies within and between subsystems that aim at supporting the in-service training of the craftsmen and utilise their ability to perform their tasks effectively. The information and knowledge that construction workers were provided on construction site appear to be poorly matched with what is required. Site managers, designers and suppliers could and should have better means and informational resources to adequately instructing the site operatives (craftsmen) in details of the task at hand. The process of accumulating and transferring knowledge on construction site is poorly developed. To improve this situation, it is important to facilitate the coordination of various system components and increase site operatives potential to perform their work in accordance with specifications and what has been agreed upon. A set of general site-use-adapted work instruction (ByggAi) was developed which is applicable to a wide variety of tasks of construction workers. ByggAi aims to be a means of furthering knowledge development and strengthening continuous improvement.

KEYWORDS: Knowledge transfer, site management, labour efficiency, craftsmen involvement, near-zone planning, working instruction guide.

INTRODUCTION

Lack of knowledge leads to mistakes

Construction firms are expected to conduct work at the construction site in accordance with drawings and specifications that are agreed upon. The client expects this to be done in a professional manner, even if this is not explicitly expressed in the contract. The specifications and the contract are normally based on national standard reference frameworks (such as NBS in the UK and AMA in Sweden). Basic workmanship and knowledge of the regulations applying to building and construction work are essential pre-conditions to perform the work in accordance with the contract.

Studies of the frequency and effects of flaws and errors in the Swedish construction process indicate that these account for some 6% of the total production costs and that about 10% of the working time is spent on correcting errors and reworking on what has been done or planned (Josephson and Hammarlund 1999). Part of the errors were caused by deficiencies in the design work, among which include the shortcomings of the knowledge of those engaged in production have at their disposal. A considerable proportion of the errors can also be traced to difficulties caused by vagueness or imprecision in the instructions that the design team provides (Josephson and Saukkorpi 2005).

Information failing to adequately support knowledge development

Architects and designers base their specifications on standard reference works and directions from suppliers, whereas site operatives (i.e. construction workers, craftsmen etc.) almost never have direct access to information sources of this type. Any contact they have had with them is usually no more than superficial, such as an introduction to such matters in upper secondary school (Persson and Bergh 2004). The knowledge of the individual is then scarcely renewed although the standard reference framework may be updated continually.

Site operatives, as well as those in charge of work at the site and others engaged in the practicalities of a construction project, are in need of adequate knowledge for carrying out properly the work to be done and to update their working knowledge to keep abreast with latest technology (Persson and Bergh 2006). A common scenario on construction site is where operatives receive at most some 4 hours of training a year, in contrast to their supervisors, who underwent about 40 hours a year. The education obtained in upper secondary school remains the most important component in the training of the majority of construction workers. When new methods and materials are developed, new knowledge is needed. In order to acquire the information needed at a construction site, the personnel (both management and operatives) should be provided with relevant information and be motivated to learn and generate such knowledge themselves (Persson and Bergh 2004, 2006).

Knowledge concerning a task that has been completed can be of genuine help at a later time (positive feedback) and may result in a new and more effective approach to the task. (Persson 2006)

Management of knowledge development is lacking

The knowledge development of site operatives tends to be very much neglected (Larsson et al. 2005). As employment is in many cases contract/project based many employers are not willing to invest in the workers further training. This is further magnified by the nature of construction with many specialised subcontractors constituting a temporary organisation on site (Persson 2006). Before performing any work, the site operatives and the site management usually discuss the planning and the execution of the work (Persson and Bergh 2003). Although this could in principle lead to optimising of plans, sadly the lack of fully adequate knowledge on the part of both the workers and the management could sabotage efforts in this direction. Another example is that according to project managers who were interviewed in a project performed in Uganda, the most important steps in improving productivity involve eliminating the incompetence's among supervisors and the lack of knowledge and skills on the part of many workers (Alinaitwe 2006: see appendix III p 10).

Problems in systems for the knowledge development of construction workers

The present system of knowledge development for the on-site personnel of construction companies (operatives, management and supervisors) can be envisaged as characterised by the following statements:

- The *large numbers of errors* occurring at construction site (and the considerable costs this results in) appear to be largely due to insufficient knowledge transfer on the part of the personnel involved.
- *Information* obtained from clients, designers, suppliers and the contractor that could potentially further the knowledge development of the on-site personnel appears not to be well adapted to this purpose or to be only particularly suitable for it.
- A management function (process) supporting the system for knowledge development appears to be either poorly developed or to be missing entirely.

The flow of information to the personnel at construction sites concerning how the tasks at hand can best be carried out is highly important for the development of knowledge of work procedures generally. With better knowledge of this sort, the number of errors can be minimised or eliminated.

Aim, objectives and methods

The aim of this paper is to investigate typical features of the knowledge management system for the construction site and to propose a guide to improve the coordination of various system components in the knowledge management process on construction sites. The paper will also examine the mismatch and interaction between sub-systems in terms of both synergy effects of the mismatch and finally a guide/tool that can be introduced for site managers, supervisors and site operatives is presented.

A systems analysis is used to describe the processes within construction companies, efforts being made to pinpoint mismatches between subsystems involved. Interactions between subsystems in terms both of synergy effects and of mismatches (Arbnor and Bjerke 1997) are analysed.

THE PROCESS MODEL

A generic process model for the performing of construction Task A at location n is shown in Figure 1. The process model contains flows of information, machinery, tools and materials. The site management prepare for the task and the site operatives carry it out. The preparations include studying the drawings and specifications with referenced, standard reference works and information accumulated in the project regarding the task at hand. There should also be some kind of check before the task is handed over to the next step in the construction process.

In efforts to gain an understanding of how various tasks are actually performed by those who carry them out, 41 cases of task performance of this sort were studied (Persson & Bergh 2006). The results are compared with the approach to solving tasks prescribed by the generic process model described in Figure 1. Results revealed that flows of information of the following types were usually absent:

- Information from a standard reference work being made available to the site operatives
- Information from legislation and building codes of relevance being made available to the site operatives

- Information about labour safety regulations being made available to the site operatives
- Further education being provided for the site operatives

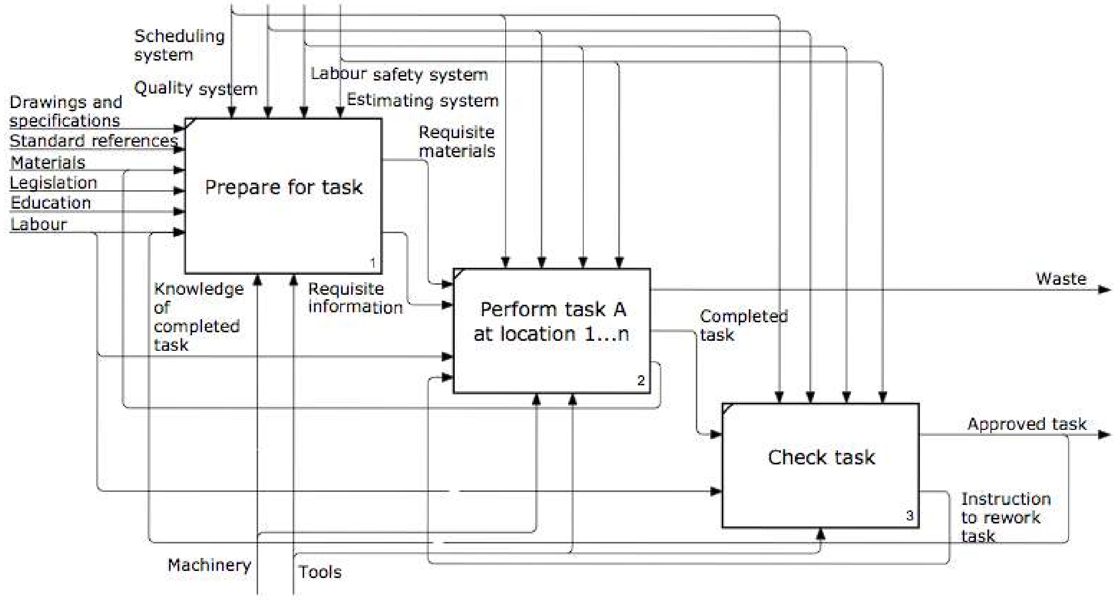


Figure. 1: A generic process model illustrating the flow of information and resources needed to perform Task A at location n on the construction site. (Adapted from CIB78 1997)

THE SUPPORT OF KNOWLEDGE MANAGEMENT SYSTEM TO THE CONSTRUCTION SITE

The knowledge development that takes place in a construction firm should be supported by a capable quality management system, as well as by the systems for cost estimating, time scheduling and labour safety. The site operatives should possess sufficient knowledge to be able to demonstrate workmanship in their work, be able to utilise effectively contract documents, drawings and specifications as the starting point for their work, and have the support of the site management and the overall management system of the firm and lessons learned and knowledge accumulated.

The task of *the knowledge management system* is to direct, enhance and coordinate knowledge development in the firm, utilising the different subsystems of relevance and seeing to it that the knowledge needed for carrying out the construction work is made readily available. A clear objective of the knowledge management system is to develop the knowledge of the staff in such a way that the conditions of each and every contract will be met and to satisfy client's desires in an effective and professional way. In most construction companies, however, an explicit knowledge management system has not been developed at all, and normally an ineffective system approach for collecting and storing knowledge within the organisation is found and little emphasis is placed on developing the competence of workers. The large numbers of errors made in construction work and the virtual lack of further training suggest knowledge management, in whatever form it may be present, to usually not function well.

The individual site operative should obtain knowledge on a continual basis so to maintain a satisfactory level of workmanship. A major part of the knowledge that a site operative possesses for the tasks to be performed is obtained during the initial professional training and as an apprentice. The formal training provided after that is usually very limited. For workers to be well prepared for the tasks to be performed requires further sources of knowledge of general or specific character and should be made readily available to them. The following are certain important considerations pertaining to this:

- Drawings and specifications (in a form that the person in question can readily comprehend) pertaining to the work at hand should be provided.
- A work execution plan (or detailed plan of the work to be done) should be made known, at the latest by the time the work gets underway.
- General descriptions of the work to be carried out should not only be accessible but also be easy to read and understand.
- There should be ample access to suppliers' instructions on how to assemble and use the materials or equipment involved.
- The laws and regulations that apply should be clear to everyone.
- Inspection routines should be clarified and any checklist to be used for control purposes should be handed out to everyone.

MISMATCHES BETWEEN SUBSYSTEMS

Figure 2 indicates the subsystems that particularly influence the knowledge development of the individual site operative. The following are various mismatches that can occur between subsystems (Persson and Bergh 2004):

- Drawings and specifications pertaining to work to be carried out often refer to standard documents or reference works or to instructions provided by suppliers. Such standard documents or reference works are usually not available at the work site. Also instructions provided by the manufacturers of material or equipment, may be lost track of. Construction workers are usually not trained in reading standard documents or reference works. Although these may contain potentially useful instructions on how work of various types is to be carried out, the instructions are often either incomplete, not up-to-date or are not easy to assimilate. The target groups for such documents are often designers and procurement personnel, since site operatives practically scarcely are involved in procurement and have limited access to them that they contribute little to the knowledge development of the work force.
- Planning sessions and toolbox talks regarding how work is to be carried out are seldom attended by site operatives, despite its being they who perform the work.
- Only in exceptional cases do site operatives have the opportunity to read the specifications for the project they are involved in or a particular standard reference work.

- Only seldom does a site operative get to read the manufacturer's instructions.
- Only in exceptional cases is a site operative encouraged or given the opportunity to reflect over, plan or carry out the quality assurance work that is usually called for.

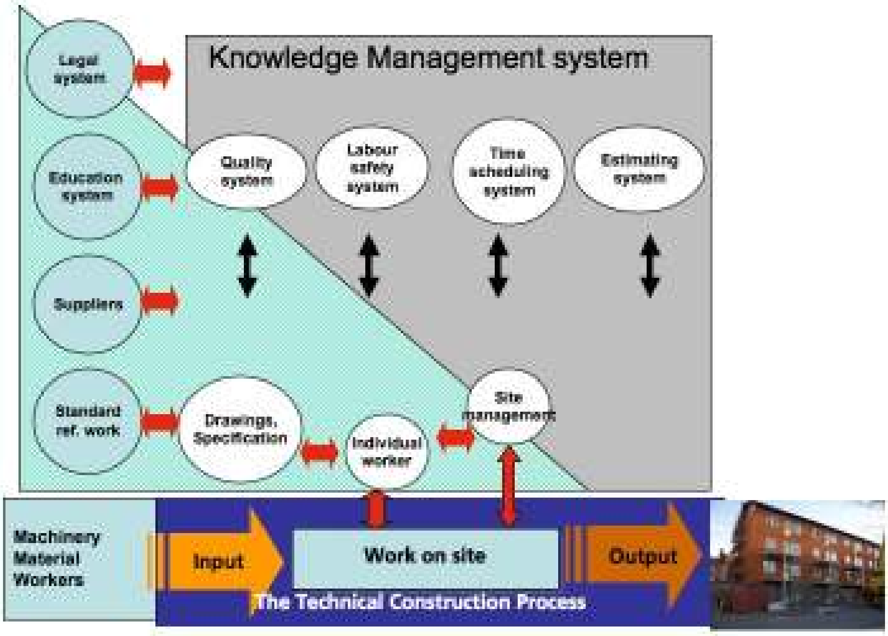


Figure 2: The subsystems that have a particularly strong influence on the knowledge development of the individual craftsman.

Mismatch between subsystems and lack of knowledge management can apply to different levels in an organization. If one aims at changing practices in respect to matters of the type just referred to in an entire construction firm, this must be undertaken at a variety of levels: Individual – site – firm – national construction sector – construction sector (Persson 2006).

The knowledge management of the sector and available information for personnel at site is not well organised to allow for an transfer from explicit to implicit knowledge according to the SECI-model of Nonaka and Takeuschi (1995) as pictured in Figure 3. The process of socialization (tacit→tacit) is shown in the bottom of Figure 3. On the left side Externalization (tacit→explicit) is shown. In the top Combining of knowledge is shown (explicit→explicit). On the right side the important process of Internalization is illustrated (explicit →tacit)

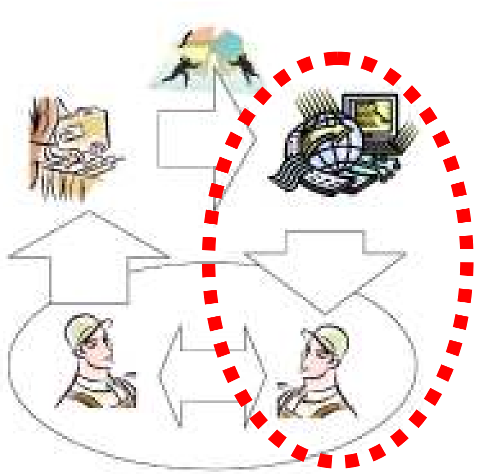


Figure 3. The SECI-model of knowledge transfer with the process of internalisation highlighted (Nonaka & Takeuschi 1995)

SUGGESTIONS FOR IMPROVEMENT

Various problems concerning mismatches between subsystems within the system that a construction firm represents have been outlined. There are various approaches that aim at suggesting, describing or providing various solutions to these problems. The Ratu-file for planning construction (www.rakennustieto.fi) is one such attempt. This file is intended to improve the productivity, safety and quality of construction work. Information regarding work procedures and work planning is collected at construction sites and is made available, information about safety in the work situation is provided, and quality assurance information is included. The file is available in a Finnish language version only. The program CITB-Construction Skills is concerned with educational matters applying to the entire construction industry (www.citb-constructionskills.co.uk).

At the Lund University, Division of Construction Management, an approach to providing task-related information available "just when you need it" to those engaged in construction work tasks has been developed in cooperation with various construction firms (Persson and Bergh 2006). The Swedish name of the system is ByggAi. The general site-use-adapted working instructions are developed to transfer knowledge on site. In a well-structured form, the basic information needed to carry out different types of work is made easily available, the needs of site management and site operatives at a construction site being in focus. The Working instructions of ByggAi contain information on personal safety, quality control, requirements, suggested tools and supplementary fixtures/materials, and pictures and description of a suggested correct way of carrying out the work. The scope of the system is to make information available from Quality system, labour safety system, suppliers and standard reference work as mentioned in Figure 3

The ByggAi-system is available on the Internet at http://www.ByggAi.se. The reasons for these instructions being designed in this way are the following: The working instructions (WI) are *general*, meaning they can be used at most construction sites and that when they are used they need to be supplemented with information specific to the project at hand. The WIs are *site-use-adapted,* meaning that they are adapted to the information requirements of the personnel conducting the work on site rather than to the needs of purchasers, designers, etc.

At this initial stage the Internet portal contains working instructions for 94 different tasks, for each set of instructions the following main headings are being employed:

Requirements – Personal safety and health – mapping of risks and suggested preventive measures. Demands or recommendations in terms of Standard reference works and according to manufacturers and suppliers instructions.

Preparations – Checking on whether the basic prerequisites are met. Equipment – suggestion tools etc. Various supporting material (fixtures): Are they available? Materials handling - deliveries, on-site transportation and waste handling.

Quality control –A basic form for registering quality control data is provided. Other specific requirements of the construction project in question calls for needs to be added.

Performance – Selected pictures accompanied by brief texts are provided, these describing and presenting a standard way of carrying out the work in question.

The working instructions are available on the Internet portal in pdf-format. A CD in powerpoint format containing the working instructions, together with a template for those wanting to prepare their own working instructions, is also available. Example of pages from a WI is shown in Figure 5.

Figure 5: Example from Working Instructions of ByggAi. (To date only available in Swedish)

CONCLUSIONS

Currently there appear to be serious problems in the flow of information needed to provide adequate knowledge on how to perform tasks at construction sites. Lack of knowledge flow indicates there exists mismatch between subsystems at this point.

Often a problem of this sort was solved for a given task at one particular site under a given set of conditions, yet despite the conditions differing at some other site, the same solution applied there too. There is thus a certain generality to the solutions suggested, which may basically apply throughout the construction sector.

The system - *General site-use-adapted working instructions* – ByggAi – thus address to a wide variety of problems. Despite ByggAi providing solutions to many problems, there is the question of the extent to which workers obtaining access to it. The supervisory personnel at the site should either make computer facilities available to the personnel or provide them access to the instructions by printing them out. The initiative lies with the supervisors to initiate meetings for the discussion of new tasks ahead of time. The best option is presumably to provide information of this sort in a structured way at an appropriate time.

Changing the way of performing a given task at construction sites within the entire construction sector as part of a movement for “continuous improvement” calls for a wide and open cooperation between those supplying information resources, the contractor, the client and others involved in the construction process.

The system of working instructions described here is in need of further development. First, the number of working instructions available need to be increased so as to create as broad acknowledge base as possible. Also various technical developments should be monitored to determine whether they provide new possibilities for the distribution and storage of information that could be useful here.

In addition the effects of the working instructions should be monitored and assessed in order to validate their use and to consider the further development of them. An indication that the ByggAi are welcomed by the construction industry is that Swedish construction companies already have started implementing this method of working described and agreeing ByggAi to be an important tools for the improvement work undertaken. Similarly, various educators have tried them out and found them to be useful.

REFERENCES

Alinaitwe Mwanaki, H. (2006) Labour Productivity in the Building Industry. Lund - Sweden: Division of Construction Management, Lund University

Arbnor, I., and Bjerke, B. (1997) Methodology for creating business knowledge. Second edition. London: Sage publications

Birve, L., and Hansson, B. (2003) The Challenge! article (keynote speech) in Hansson, B., and Landin, A. (editors) Construction Economics and Organization, Proceedings of 3rd Nordic Conference. Lund - Sweden: Division of Construction Management, Lund University

ByggAi - Website of Site Adapted Work Instructions Internet: http://www.ByggAi.se

CIBW78 (1997) Working Commission W78 workshop Information Technology Support for Construction Process Re-engineering, Cairns, Australia, July 9-11, 1997

Josephson, P.-E., Hammarlund, Y. (1999) The causes and costs of defects in construction: a study of seven building projects, Automation in Construction, Vol. 8, Issue 6 pp 681-687

Josephson, P.-E., Saukkorpi, L. (2005) Slöseri i byggprojekt - Behov av förändrat synsätt, FoU-väst Rapport 0507, Göteborg Sweden

Larsson, S., Lundin, L-Å., Ruden, J., Tilly, H., Östlund, H. (2005) Satsa på yrkesutbildning (translated: Invest in vocational traing), Sydsvenska dagbladet, June 28, 2005

Nonaka, I., Takeuschi (1995) The Knowledge-creating company, Oxford University Press, New York

Persson, M., Bergh, Å. (2003) Planering i bygg- och anläggningsföretag – framtagning av utbildningsmaterial. (in Swedish), ISRN LUTVDG/TVBP--03/3083--SE. Lund - Sweden: Division of Construction Management, Lund University

Persson, M., Bergh, Å. (2004) Förstudie - Upplärning med systematiska arbetsinstruktioner. (in Swedish), ISRN LUTVDG/TVBP--04/3085--SE. Lund - Sweden: Division of Construction Management, Lund University

Persson, M., Bergh, Å. (2006) Arbetsplatsanpassat lärande – rapport från utvecklingsarbete, (in Swedish) ISRN LUTVDG/TVBP/2006/3087--SE. Lund - Sweden: Division of Construction Management, Lund University

Persson, M. (2006) Lessons Learned in Knowledge Management – the case of construction. ISRN LUTVDG/TVBP2006/1021--SE. Lund - Sweden: Division of Construction Management, Lund University

DEVELOPING A CONCEPTUAL FRAMEWORK TO EVALUATE THE PERFORMANCE OF A CO-LOCATED HIGHER EDUCATION AND FURTHER EDUCATION PROJECTS

Alaa Abdulrahman, Stephen Allen and Ammar kaka
Heriot Watt University, Edinburgh, UK
aa366@hw.ac.uk

The aim of this paper is to present the development of a framework to evaluate the performance of higher education and further education co-location projects. The paper also attempts to provide a clear understanding of the criteria that determine long-term success of such projects, while investigating the cost and benefits of co-location projects using a case study of the development of the Scottish Borders Campus (SBC) in Galashiels, Scotland.

The importance of this research lies in the growing competition among education institutions to provide improved facilities that cater for a variety of learning provisions, and to do this in a cost effective manner. This initiative can be directly related to the policy of the Scottish Executive from 2004 to build a better Scotland through efficient and effective service provision.

KEYWORDS: Performance measurement, higher education, further education, shared facilities.

INTRODUCTION

Higher education organisations attempt to increase efficiency to encounter escalating running costs and to meet the growing demands of end users for quality and value for money (Varcoe, 1995, cited by Amaratunga and Baldry, 2000). A study published by CABE (2005) provided evidence of the link between the functions and facilities of education buildings and the recruitment, retention and performance of both the staff and students of higher education institutions. On the other hand, Douglas (1996) was certain that change is inevitable, especially when considering the future of higher education estates that are not completely foreseeable. The speed of ‘buildings’ change, influenced mainly by technological and financial factors, is likely to rise, and that in turn will increase the need to adapt more economic use of the space of higher education buildings (ibid). It may be suggested that adopting sharing education facilities is one of the outcomes of these changes. This can take the form of co-locating educational operations at one particular site. However, this approach can be considered as an effective, efficient and strategic solution for enhancing education infrastructure in a particular location. Nonetheless, it brings significant financial, curricular, and structural advantages not achievable through occupation of separate estates. However, the escalating need for such change in the education sector has become more evident (Duffy *et al.,* 1993 cited by Douglas, 1996). As a result, effective techniques of measuring building performance will assist in adapting to those changes, and implement new initiatives (Douglas, 1996). It can be argued that education institutions adopt more commercial methods to allocate resources than they used to do in the past (Clarke, 1997). It is, for that reason, recommended that models of performance measurement can be more useful to enlighten resource allocation in education initiations, and to form a guide to the improvement of new resource-based methods for commercial competitive advantage (Preiser, 1995). In fact, governments worldwide consider evaluating the performance of further and higher education an issue of especial interest in the attempt to enhance educational provision effectiveness and maximise value for money (Belcher, 1997).

Advances in performance measurement

Traditionally the techniques that have been used to measure business performance relied mainly on monetary figures and accounting numbers. In the 1920s, the DuPont Company presented the return on investment 'ROI' measure, and the General Motors Corporation introduced original financial management ways in that era. Since then, several management accounting practices that are currently in use, such as discounted cash flow (DCF), residual income (RI), earned value analysis (EVA) and cash flow return on investment (CFROI) (Bassioni *et al.,* 2004; Neely *et al.,* 2000; Kaplan 1984; Chandler 1977) have been developed. On the other hand, general dissatisfaction with performance measurement models that were based solely on financial approaches began in the 1950s, and since the 1970s, this dissatisfaction has explicitly become the subject of escalating criticism (Bassioni *et al.,* 2004). Reasons for not meeting professionals' expectations have been explained in the work of many researchers. Skinner (1974) argued that traditional systems ignore the strategic perspective, while Hayes *et al.* (1982) reported that they promote short termism. Nevertheless, authors have advocated that financially based practices do not improve performance; rather they maximise shareholders' gains (Johnson and Kaplan, 1987; Lynch and Cross, 1991) and lack concentration (Kaplan and Norton, 1992). Neely *et al.* (2000) advocated that this dissatisfaction with performance measures was the trigger for the emergence of more "balanced" or "multi-dimensional" performance measurement systems. Indeed, to obtain a comprehensive perspective about how a business is performing, a broader evaluation, which involves considering the potential perspectives and aspirations of the company's corporate strategy, business processes, and customers' requirements (Zairi, 1996 and Olve *et al.,* 1999), and goes beyond the "traditional" backward looking and limited measures, needs to be carried out. However, the newly developed systems have expanded to include non-financial measures that cover potential perspectives (Bourne *et al.,* 2000). The same work of Bourne indicated examples from studies such as that of Keegan *et al.* (1989) who developed a balanced measurement matrix that included internal and external business criteria, and financial and non-financial metrics; others, like Lynch and Cross (1991), introduced a pyramid of performance measures that is parallel to the order of an organisation's structure. Neely *et al.* (2000) pointed out that in the last decade of last century, the approaches to measuring business performance moved towards developing frameworks that involve "integrated measurement systems". They indicated that the balanced scorecard introduced by Kaplan and Norton in 1992 was one of the most notable examples. It can be argued that other performance frameworks have been developed since the 1950s, although they were quality-based performance frameworks, such as the Deming Prize initiated in Japan in 1950, the Malcolm Baldrige National Quality Award that was established in 1987 and the European Foundation for Quality Management launched in 1989. However, the last three models include a set of criteria that encourages total quality management by focusing on personnel, processes, strategic planning, leadership, customer satisfaction as well as the end product.

Aim and objectives

The main aim of this paper is to present the development of a performance measurement framework that can be used to measure the success of co-location projects in the education sector. However, under the main aim, the research will try to identify the criteria that determine the long-term performance success of supporting services and facilities through identifying the benefits of co-location projects.

Performance Measurement of Education Institutions

Gauging the property and facilities performance of new projects in the education sector is a critical element of managing construction projects and provides a wider prospective for better actual performance, improved educational services and possible generated savings. It gives education institutions the opportunity to compare their property and facilities performance against other institutions, boost their decision making regarding buildings, and probably enhance curriculum delivery. Hedley *et al.* (2001) conducted a consultative study aimed to generate indicators representing key "estate management statistics" for the UK higher education sector. The study revealed 16 key ratios which were grouped under five headings, namely condition and suitability, non-residential property costs, component property costs, non-residential space ratios and residential ratios. The researchers were able to create related definitions and collect data; this was considered the first study of its kind in the UK. Osseo-Asare *et al.* (2002) used an assessment tool developed by the European Foundation for Quality Management (EFQM) to examine the quality of a UK higher education institution. The case study recognised that "people satisfaction" and "leadership" are critical issues among many areas that need improvement. It would be of particular importance if these two criteria were to be gauged in education institution properties. Cheng and Tam (1997) suggested that the quality of education can be measured based on seven models. These models are the goals and specification model, the resources input model, the process model, the satisfaction model, the legitimacy model, the absence of problems model, the organisational learning model. To a certain extent, the various aspects of measures that these models cover create a comprehensive measurement framework for realising quality in education. However, these seven models can be adapted for use as an assessment of property and facilities of education institutions. Amaratunga and Baldry (2000) presented the development of a measurement framework using the balanced scorecard (BSC) to assess the performance of higher education institutions. The study was based on the four perspectives of the BSC and the internal cause and effect relationships between these perspectives. They concluded that the BSC has a major input in three main categories in facilities and property management: communication and teamwork, commitment and feedback and learning.

Methodology

In order to develop the performance measurement framework that can be used to measure the success of co-location projects, a comprehensive literature review, focus group workshops and detailed data collection were undertaken. However, in the literature review, an exploration of best practice of performance measurement frameworks, investigation of the efficiency of the current frameworks and verification of what a project performance measurement system should cover in terms of measures, objectives, type of data and methods of implementations were carried out. Then, the research underwent a series of focus group workshops. By using this technique, professionals whose opinions are very crucial in the fields of education, architecture, estate management would be brought together in a number of organised and facilitated workshops to discuss the criteria that determine the success of co-location projects by identifying a set of key performance indicators (KPIs). This technique is imperative because it allows the participants to discuss one issue at a time from different perspectives in a structured way. This will form the basis for further development of the framework at later stages.

Framework development

From the literature review, a baseline performance measurement framework was developed; this consisted of 82 indicators covering the whole-life aspects of a project. The framework was based on the final objectives a co-location project tries to attain throughout its various stages. Those objectives were derived from studying what construction projects in the education sector are trying to achieve in terms of cost, time, quality, safety, sustainability and potential educational and business benefits of such projects. The following step was to undertake a series of focus group workshops to refine the measures and to identify a manageable number of key performance indicators.

Focus group workshops

The next stage of building the performance measurement model embraced an in-depth focus group workshop. Axelrod (1975) claimed that this technique is considered as a main data-gathering method used by researchers who are required to form certain types of strategies. This is particularly applicable in the current case, as, in the opinion of Kagioglou *et al.* (2001), the metrics of a performance measurement system should relate to the strategic objectives of an organisation. This is applicable also on a project level, as projects usually operate in the context of achieving organisational goals. Nonetheless, Greenbaum (1988) explained that the focus group session typically incorporates 8-10 people drawn together in one place to deal with questions that are of great concern to the researcher(s). Hence, the focus group was undertaken with representatives of a cross section of professionals to reveal variables to be tested empirically at the second stage of the research project. Easterby-Smith *et al.* (1991) stated that the main responsibility of the researcher was to provide a rationale about the workshop, and create and promote a suitable environment for discussions. However, the workshop was organised by an independent facilitator who managed to keep the participants focused on the issues under consideration. Frey and Fontana (1993) described how the focus group usually takes the form of a structured interview, and in an ordinary interview the facilitator directs its process. The focus group consisted of eight individuals who were chosen to represent different project disciplines. Actually, the main idea behind implementing the focus group approach was to consider, examine and discuss criteria that are critical to the co-located type project success. Another reason was to provide different opinions from various backgrounds and from diverse personal experiences. The facilitated workshop was an opportunity for creating such an environment suitable for open arguments and steered discussions. During the workshop two main questions were under focus: the first was to list the top five performance indicators that the participants think are most critical for the project from their own perspective. The justification for this question was to focus on how the participants perceive success from different angles. This would provide the means to appreciate the group's rational perception and understanding regarding different issues. However, a focus group would also permit a diversity of ideas to be considered. As part of the exercise, the project success criteria are split into two main stages; the first is the delivery stage which includes project phases from inception through to project handover. The second is the post-delivery stage which starts thereafter and continues till the end of the proposed age of the facility. Consequently, 82 indicators, developed from the literature, were divided and set up within the two main stages. Therefore, the participants were split into two groups. Each group was to deal with one stage of project success. The first group dealt with the project delivery stage and consisted of the director of HWU Borders campus services, the assistant director of HWU estates, the HWU consultant and the Borders Campus project manager. The second group comprised the HWU director of planning, the project architect and the Borders College Assistant Principal. The reason for dividing the participants into two groups was to have their understanding and realisation of the project objectives, which were expressed in the first half of the workshop, converted into valuable ranking inputs according to their expertise and the participant's positions of responsibility. Thus, the second question was to rank the set of KPIs on a high, medium and low scale. New indicators were added (marked in red) to accommodate suggestions made by the participants during the workshop. The newly generated list of key performance indicators will be used as measures for the Borders Campus Project. The outcome of the workshop revealed a refined framework (Figure 1). In this framework, the success of a co-location project is determined largely on maximising the value of public money and achieving a successful transition to the stage where FE and HE can work collaboratively and within a sustainable environment.

The conceptual framework

The outcome of that workshop was a milestone as the research took a new direction towards more operational and organisational issues. Another focus group workshop is needed to discuss, modify and validate the developed framework. However, the recent status of the framework is shown in Figure (1).

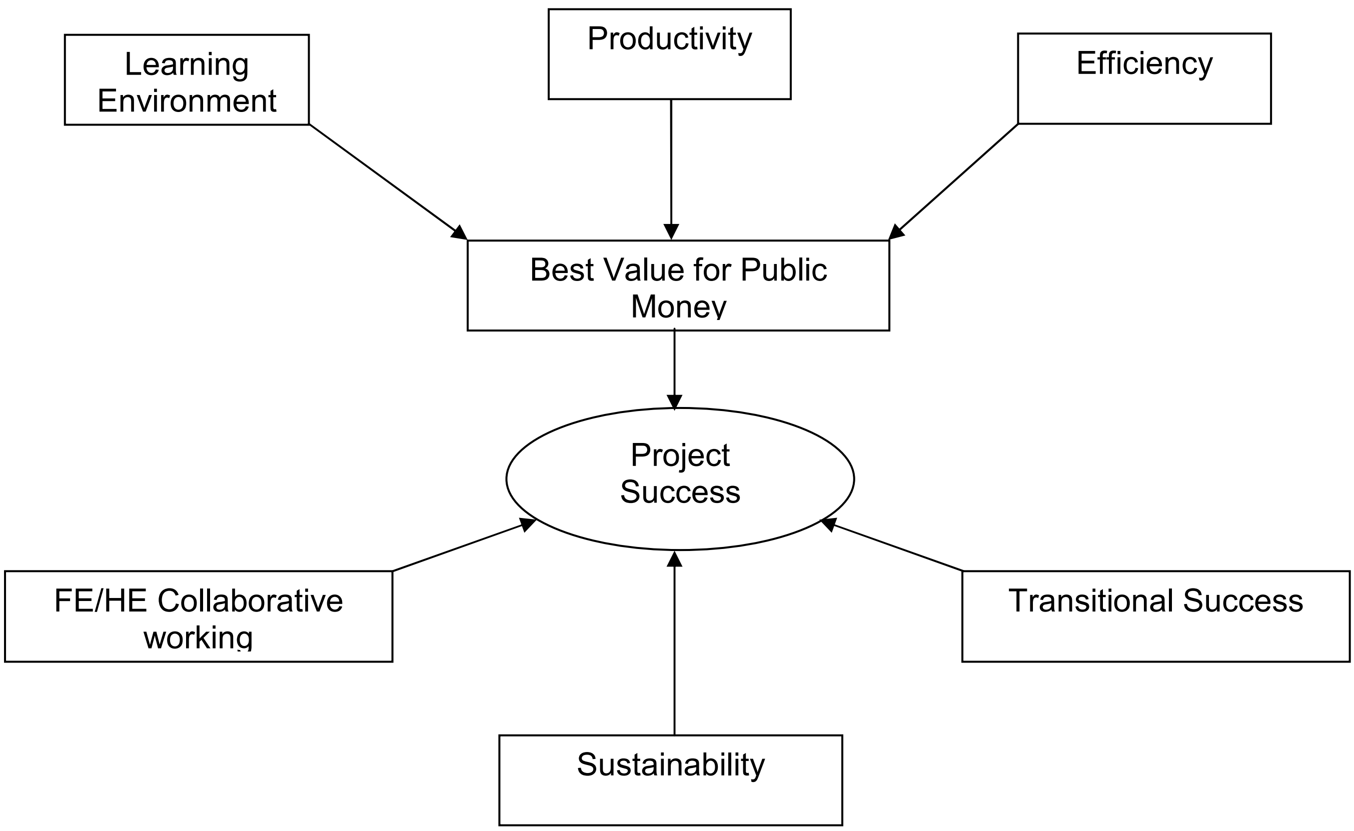


Figure 1: the recent status of the framework

Best value of public money

To maximise the value of public money spent on co-location projects, the building which is the physical environment has to be shaped and structured to the highest possible quality offering suitable and efficient space, cost, service, energy, etc. This efficiency and effectiveness of cost, together with delivering high educational provision, indicate that sufficient resources are allocated properly and perhaps create a culture of continuous educational and service improvements.

Efficiency

One of the main objectives of the co-location project is to provide efficient education infrastructure that support the delivery of an effective, high quality and innovative education services. Nonetheless, the new challenges to meet the requirements of modern education in addition to the escalating costs of utilities, leases, maintenance and building materials have placed a greater importance on the way the space is used and utilised, and on the whole-life cost of the building and its facilities. Consequently, measuring space efficiency and cost effectiveness is essential to provide better management of space and budget which could have an impact on driving up the quality and performance of education estates. The measures are quantitative ratios based on three main variables; end-user population, space areas and associated costs. (See appendix A for more details of the efficiency measures).

Productivity

This objective is to increase space and business productivity. It reflects the attempts of the participating organisations to maximise the effects of the physical environment on students and staff by concentrating on optimising the space design (and its facilities and services) in terms of functionality, flexibility, adaptability, accessibility, and maintainability. These characteristics could be considered as drivers to a productive space. However, the ultimate measure of this objective is through the linking of the income the participating institutions make (e.g. teaching income, research income and total income) to the corresponding space (teaching space, research space and net internal area NIA). (See appendix A for more details of the productivity measures).

Learning environment

The learning environment provides students with the opportunities to explore, learn and develop with the support of the available facilities and services. The objectives of good learning environment include maintaining high level of student and staff satisfaction with the building (in terms of space, function and use), promoting learning by encouraging students to join the collocation campus and benefiting from the accumulation of experience and expertise that collocated institutions offer. Furthermore, co-location project may also promote further education students to progress to higher education. Moreover, measures of students' recruitment, retention and achievements rates provide the ultimate indicators of the learning environment performance. (See appendix A for more details of the learning environment measures).

FE/HE Collaborative working

When FE/HE institutions work together, collaboration between them will create added value provided that the experience of the integration end-users, services, and shared space is successful. This area of the framework needs further research. Malhotra *et al.,* (2005) advocated that collaboration involves processes that are internally linked with each of the collaborating parties providing an access to a wealth of shared information and constructing communication infrastructures that will generate new knowledge through the processing of the information gathered by those interlinked parties. In the same way, Bowersox (1990) found that the scope of collaboration shows several ultimate advantages like profit expansion, cost reduction and more operational flexibility. Besides, information sharing, mutual planning, joint problem solving and joint decision-making reflect a number of collaboration attributes discussed in the literature.

Sustainability

One of the main factors necessary for achieving success in co-location projects is sustainability. Sustainable buildings provide a reasonable and practical answer to issues that have environmental impact and resource consumption. Moreover, sustainability approaches cover the whole life cycle of the building and its different elements (Kibert, 2008). However, the goals of sustainability addressed in the framework aim particularly at rationalising the use and consumption of water, energy and materials as well as maximise the positive impact of the co-location in the context of its community. Consequently, measures of sustainability embrace assessing the water consumption per square meter, energy consumption per square meter, materials recycling and CO_2 emissions as a result of transportation. (See appendix A for more details of the sustainability measures).

Transitional success

Higher education and further education now have an opportunity to participate in shaping the future of educational provision. In order to determine how well institutions are prepared for successfully co-locating their processes, facilities and services, certain objectives (like effective design and construction, achieving smooth integration and change management, and minimising the negative impacts on the educational process) have to be met. Gauging the attainment of these goals could be done through a range of quantitative and qualitative measures like the construction industry KPIs (Scottish Construction Industry, KPI Pack, 2005) in addition to evaluating leadership, communication, consultation and commitment throughout the different co-location project stages.

Future work

The research work plan for the next 18 months will cover four phases. These areas are listed below with brief descriptions of their objectives:

Complete the data collection exercise

Further work will be needed to complete the development of the performance measures. The data collection exercise will take place initially to validate the framework and in particular to inform the research team on the availability of the data required. Fortunately, a large portion of the quantitative data needed exist in the estate management statistics (EMS) and the e-mandate, which both are electronic databases available for the sectors to manage and benchmark the estates performance of higher education and further education institutions respectively. The data collection exercise has already started and will continue to provide the information relating to the four main dimensions of the measurement framework.

Benchmark with the sector

The objective of benchmarking the performance of the co-location campus is to continuously gauge its performance against the strategic and operational goals of the collaborating institutions, and to assess the current performance position when comparing to other institutions within the education sector. Therefore, it is important that the measures selected cover critical areas that are key to the co-located campus success. The benchmarking will be carried out in the following areas of the framework: efficiency, productivity, learning environment, and environmental sustainability.

Identifying the potential benefits of co-locating HE/FE

The objective of developing a measurement framework of potential benefits of further and higher education collaborative work is to explore these benefits, and to investigate their effects and impacts on the end result of the co-location project. In other words, these identified benefits will form the drivers and enablers to achieve the required level of performance. The research proposes that a project capability maturity model (CMM) is adopted to asses the level of expected performance. The key associated benefits will be identified through a literature review of collaborative approaches in addition to the consideration of the list of benefits identified in the co-location project archive. Developing a project capability maturity model is essential in the formalisation of the potential benefits of the co-location project. This model will act as an assessment technique of the enablers to achieve the ultimate project. The CMM will therefore indicate the extent to which the enablers were effectively managed given that this will have a direct impact on the end results.

Questionnaire

A questionnaire representing the performance measurement framework will be developed and distributed to estates and facilities managers of higher education and further education institutions in Scotland. The purpose of this exercise is to gather the participants' views, attitudes and thoughts about the measurement framework in terms of the comprehensiveness of the co-location measures, and the overall validity of the model.

CONCLUSION

It is often difficult to propose an extensively approved framework for determining the project success, although it has been the topic of many research studies. The consensus is to go beyond achieving the traditional project objectives in terms of cost, time and quality to more operational and organisational levels. This was highlighted in the study by adding more success criteria, like achieving excellent integration of college and university staff and students, student recruitment and retention, good educational and social cohesion, successful FE/HE work collaboration and, ultimately, attaining the best value for public money. Nonetheless, the literature on this subject shows a general push for performance measurement frameworks that are based on time, cost and quality measures - “hard measures”. In all the cases, there are very limited sources of “soft measures”, particularly relating to “co-location projects” and the associated shared services and facilities in the education sector. All education institutions have essential support services, including procurement, HR, IT, and finance, legal and communications services. Facilities mainly include education assets and their maintenance, space usage, health, safety, environment and security. Nonetheless, sharing these services and facilities has the potential to generate substantial efficiency savings and cost reduction. Hence, it is very important to measure the performance of there types of projects in a way that could identify weaknesses and strengths which in turn will help in the application of best practice in similar future projects.

REFERENCES

Amaratunga, D. and Baldry, D. (2000), “Assessment of facilities management performance in higher education properties”, Facilities, Vol. 18, No. 7/8, pp. 293-301

Axelrod, M. (1975), “Markets get an eyeful when focus groups expose products, ideas, images, ad copy, etc. to consumers”, Marketing News, 8, 6-7.

Barrett, P. and Baldry, D. (2003), “Facilities Management”, Blackwell Publishing, Oxford, UK.

Bassioni, H.A., Price, A.D.F. and Hassan, T.M. (2004a), “Performance measurement in construction firms”, Journal of Management in Engineering, 20(2), 42–50.

Belcher, R.G. (1997), “Corporate objectives, facilities, measurement and use: a university model”, Proceedings of the RICS Cobra Conference, Portsmouth.

Bowersox, D.J. (1990), “The strategic benefits of logistics alliances”, Harvard Business Review, Vol. 68 No. 4, pp. 36-43.

CABE (2005), “Design with Distinction: The Value of Good Building Design in Higher Education”, (www.cabe.org.uk)

Chandler, A. D. (1977), "The Visible Hand: The Managerial Revolution in American Business". Harvard University Press, Cambridge, Mass.

Cheng, Y. C. and Tam, M. (1997), "Multi-models of quality in Education", Quality Assurance in Education, Vol. 5, No. 1, pp. 22-31

Clarke, G. (1997), "Reassessing resource allocation strategies in higher education: methods for analysis", International Journal of Educational, Vol. 11 No.6, pp.286-92.

Douglas, J. (1996), "Building performance and its relevance to facilities management", Facilities, Vol. 14, No. 3/4, March/April, pp. 23-32.

Easter-Smith, M., Thorpe, R. and Lowe, A. (1991) "Management Research: An Introduction", London, Sage.

Frey, J. H. and Fontana, A. (1993), "The Group Interview in Social Research", in Morgan, D. L. (Ed) "Successful Focus Groups", Sage Publications, California, USA.

Hayes, R.H. and Abernathy, W.J. (1980). "Managing Our Way to Decline". Harvard Business Review, July-August, pp. 67-77.

Hedley, C., Smith, A. and Whelan, J. (2001), "Defining, collecting and using property performance indicators: The UK higher education sector experience", Journal of Facilities Management, Vol.1, No.2, pp. 177-187.

Johnson, H.T. and Kaplan, R.S. (1987). "Relevance Lost. The rise and fall of management accounting". Harvard Business School Press, Boston, MA.

Kagioglou, M., Cooper, R. and Aouad, G. (2001), "Performance management in construction: a conceptual framework", Construction Management and Economics, 19, pp. 85-95.

Kaplan, R. S. (1984). "The evolution of management accounting". Account. Rev., 59(3), pp. 390–418.

Kaplan, R. S. and Norton, D. P. (1992), "The balanced scorecard – measures that drive performance", Harvard Business Review, January–February, 71–79.

Kibert, C. J. (2008), "Sustainable construction: Green building design and Delivery", John Wiley & Sons, Inc., Hoboken, New Jersey, USA

Krueger, R. A. (1988), "Focus Groups: A Practical Guide for Applied Research", Newbury Park, CA:Sage.

Lynch, R.L., Cross, K.F. (1991), "Measure Up! Yardsticks for Continuous Improvement", Blackwell, Cambridge, MA.

Malhotra, A., Gosain, S. and ElSawy, O.A. (2005), "Absorptive capacity configurations in supply chains: gearing for partner-enabled market knowledge creation", MIS Quarterly, Vol. 29 No. 1, pp. 145-87.

Neely, A., et al. (2000), "Performance measurement system design: Developing and testing a process-based approach". International Journal of Operations and Production Management, 20(10), pp. 1119–1145.

Nutt, B. (2000), "Four competing futures for facility management". Facilities, 18 (3/4), pp. 124-132.

Olve, N., Roy, J. and Wetter, M. (1999), "Performance Drivers: A Practical Guide to Using the Balanced Scorecard", Wiley, Chichester.

Osseo-Asare, A. E., and Longbottom, D. (2002), "The need for education and training in the use of the EFQM model for quality management in UK higher education institutions", Quality Assurance in Education, Vol. 10, No. 1, pp. 26-36

Preiser, W.F.E. (1995), "Post-occupancy evaluation: how to make buildings work better", *Facilities*, Vol. 11 pp.19-28

Skinner, W. (1974). "The focussed theory". Harvard Business Review, May-June, pp. 113-21.

Then, D. (2004), "Concepts in facilities management", in Murray, M. and Langford, D. (Ed) "Architect's Handbook of Construction Project Management", RIBA Publications, London, UK

Zairi, M. (1996), "Benchmarking for Best Practice", Butterworth-Heinemann, Oxford http://www.bifm.org.uk/bifm/about/facilities (Accessed 15-03-08)

Appendix A

Group	Objectives	Measures
Efficiency	Efficient space	Total population (students & staff) per sq m NIA; Taught students FTE per teaching NIA; Research students & staff FTE per research NIA; Academic staff FTE per office NIA; Total students & academic staff FTE per library NIA; Ratio of NIA to GIA; Frequency rate; Utilisation Rate; Occupancy rate;
	Cost effectiveness	Total maintenance costs per sq m GIA; Total facilities costs per GIA; Total property costs per sq m GIA;

Efficiency measures

Group	Objectives	Measures

Productivity	Space and business productivity	Research income psm research NIA; Teaching income per teaching NIA; Total income per sq m NIA;

Productivity measures

Group	Objectives	Measures
Learning Environment	End-users' satisfaction	Satisfaction with the building (space, function, use)
	Educational provision	Student recruitment rate; Student retention rate; Students' academic achievements;

Learning environment measures

Group	Objectives	Measures
Sustainability	Energy efficiency	Total energy consumption per FTE student; Total energy consumption per sq m GIA;
	Effective use of water	Water/sewerage consumption per FTE student; Water/sewerage consumption per sq m GIA;

Efficient use of materials	Recycled waste proportion; Waste mass (tonnes) per m2 GIA; Waste mass (tonnes) per FTE student;
Maximise positive social impacts	Education and social cohesion (activities and achievements of public relations and marketing, public image, reputation or status in the community);

Sustainability measures

A BEHAVIOURAL APPROACH TO RESEARCHING RISK MANAGEMENT IN REAL ESTATE DEVELOPMENT

Ellen Gehner
Delft University of Technology, Delft, The Netherlands
e.gehner@tudelft.nl

Real estate development is an increasingly complex and dynamic business in which many risky decisions are made. To help improve developers to manage risk and make the right decisions, first the current state of risk management in this field must be researched. This is done by applying two different perspectives on risk management, a traditional engineering and a behavioural perspective. The behavioural perspective seems very promising to get more insight in the actual risk behaviour of developers, but an adequate framework is lacking. Therefore, this paper presents seven propositions to analyze what characteristics of the investment decision making process contribute to successfully dealing with the risky nature of real estate development.

KEYWORDS: risk management; real estate development; behavioural perspective.

INTRODUCTION

A real estate developer operates in a highly complex and dynamic environment characterised by a lot of uncertainty. Thus, the decision to invest in a real estate development project implies a risky enterprise with a high penalty on errors. This complexity in itself already asks for some form of risk management to keep control over a project. Moreover, in recent years some trends and changes have increased the risk profile of a real estate development project, such as the changing character of development projects increasing complexity, new contractual forms for cooperation, the need for financial transparency, and changes in organizational structures.

Risk management is supposed to contribute in taking risks knowingly, making more informed decisions, and reducing risks. The aim of applying risk management in contractual negotiations is to share or transfer risks and making informed decisions. Applying risk management in order to increase financial transparency assumes that by transparency calculated risks are taken and a company is trustworthy. Finally, risk management is used as a means to streamline organizational procedures and risk behaviour. In the end the aim of risk management is the same: supporting the decision making process and making better informed decisions, which is assumed to lead to the desired outcome. Thus, one might expect that, in some way or another, real estate developers make use of formal risk strategies to support their decision making process. On the other hand, are decisions to purchase a parcel of land or to invest in a new project based on more than just a short calculation on the back of an envelope? Don't real estate developers only use their gut feeling? Or is it more sophisticated than popular tales tell us?

To give an answer to this question, the perspective on risk management is crucial. In the academic literature two broad perspectives on risk management can be found: an engineering perspective prescribing risk analysis techniques, and a decision making perspective describing risk taking behaviour. The engineering perspective argues that risk management in real estate development is largely absent. This means that the tales are true. But when looking from the decision making perspective, risk management seems to be present. In this respect, the popular truth is a tale.

This paper is a positioning paper on these two perspectives on risk management resulting in a methodological approach to research how risks are dealt with in the practice of real estate development. The insight in the actual decision making behaviour on risk is crucial for academics when they aim at playing a role in improving the way practitioners deal with risk.

PERSPECTIVES ON RISK MANAGEMENT

Risk management can be defined as 'the process of proactively working with stakeholders to minimize the risks and maximize the opportunities associated with project decisions. The aim is not to avoid risk but to take calculated risks, make more informed decisions, avoid unpleasant surprises, identify opportunities and encourage people to think more carefully about the consequences of their decisions' (Loosemore, Raftery, Reilly and Higgon, 2006: 29). Risk management is often regarded as a process of risk identification, assessment and control (or similar phases) ((Association for Project Management, 2004; Institute of Risk Management, 2002; Institution of Civil Engineers and The Actuarial Profession, 2005; Wang and Roush, 2000) taking place as a discrete process, but in the end risk management is closely related to decision making. Both in risk management and decision making two broad perspectives can be distinguished: a traditional engineering or prescriptive and a behavioural or descriptive perspective. These perspectives are explained in order to answer whether risk management is absent or not in the field of real estate development.

Traditional engineering perspective

A substantial part of the literature on both risk management and decision theory is grounded in a traditional engineering approach, that is based on the idea of rationality. 'Rational decision makers are assumed to select the course of action that maximizes their expected utility' (Noorderhaven, 1995). Being able to make a fully rational decision assumes (among others) the availability of complete information - the outcome and probability of a risk can be assessed objectively - and the ability of computing with perfect accuracy and fully rational. This perspective on decision making is analogous to the gamble view on risk and has been developed since Bernouilli (1738).

The dominant paradigm within this perspective on risky decision making is based on the subjective expected utility (SEU) model by Von Neumann and Morgenstern (1947). The main contribution of this theory in relation to the former model of expected utility is that it accounts for subjectivity in two ways. 'In the first place, the probabilities associated with outcomes are subjective assessments of the decision maker rather than objectively known. Secondly, utility rather than value is assumed to be maximized. In this way, the fact that a bundle of goods can have different values for different individuals is taken into account' (Noorderhaven, 1995: 41). Although this theory takes into account that risk cannot be objectively assessed and risk is relative to the person that takes the risk, it is still based on the assumptions that humans take fully rational.

The practical application of the prescriptive approach (how people should make decisions) is called decision analysis, and aimed at finding tools, methodologies and software to help people make better decisions. The most systematic and comprehensive software tools developed in this way are called decision support systems (DSSs). The development of DSSs has taken place within the operations research (Ackoff and Sasieni, 1968). Most of the quantitative risk analysis techniques are part of these decision support systems. Most techniques are related to the expected monetary value (EMV) method or stochastic models (Byrne and Cadman, 1984; Raftery, 1994; Flanagan and Norman, 1993).

Since the introduction of the concept of bounded rationality by Simon, stating that ‘people act intentionally rational, but only limitedly so, as reality is complex and ambiguous, information is limited, and time pressure is often high’ (Simon, 1977), psychologists have done a lot of research on the behavior of an individual and theories have been developed to explain the differentiations of human risk behavior from the SEU model. The best known theory is the prospect theory (Kahnemann and Tversky, 1979), although this theory has been criticized as well. The main critique is that ‘prospect theory retains the gamble metaphor from prescriptive theory and this metaphor is increasingly seen as inappropriate for many, if not most, real-world decisions’ (Beach and Connolly, 2005: 95).

Behavioural perspective

Next to the prescriptive perspective, a group of theorists, mostly organizational scientists and managers, started to describe how people actually make decisions. This generation of decision theorists ‘abandons the gamble analogy and views decision making as a form of problem solving’ (Beach and Connolly, 2005: 9). In line with the fact that decision makers’ cognitive capacity is limited, people not only reduce information processing and base their decisions solely upon a ‘bounded’ representation of the problem, people also search for a decision that is satisfactory instead of maximizing. The decision strategy of ‘satisficing’ means that the first option that meets a decision makers’ set of standards is selected; not all possible options are assessed and the best is chosen, which is a maximizing strategy.

The descriptive research is mainly done in an organizational context (instead of in a laboratory setting). The level of analysis varies from the individual to the organization. Organizational theorists tend to see the organization as a unit that makes decisions, presuming something like an organizational mind. The individual is seen as a decision making agent acting exactly according to the organizational norms and values. Behavioral decision theorists focus on individuals and regard an organizational decision as a function of the collaborative decisions made by its individual members. In the latter view is more place for concepts like politics and power.

Within this line of thinking, the best that can be achieved is procedural rationality instead of substantive rationality. Substantive rationality corresponds with the prescriptive perspective that the alternative that is objectively best is chosen. Procedural rationality is ‘the extent to which the decision process involves the collection of information relevant to the decision and the reliance upon analysis of this information in making the choice’ (Dean and Sharfman, 1993). In other words, given the available information and cognitive faculties, a reasonable decision-making procedure is followed (Noorderhaven, 1995; March and Simon, 1993). More important is that the assumption of intended, limited rationality, does not ignore the important role of emotions in behavior (March and Simon, 1993: 8), nor the role of intuition.

In the line of descriptive theories on decision making the focus on risk and uncertainty vaporizes a little and risk comes up less explicitly. Still, risk is inherent to decision making, and especially in strategic decision making, as commitments will be made towards an uncertain future. Explicit research on managerial perspectives on risk shows us that managers show little desire to reduce risk to a singly quantifiable construct and they think of risk as controllable (March and Shapira, 1987). Their risk behaviour can better be explained by systems of organizational controls and incentives and the context in which choices take place.

THE ABSENCE OF RISK MANAGEMENT: TRUTH OR TALE?

The truth about risk management being absent in real estate development

Looking from a prescriptive perspective to the usage of risk management it is true to say that risk management is largely absent in the real estate development sector. In line with this perspective the presence of risk management is to be measured by the application of quantitative risk analysis techniques, such as the expected monetary value-method, decision analysis, Monte Carlo simulation, and decision trees. These techniques are used to assess and evaluate all possibilities by their probability and their impact thereby supporting the decision strategy of maximizing the expected value.

The statement that it is true that risk management is absent in real estate development is based on the following studies:

- Akintoye and MacLeod's (1997) survey with a sample of 100 top firms in the UK construction industry with a response of 30 general contractors and 13 project management practices;
- Baker, Ponniah and Smith's (1999) survey with a sample of the 100 largest construction companies in the UK with a response of 40 construction companies and 12 oil companies;
- Uher and Toakley's (1999) survey with a sample of 713 Australian firms involved in the conceptual phase of construction projects with a response of 200 companies of which 37 property developers;
- Lyons and Skitmore's (2004) survey with a sample of 200 organisations in the Queensland engineering construction industry with a response of 17 contractors, 11 consultants, 10 owners and 6 developers;
- Gehner, Halman and de Jonge's (2006) survey with a sample of 31 of the largest real estate developers in the Netherlands with a response of 15 developers.

The overall result is that quantitative risk analysis techniques are significantly less used than qualitative techniques. Akintoye and MacLeod (1997: 36) show that only 3% of the contractors use stochastic techniques and 13% decision analysis, although 20% respectively 44% of them are familiar with the technique. Lyons and Skitmore (2004: 53) show that developers make least use of Monte Carlo simulation, EMV and decision analysis techniques, whereas intuition, risk premium and sensitivity analysis are mentioned as most used.

Similar results are found in a study among real estate developers by Gehner, Halman and de Jonge (2006): no single respondent makes use of probabilistic techniques, whereas intuition and qualitative techniques are often used (see Table 1). Specifically, all real estate developers make use of some risk identification technique as part of an investment proposal consisting of a financial estimation and a qualitative description of the project. The risk identification is not aimed at completeness, but at making the most prominent risks explicit. For this aim a checklist can be useful so as not to overlook risks, especially when it concerns inexperienced managers. Other instruments to identify risks, such as a risk matrix, are hardly used: the question remains how they do deal with risks.

The results of Baker, Ponniah and Smith (1999: 99) show us that the construction industry makes less use of quantitative risk analysis than in the oil sector: whereas the construction industry only three of the techniques, EMV, break-even analysis and scenario analysis, are widely used, the oil sector uses the same and five more quantitative techniques, expected net present value, algorithms, decision matrix, decision tree, and simulation. The reasons for not using techniques are a lack of familiarity, difficulties in seeing the benefits, lack of reliable data, lack of expertise, and the idea that risks that are fairly subjective are better dealt with based on experience from previous contracts undertaken by the firm. Overall the construction industry is quite reluctant to implement quantitative techniques, as they do not think the investment in these techniques warrant a better performance. Thus they keep relying on their current practice. The question the academics should ask themselves whether it is not inherently impossible to guarantee a better performance by applying the quantitative risk analysis techniques.

Table 1: Application of risk analysis techniques in the Dutch real estate development sector (Gehner, Halman and Jonge, 2006)

Risk analysis technique	Respondents	Percentage
Intuition/experience	15	100%
Qualitative description	15	100%
Scenario/sensitivity analysis	12	80%
Risk premium	4	27%
Checklist	3	20%
Assessment of total risk exposure	2	13%
Probabilistic techniques	0	0%

The tale about risk management being absent in real estate development

From the previous section we can conclude that the absence of risk management in the sense of risk analysis techniques is not a tale. Nevertheless, it seems paradoxical that real estate development is a risky business and at the same time developers do not manage these risks. This is even more peculiar when we look at the success of real estate developers. In recent years some smaller companies entered the Dutch development market successfully and have grown in a rapid rate, while the larger companies went through a steady growth. Did they merely profit from an economic boom and expansion in the real estate market or have they found other methods to manage their risks? In other words, is there another truth and is the absence of risk management just a tale? To find out whether risk management is really absent, another research approach is asked from the researcher.

BEHAVIOURAL RESEARCH APPROACH ON RISK MANAGEMENT

When we want to discover this other truth, we have to take a descriptive and behavioural perspective on risk management and examine how developers actually manage their risks. We might expect that risk management is incorporated in the daily activities of the developer. Within their daily practice developers take many decisions, from operational to strategic, and in doing so they are dealing with risk. Especially when making investment decisions in a real estate development project, as at these decision moments large financial commitments are made and thus high risks are involved. The investment decision making process is regarded as a condensed representation of the way risks are dealt with: moreover, it is assumed that a good decision is positively related to a good (project) outcome and organizational performance. The question is what characteristics of the investment decision making process contribute to successfully handling risks?

In this section seven propositions are formulated to analyze what characteristics of the investment decision making process contribute to successfully dealing with the risky nature of real estate development. These propositions are related to the steps in a decision making process based on various findings of decision routines (Simon, 1977; Mintzberg, Raisinghani and Théorêt, 1976; Nutt, 1990; Noorderhaven, 1995) and decision phases related to the steps in a risk management process (Chapman and Ward, 2002; COSO, 2004). These steps are: recognition, determination of criteria, search for information, design options, evaluation, and authorization. The propositions are directly aimed at how each decision step can contribute to successfully dealing with risk.

Propositions on risk management from a behavioural perspective

The first proposition is: *Timely recognizing situations in which the risk profile of a project is about to change significantly contributes to successfully handling risk.*

A timely recognition of a need for an investment decision is crucial for successfully handling risk, for two reasons. In the first place, time is crucial for gathering information and control over a project which leads to risk reduction. At the moment an investment decision is to be made, enough information must be available and control measures taken (thus risk must be reduced): it must be opportune to make a decision. On the other hand, a situation ca arise in the development process which asks for an investment decision while the desired level of information and control is not yet available. In these situations, such as a deadline or changing market conditions, time can be pressing and waiting will only increase the level of risk.

The second proposition is: *Determining criteria regarding the acceptable level of risk contributes to successfully handling risk.*

In relation to general criteria, such as continuity and profit, it is crucial to determine the acceptable level of risk for each project in order to successfully deal with risks. The acceptable level of risk in relation to the objective of continuity is that the total risk in a project must not jeopardize the survival of the organization. The total risk capital is the possible loss in a worst case scenario – in other words how much equity capital is at stake. As in most real estate development organization multiple projects are developed simultaneously, the total risk capital of the portfolio must be kept under a certain limit. This implies that the risks which are accepted are (to some extent) controllable, whereas the risks exceeding this level are a gamble. As for the controllable risks, a risk mitigation plan can also be predefined in terms of decision criteria for each of the decision moments, such as a pre-rental percentage.

The third proposition is: *Making use of sufficient, reliable and relevant information contributes to successfully handling risk.*

Sufficient, reliable and relevant information is necessary in terms of managing risks, as to prevent under- or overestimation of risks which affects the risk actually taken. If the risk is underestimated, decisions will reflect greater risk taking than is intended. If the risk is overestimated, decisions will reflect less risk taking than is intended' (March and Heath, 1994: 35). Sufficient information means that the level of detail of the information must bear a proper proportion to the decision moment related to a development phase. Complete information – as far as technically possible – is not the aim: it must be related to the limited time and the capabilities available, as well as to the level of risk involved. ‘A balance must be struck between the level of detail and effective communication, too much detail may render the picture messy and confusing; it may also detract from the overview’ (Lee, Newman and Price, 1999: 152). Relevant information in terms of an investment decision means that information must be gathered with respect to all aspects of a development project generating an integral view on the project. The investment decision moments are the (scarce) moments in a development project when each development aspect is put explicitly into perspective of the whole project consisting of a series of development aspects. Reliable means that estimates must be made as objective as possible. However, not everything is predicable or controllable, thus in such a case the limitations of the validity of the estimate must be indicated. As a real estate development project integrates a lot of disciplines, it is preferable to use multiple perspectives (Nutt, 1990) when making estimates. These perspectives can be for example different disciplines, level of experiences of decision makers, or level of involvement in a project. Another way of ensuring the use of reliable information is to base the choice on real time information instead of future estimates (Eisenhardt, 1989).

The fourth proposition is: *Identifying and analyzing multiple courses of action contributes to successfully handling risk.*

Identifying multiple courses of action is necessary from the perspective of successfully handling risks as each course of action or strategy amounts to its own set of risks and at the same time the strategy indicates how these risks will be managed. Two types of strategies can be distinguished: ‘normal’ strategies and ‘exit’ strategies. Normal strategies are alternatives developed to deal with the ‘normal’ risks – those risks with a normal variability/probability distribution e.g. construction costs, inflation, etc. – and risks with a discrete distribution which are still acceptable e.g. soil pollution. Exit strategies are courses of action to deal with extreme risks which prevent a successful continuation of a development project, e.g. a building permit is not granted (or a zoning plan is not adjusted), a site cannot be purchased or financing cannot be arranged. As long as these extreme/exit risks are still present, an exit strategy gives insight in the fallback options.

The fifth proposition is: *Evaluating the courses of action on the predefined criteria systematically contributes to successfully handling risk*.

In the previous steps only a limited number of alternatives is designed which must be evaluated against the criteria determined according to proposition 2. In line with the bounded rationality paradigm, one alternative should satisfice all those criteria. However, in practice it is sometimes not even realistic that all criteria are met; moreover, once started a project quitting is no loss-free alternative as well. Therefore, appropriate priorities and trade-offs between different criteria, reflecting the risk preference of the decision maker(s), must be determined as well distinguishing preconditions and targets. This way an alternative can be evaluated systematically and ensures that the decision maker is aware of taking more or less risk than the preferred risk profile.

The sixth proposition is: *Authorizing the decision at the organisational level that is capable of dealing with the involved risk level contributes to successfully handling risk.*

Making an investment decision means that the total risk profile of the project must be integrally surveyed – taking into consideration all different perspectives (such as financial, technical, legal, marketing) – on the level of both the project and the portfolio. This implies that the project manager is not suitable of making these decisions; investment decisions should be authorized at the tactic or strategic level. The actual decision structure largely depends on the organizational structure and culture, as well as on the size of the organization and the project. Some of the variables determining the way decisions are authorized are the decision setting (individual / group), decision rule (consensus, unanimity), influence of shareholder (direct / mandate), and who is held responsible for the success of a project.

The seventh proposition is: *Limiting the duration of the decision making process to the urgency of the decision contributes to successfully handling risk.*

The duration of the decision process is important in general, as ‘decision processes take managerial time and therefore impose a cost upon an organization, and through the opportunity cost of possible benefits foregone while the search for algorithms goes on’ (Butler, 1991: 63). In particular the duration of the decision process is important as during the approval process the development activities are suspended. This becomes critical when the time pressure in the development process is high for reasons of a sudden opportunity, a deadline, or market dynamics as is explained at proposition 1. The decision speed can be influenced by the way all decision activities are carried out, but it is also influenced by the formal organizational processes (such as frequency of decision meetings) and by the flexibility applied to the intentional decision procedure. In the end the decision speed must be aligned with the comprehensiveness of the other activities which guarantee procedural rationality and speeding up the process must not conflict with the authorization process.

Qualitative case study method

The propositions are developed in order to have a analytical framework to study the investment decision making process from a behavioral perspective and to get insight in how real estate developers actually deal with risk. In the first place, these proposition must be tested on their validity; and secondly, and even more important, an explanation is required of *how* the decision makers arrive at fulfilling these propositions.

To study the actual decision behaviour of real estate developers, and explore explicitly and implicitly used risk management strategies, an in-depth, holistic analysis of the decision making process in a real estate development organisation is needed. A case study is best suited for the research question, in the first place because the nature of the research is exploratory and not limited to certain variables and their causal relations. Secondly, a case study is well suited for understanding the ‘how and why?’ of phenomena in their natural settings (Yin, 1989). In the case study can be made use of multiple research methods to collect data, such as observations, interviews, and document analysis. The application of case studies is not new, however, ‘particularly rare are empirical studies employing participant observation of the boardroom’ (Parker, 2007: 7) and the boardroom is exactly the place where investment decisions are made.

This research method is currently applied to three Dutch real estate development organizations. These organizations were selected because of their outstanding performance in this sector over many years, their portfolio consisting of an investment value over € 250 mil. (m^2 x rental value/m^2 x gross yield), their background as an independent developer, and their internal stability. At each organization all strategic meetings concerning investment decisions were attended, a total of 11-15 in-depth interviews are conducted with representatives of each level of the organisation, and documents were analyzed regarding the intentional decision procedure and documents supporting the decision making process. The results of these case studies are very promising: not only can the propositions be validated, but also a set of decision strategies for each proposition can be deduced that explains the risk behaviour of real estate developers. Based on these decision strategies suggestions for improvement can be made integrating the behavioural and engineering perspective on risk management.

CONCLUSIONS

In this paper the question is raised to what extent risk management is applied in the Dutch real estate development sector. When looking from a traditional engineering perspective, it can be stated that hardly any formal risk analysis techniques are applied; however, this seems contradictory as many real estate developers are successful over many years and real estate development is a risky business. Therefore, it is suggested that risk management should be regarded as a behavioural phenomenon. This view enables the academic to describe and understand the strategies, procedures and operations, both implicitly and explicitly, applied in practice.

In order to study actual decision making processes in the boardrooms of real estate development organisations, a framework is necessary in which theory on decision behaviour in strategic decision making processes is specifically directed at dealing with risk. This paper provides such a framework in the form of seven propositions on successfully handling risk. The first results making use of this framework indicate that the risk behaviour of real estate developers encompasses much more than applying risk analysis techniques and this perspective enables academics to uncover the strategies and practices used in real estate development in order to manage risks.

REFERENCES

Ackoff, R. L. & Sasieni, M. W. (1968) Fundamentals of operations research, New York,, Wiley.

Akintoye, A. S. & MacLeod, M. J. (1997) Risk analysis and management in construction. International Journal of Project Management, 15(1), 31-38.

Association for Project Management (2004) Project Risk Analysis and Management Guide, Buckinghamshire, APM Publishing Limited.

Baker, S., Ponniah, D. & Smith, S. (1999) Survey of risk management in major U.K. companies. Journal of professional issues in engineering education and practice, July, 94-102.

Beach, L. R. & Connolly, T. (2005) The psychology of decision making: People in organizations, Thousand Oaks, Sage Publications.

Bernouilli, D. (1738) Specimen theoriae novae de mensura sortis. Comentarii Academiae Scieniarum Imperiales Petropolitanae, 5, 175-192.

Butler, R. (1991) Designing organizations: a decision-making perspective, London, Routledge.

Byrne, P. & Cadman, D. (1984) Risk, uncertainty, and decision-making in property development, London, Spon.

Chapman, C. B. & Ward, S. C. (2002) Managing project risk and uncertainty; a constructively simple approach to decision making, Chichester, John Wiley & Sons.

COSO (2004) Enterprise Risk Management - Integrated Framework: Executive Summary and Framework, available at: http://www.coso.org.

Dean, J. W. & Sharfman, M. P. (1993) The relationship between procedural rationality and political behavior in strategic decision making. Decision Sciences, 24(6), 1069-1083.

Eisenhardt, K. M. (1989) Making fast strategic decisions in high-velocity environments. Academy of Management Journal, 32(3), 543-576.

Eisenhardt, K. M. & Zbaracki, M. J. (1992) Strategic decision making. Strategic Management Journal, 13, 17-37.

Flanagan, R. & Norman, G. (1993) Risk management and construction, Oxford, Blackwell Scientific Publications.

Gehner, E., Halman, J. I. M. & Jonge, H. d. (2006) Risk management in the Dutch real estate development sector: a survey. In Amaratunga, D., et al. (Eds.) 6th International Postgraduate Research Conference. Delft University of Technology, University of Salford.

Institute of Risk Management (2002) A risk management standard, available at: http://www.theirm.org.

Institution of Civil Engineers and The Actuarial Profession (2005) Risk analysis and management for projects, London, Thomas Telford.

Kahnemann, D. & Tversky, A. (1979) Prospect theory: an analysis of decision under risk. Econometrica, 47(2), 263-291.

Lee, D., Newman, P. & Price, R. (1999) Decision making in organisations, Harlow, Prentice Hall Financial Times.

Loosemore, M., Raftery, J., Reilly, C. & Higgon, D. (2006) Risk management in projects, Abingdon, Taylor and Francis.

Lyons, T. & Skitmore, M. (2004) Project risk management in the Queensland engineering construction industry: a survey. International Journal of Project Management, 22(1), 51-61.

March, J. G. & Heath, C. (1994) A primer on decision making : how decisions happen, New York, Free Press.

March, J. G. & Shapira, Z. (1987) Managerial perspectives on risk and risk taking. Management Science, 33(11), 1404-1418.

March, J. G. & Simon, H. A. (1993) Organizations, Cambridge, Massachusetts, Blackwell Publishers.

Mintzberg, H., Raisinghani, D. & Théorêt, A. (1976) The structure of 'unstructured' decision processes. Administrative Science Quarterly, 21, 246-275.

Noorderhaven, N. G. (1995) Strategic decision making, Wokingham, Addison-Wesley.

Nutt, P. C. (1990) Preventing decision debacles. Technological Forecasting and Social Change, 38(2), 159-174.

Parker, L. D. (2007) Boardroom Strategizing in Professional Associations: Processual and Institutional Perspectives. Journal of management Studies, In Press, 1-27.

Raftery, J. (1994) Risk analysis in project management, Londen, E. & F.N.Spon.

Simon, H. A. (1977) The new science of management decision, New Jersey, Prentice-Hall.

Uher, T. E. & Toakley, A. R. (1999) Risk management in the conceptual phase of a project. International Journal of Project Management, 17(3), 161-169.

Von Neumann, J. & Morgenstern, O. (1947) Theory of games and economic behavior, Princeton, NJ, Princeton University Press.

Wang, J. X. & Roush, M. (2000) What every engineer should know about Risk Engineering and Management, New York, Marcel Dekker.

IMPACT OF NETWORKS ON SME'S PERFORMANCE

Birgitte Steenstrup
Rambøll Management Consulting
bies@r-m.com

Firms in the construction industry have been accused of both too little and too much cooperation and often give rise to negative associations. This paper investigates the existence and possible positive implications of informal cooperation between small and medium-sized enterprises (SMEs) on company performance. Data are collected by means of a three step strategy, including qualitative interviews, a questionnaire and expert interviews. The results presented in the paper indicated that the use of working with known and permanent relations is common in the Danish construction industry. This trend has positive implications both for the efficiency of the workflow of the individual project and the total performance of firms. Working in networks is connected with the high degree of interdependence between firms in the construction industry. Conclusions indicate that SME performance depends on external company relations and hence reflects more than the single firm. Furthermore, the relations are highly personalised.

KEYWORDS: Network theory; inter-firm relations, complexity, performance.

INTRODUCTION

The construction sector has often been accused of low productivity and an inefficient work flow (The Danish Government, 2003). Criticism of the organisation in the construction industry has been harsh. On one hand, some critics have stated that the firms in the construction industry have traditionally paid very little attention to lasting cooperation (Dubois and Gadde, 2002) leading to poor economic performance as well as low-quality results. On the other hand, the firms have also been accused of cooperating *too* much and attention has been drawn to the element of limited competition, i.e. the existence of price cartels (The Danish Government, 2003). Therefore, the terms "cooperation" and "construction" together do have negative associations of some kind.

This paper investigates the use and importance of networks in relation to SME performance in the construction industry. Contradicting the mentioned criticism, results are presented that indicate the existence and positive influence of lasting informal cooperation on the performance of SMEs. However, the element of a possibly limited competition cannot be ignored and the paper therefore attempts to investigate the downside of lasting cooperation. The analysis mainly focuses on contractors and small firms run by craftsmen, but also includes the relevance of networks in relation to construction clients and architects. The implications on performance are based on analyses of firm flexibility, efficiency, economic risks and price as well as profit rates.

The aim of the paper is to assess whether informal inter-firm cooperation exists, or, in other words, cooperation that is not based on formal agreements or permanent consortia structures. Hence, this paper broadens the academic analysis of cooperation between firms in the construction industry, which in the past decade has primarily been focusing on strategic partnerships and partnering (Gottlieb and Storgaard, 2006). A set of background assumptions of this paper is the concepts of bounded rationality as described by March and Simon (1958) and opportunism as explained by Williamson (1985).

Production in construction is organised in projects. Generally much attention has been devoted to analysing the implications of working in projects. Initially production in the industry of construction is characterised by not having a permanent production structure as found in manufacturing industries (Grabher, 2002). The location of production changes for each project. According to Dubois and Gadde (2002), so does the team of companies involved in the project. In the diverse literature on projects, much attention has been devoted to the construction process as a complex character (Gidado 1996). This paper takes the initial standpoint that production in construction is a complex process. Hence, attempts will be made to analyse how complexity influence the use of informal cooperation.

Structure of the paper

Beyond the notion of the complexity, it is relevant to include theory on inter-firm relations and networks to analyse the use of informal cooperation between construction firms. Therefore, the theory is focused on two main topics; complexity and network relations.

The paper is structured as follows: After an introduction to the methodology of the paper, the theory used for analysing network and cooperation between firms is presented. Next, results presented are structured by means of first investigating the existence and use of long-term relations and followed by the exploration of the implications on firm performance. Finally, the presented results are discussed in relation to the presented theory and supplementary theoretical statements on the negative aspects of working in networks. As data have been collected from Danish firms, the results found in this paper are limited to the Danish construction industry.

METHODOLOGY

Data have been collected by a three-step strategy. Firstly, 14 qualitative interviews with owners and project managers of contracting firms and different forms of craftsmen firms and architects have been conducted. Furthermore, both general and trade contractors were interviewed. Both respondents that knew each other from past projects and respondents with no acquaintance with the other respondents were included. As the paper focuses on SMEs, all respondents represented firms of less than 250 employees. Only three respondents came from companies with over 100 employees, the rest represented firms of less than 50 employees. Several firms with less than 5 employees have been included. The theories of network relations and complexity associated with working in projects were used to focus and structure the interviews.

Secondly, a questionnaire was carried out with the 14 respondents. The questionnaire was included to enhance the validity of the qualitative statements of the interviews and make all respondents estimate quantitatively the importance of working with known relations. In the questionnaire, a scale of 1 to 5 was used, where 1 was low/unimportant and 5 was high/very important. Finally, validation was increased by means of expert interviews with representatives of construction clients (Danish Association of Construction Clients) and The Danish Construction Association. The aim of conducting expert interviews was to present the collected data to experts with in-depth knowledge of the practise in the construction industry.

THEORISING NETWORK AND INFORMAL COOPERATION

Complexity

Gidado (1996) terms production in the construction industry as one of the most complex processes in all markets. The complexity originates from a number of sources: resources employed, the environment in which production takes place and the high level of different trades involved in the process (Gidado, 1996). Furthermore, the complexity can be understood as intensified due to the fact that firms are involved in several projects at the same time. Very often, problems deriving from one project can easily spread to all projects that a given firm is involved in. At the same time the interrelated character of the construction process causes difficulties in one field of the process to spread to all other trades involved in a particular project. Hence, the profit of each firm involved in a construction project depends on the efficiency of the other participating firms (Dubois and Gadde, 2002).

The complex character of the construction process calls for a constant need for coordination between the firms involved (Dubois and Gadde, 2002). However, good intensions of coordination and planning can be difficult to fulfil. Planning in construction is a complicated matter due to the high number of incidences of unforeseen aspects and complications. Often practical issues, such as delayed construction materials or bad weather cause the construction process to complicate further. In this paper the term flexibility is understood as the ability to cope with the complexity described, both in relation to handling the multiple projects and in relation to maintaining a high level of capacity.

Network theory

Critics have argued that lasting cooperation among firms in the construction industry is rare. However, the theory on the subject of network and cooperation of firms in general is diverse and offers multiple indications of how networks theoretically can be expected to be used. Network analysis has been given increased attention in the last decade (Smith-Doerr and Powell, 2005). The interest in the subject includes the tendency to see relations between actors as vital for the economic performance of firms. Ties between actors are considered to determine the allocation of resources such as knowledge, information and qualified labour, as the exchange flows in the network-based relations. In this regard, the focus can be put on both ties between individuals and firms (Grabher, 2002). Taylor and Asheim (2001) question the boundaries of the firm, arguing that the role of the firm is diminished as it is networks of firms or relations between individuals in firms that are thought to be decisive for economic performance.

In a study on the advertising industry, Grabher found that successful projects reproduced themselves by stronger relations between the individuals involved, resulting in more permanent structure of networks relations. Grabher states that "know who" is to be considered as a form of tacit knowledge with great influence on the success of a project and performance of companies. Or as Grabher puts it: "*Who you know matters almost as much as what you know*" (Grabher, 2002). As a contrast, Dubois and Gadde do not find that reproducing cooperation is evident in relation to the construction industry. In a study the authors did not find any evidence that companies modified their ways and routines of production to adapt to each other on a permanent basis. Also, no relations were identified to last longer than a single construction project. Hence, the element of working in networks was not identified (Dubois and Gadde, 2002).

Although the main focus of network theory is to estimate the performance of firms, the analysis is not restricted to the level of the firm. Instead, individuals are seen as a valuable level of analysis (Boggs and Rantisi, 2003). The social dimension of individuals is considered to be of vital importance to the performance of firms. Trust is a concept that has drawn great attention in network theory. Ettlinger regards trust as fundamental for successful transactions between individuals in different firms (Ettlinger, 2003). Hence, network relations are theoretically believed to be personalised and the implications of trust evident.[1]

According to the presented theory, what defines working in networks is the long-term cooperation or relations and possible mutual adaptation between specific actors. Hence, this paper adopts the definition of a relation as a connection between actors (that may be individual or firms) characterised by lasting longer than the single project. In this paper the term “known” relations or partners is used to describe this connection, as an opposite of unknown partners, which is understood as actors where no prior or only very limited relations exist.

RESULTS

The existence and use of networks, results of interviews

All respondents clearly expressed the opinion that long-term relationships are widespread in the Danish construction industry. All respondents answered yes to the question of whether they had relations with whom they had worked on a basis of several years and multiple projects. Of these long-term relations both firms and individuals were mentioned as important. Respondents from both small and medium-sized firms indicated that the long-term relations primarily consisted of relations to firms in vertical directions of the production line. Examples were relations between craftsmen of supplementing trades such as bricklayers and carpenters, permanent connections between general and trade contractors or the continued relationship of architects and contractors. The common view among respondents was that small firms normally frequent one or two firms of each trade, choosing from a pool of up to five permanent suppliers from each trade. The one or two main suppliers were often year-long partners. It was indicated that the larger group of up to five suppliers served as backup. Respondents in medium-sized companies indicated the same tendency except the fact that colleagues in the same company might use different permanent suppliers. Hence, the connections appeared to be personalised. Results suggested that when possible the permanently cooperating firms normally provided each other with jobs and a form of job exchange was shown to exist between them. Furthermore, respondents stated that prices were

[1]In this connection a relevant aspect is the implication of close versus loose relations (Dubois and Gadde, 2002). Unfortunately, the limited space does not allow us to elaborate this subject further.

normally fixed more quickly with known suppliers, thus causing the process to be both easier and faster for the respondent. Likewise an important outcome was that time was saved looking for suppliers. Additionally, respondents stated that they were acquainted with a larger number of people in different firms with whom they did not do business on a permanent basis. The results were confirmed by the expert interviews.

Implications of informal network on performance, results from questionnaire

All respondents indicated that known relations or clients (including other firms, private and professional construction clients) accounted for the vast majority of the firm turnover. All respondents estimated the turnover deriving from known relations to be 70-90 %. As a result it is possible to conclude that among the 14 respondents, a widespread use of lasting relations exists.

In order to investigate the implications of permanent relations, all respondents of the questionnaire were asked to judge a typical construction project with unknown partners and one with known partners. The estimation was made in relation to the perceived personal flexibility for the respondent in the project, efficiency for all partners of the project, individual profit of the project and estimated economic risk. The individual judgements were made on a scale from 1 (low) to 5 (high). The results are presented in Table 1. The numbers show the respondents that estimated the specific scale as representative of the question.

Table 1: Distribution of respondents in relation to scale

Scale on 1 (low) to 5 (high)	1	2	3	4	5	1	2	3	4	5
Category	Unknown					Known				
Personal flexibility for the respondent	0	8	6	0	0	0	0	0	11	3
Efficiency for all participants	1	4	9	0	0	0	0	2	9	3
Individual profit of the specific project	0	4	10	0	0	0	0	4	9	1
Perceived economic risk (1= low risk, 5= high risk)	0	0	6	7	1	4	9	1	0	0

As presented in Table 1 the estimation of respondents was relatively similar and the replies were distributed within a limited area. In relation to projects with unknown partners, no respondents indicated either high personal flexibility or total efficiency of the project. Furthermore, no respondents indicated high individual profit connected with the specific project. Instead, more than half of the respondents estimated the economic risk of projects with unknown partners to be high. Table 1 also shows the respondents' estimation of projects with known partners. Most respondents estimated that the latter project is conducted with high flexibility for the respondent and also high efficiency for all involved partners. The individual profit was expected to be higher than on the project with unknown partners. And, finally, the economic risk was estimated as low.

Results from interviews on the connection between relations and performance

The views expressed in the interviews reflected the qualitative indications. When asked how working with known relations affected flexibility, the general opinion of the respondents was positive. Most respondents emphasised the case that partners with whom you had a stable relationship were most likely to respect mutual agreement of quality and time management. Hence, less time was spent on waiting and other inefficient activities. The belief that unknown partners would not respect agreed time tables and arrangements was strong and connected with the lower expected profit. An important point was that respondents expressed a clear belief that communication was easier with known partners and all respondents emphasised trust as important for the relationship. Respondents expressed a clear belief that they trust especially their well-known permanent partners to keep to the agreed time and quality of projects causing the important coordination activity with partners to be smooth. Respondents explained that they would be willing to make an effort to fulfil the wishes of their permanent relations.

Furthermore, it was commonly stated that the known partners responded quickly when asked to redo a job or improve time or quality. The lower perceived economic risk with known partners was due to the fact that the process was expected to be smooth and the risk of major problems low. At the same time, respondents trust known partners to comply with dates of payments. Hence, the results indicated a positive effect associated with working with known partners. A common point of view was, however, that prices should be checked often to ensure that the known partner did not misuse his position to charge higher prices. Therefore, an important point was that the relationship should not become too close or be automatically expected on a permanent basis. The trust was somehow restricted to current projects in progress. When asked to choose between a known supplier and a slightly cheaper unknown alternative, respondents all preferred the known partner. However, all respondents expressed a clear mutual reliance on the long-term relations with a clear shared understanding that it should not be taken for granted. In relation to the future, all respondents wanted to keep an arms-length relationship and not integrate activities in consortia, joint ventures or other permanent legal arrangements. An important aspect of the permanent cooperation was the expectation that if a major unexpected problem arose on a specific project, known partners were much more likely to sort it out in a good manner. Whereas the expectation was that unexpected complications in an average project with unknown partners would most likely cause further complications and in the worst case cause a conflict or even industrial arbitration. The data were confirmed by the expert interviews.

DISCUSSION

The implications of complexity on working with known relations

As described, the process of production in construction is a complicated matter and the need for coordination significant. A possible explanation of the reliance on known partners can be found in the easier communication used when coordinating. Respondents trust that long-term partners respect agreements and that understandings are more easily found. Hence, the time spent on inefficient matters are lower when working with known partners. The belief that a project with known partners will more likely avoid conflicts is evident. Following this argumentation, the priority of known relations represents a rational risk minimisation strategy by the respondents in relation to the single projects. Furthermore, the interdependence of different projects forms a further argument for the assumption that it proves useful for actors to work with known partners. As the lower risk of complications of the construction process also bears implications for the other projects a given firm is involved in, each project represents a risk of ruining the total flexibility and efficiency of the firm. Also, respondents rely on the mutual flexibility of partners in relation to e.g. quick response on inquiries of prices or practical planning to improve their own overall flexibility. This mutual flexibility is enhanced when continuously working with known partners. An important argument is that project teams of known partners more easily cope with unforeseen events. The complex character indirectly enhances the interdependence of actors and causes the dependence of external partners to increase. Hence, working with known partners forms a risk minimisation which addresses the complicated and dynamic character of the production process in the construction industry.

The existence of permanent relations during multiple projects

The fact that cooperation should not be taken for granted can be explained by the risk of opportunism. Actors protect themselves from actions of opportunism from partners, by keeping a clear and shared understanding that the cooperation should not be taken for granted. Still, cooperation was shown to last longer than the single project, and even continue for several years. Hence, although all partners are not taking the cooperation for granted they still show the permanent partners a special attention and flexibility. The driving force of the latter could be explained by the concept of trust. The existence of trust is associated with the relations or ties between actors being personal. The individuals base their trust on past experiences of successful projects with the specific partners, and expect a positive feedback that lasts longer than the single project. The strategy is logical, especially in regard to the interrelated trades of production in construction. Even without trust and shared understanding, companies are dependent on each other in order to perform successfully. Hence, the priority of partners with a common basis of effective communication and trust seems rational as a risk minimising strategy. The relations are not stronger than the next successful project as trust can easily be lost if a partner does not meet the expectations. On the other hand, if not interrupted, positive experiences reproduce themselves, like explained by Grabher. Hence, the projects' organisation and the interrelated character of production at first hand determine the rationale behind working with known partners on a longer perspective than the single project.

The statement presented by Dubois and Gadde of no permanent tight relations in construction beyond the single project seems doubtful in the perspective of the presented results. Respondents gave clear indication of mutual interdependence with yearlong relations. The integrated way of production is longer than the single project. Project teams consisting of the same firms are often repeated for several projects. The total team will in most cases not be the same, but the permanent connections between firms are reproduced in mutual projects. Hence, the tendency of reproducing systems of project organisation can be found in construction and contradicts the statement by Dubois and Gadde of no tendency of tight long-term ties found in construction.

Moving on to the questions of whether the partners adapt to each other's way of production, the indications found at the interviews were positive. The flexibility performed by different trades in relation to the specific project can be considered a form of adaptation restricted to the single project. However, more importantly, the mutual adaptation in relation to planning and flexibility stretching over several projects can be seen as a form of permanent adaptation to the production processes of partners. Hence, lasting adaptation in the network structures was identified.

The personal implications of inter-firm relations

Theoretical indications suggest that the relations between firms are based on individuals. Respondents clearly stated that colleagues of middle-sized companies might very likely use different subcontractors supporting the statement that relations are personal rather than firm-based. Furthermore, implications were made that the relations could easily be of more permanent character than the employment itself. One respondent of a general contracting company put it quite clearly "*In reality, another name could easily be printed on the sign, it would not make a difference to me*". The respondent is referring to the name of the company and is explaining his opinion that the employment in the individual firm is of minor importance. What matters to him is his relationship with subcontractors and other actors in the vertical production line. Often individuals employ the same subcontractor independently of their own employment. Relations are carried over employment to employment. This way, the networks of individuals prove more important than firms, which merely perform as incubators of the network structures. Some respondents mentioned connections between specific firms that lasted for years. However, these connections were always limited to the individuals of the specific firms. The highest risk of losing an inter-firm connection is taking place if individuals are replaced. Hence, the findings of the paper support the statement of Taylor and Asheim advocating the importance of networks of individuals in firms rather than the individual firms in relation to performance.

It is important to bear in mind that internal firm capabilities such as calculation of the appropriate price for use in competitive tenders should not be ignored as an important deterrent for company profit. Still, when analysing the performance of the firms when conducting construction projects, cooperation with external partners proves to be the biggest challenge and hence most important for a successful performance.

The negative effects of working in networks

The results presented in this paper emphasise the positive aspects of working with known relations. When collecting data, a challenge is always to include negative as well as positive implications, as respondents are reluctant to exclude negative parts of the story. Except for the obvious risk of opportunism, respondents did not point out any negative effect of working with known relations. When asked directly on the subject, respondents replied that they saw no obvious disadvantages, but if such should arise, it would be easy to avoid them. Theoretically some indications can be generated on the subject of negative effects. Firstly, working in networks might exclude some actors from participation and hence limit the element of competition causing prices to increase (Smith-Doerr and Powell, 2005). This element can, however, partly be ruled out by the fact that respondents claim to be aware of this danger and normally check prices with multiple suppliers. However, it is impossible to completely exclude the fact that respondents might be able to find lower prices if working along another strategy.

Secondly, working in networks might limit the diffusion of new ways of working and new products (Gann and Salter, 2000). In this regard respondents - when asked directly on the matter

- expressed the opinion that cooperation does not diminish the diffusion of new ideas. Respondents are in fact aware that multiple partners (although in a limited number) represent access to resources like new ideas etc. However, it is impossible to exclude the possibility that respondents are missing out on valuable information or new ideas without being aware of it. The argument is supported by the assumption of bounded rationality. Whether this is in fact the case is difficult to estimate in the present paper. On the other hand, a contrary argument can be made. Taking the complex and dynamic character of the construction process into consideration, it can be argued that as respondents are only able to confront a given amount of the total information available, the relations could be seen as helping them prioritise the information. If put this way, the network structures represent a strategy of only dealing with a limited amount of information, but at the same time dealing with the relevant part of the information available. What defines *relevant* is the specific information that makes the projects that the firm is involved in possible to conduct, despite the complex and dynamic character of production. Of course, it could always be argued that more relevant information might be available. But the implications of forsaking the cooperation with known partners may not represent a possible advantage that equals the increased risk such a strategy would imply.

A last negative implication of working in networks might be that the cooperating firms deliberately let the permanent relations charge a higher price as subcontractors and hence causing the price for the costumer to increase. If so, the tendency could take place both ways, creating a system where known partners ensure each other higher prices at the expense of the shared customer. This situation should, however, be expected to be diminished by the elements of competition between teams of firms that the customers can choose from. This paper considers the latter danger as most outstanding in times of economic boom and increased demand. Concerning prices between known relations, respondents did acknowledge that they do, from time to time accept slightly higher prices from partners they know well. However, the higher price also affects the profit of the first firm. Furthermore, only very minor price differences will be tolerated as higher prices limit the competitiveness of the total project team. Instead respondents explain that *if* higher prices occur between partners, the total profit of the project is not necessarily affected negatively compared with working with unknown partners. Respondents consider small price differences as being of minor importance to the total profit of a given project. Concerning competitiveness, respondents find it more important that the construction process with known relations precedes more smoothly causing the efficiency of the process to increase both in relation to the single project but also concerning the total performance of the firm in question. Theoretically the total project price based on teams of known partners should be lower than an equivalent project with unknown partners. Whether this price reduction reaches the end customer is doubtful. A positive effect that does indeed reach the final consumer is the advantages of a project with diminished risk of major conflicts or industrial arbitration.

CONCLUSIONS

The results of the present paper suggest that the use of working with known relations is widely common in the Danish construction industry. This trend had positive implications for the performance of the firms in question. The efficiency and flexibility are enhanced both in relation to the single project but also concerning the total performance of the firms involved. The relationships forming the networks are highly personal and based on the existence of trust. However, the cooperation is not to be taken for granted, as this would enhance the risk of opportunistic behaviour of the partners. However, the network might help actors distinguish the most relevant information in the huge amount of information available. Finally, it has been proposed that the advantages of firms working with known relations might not necessarily result in lower prices for consumers. However, the risk of a construction process characterised by conflict and the additional costs this would imply for all partners involved including the client is on the other hand diminished.

REFERENCENS

Boggs J. S. and Rantisi N. M. (2003) The "relational turn" in economic geography. Economic Geography, 3, 109-116

Dubois A. and Gadde L. (2002) The construction industry as a loosely coupled system: implications for productivity and innovation. Construction Management and Economics 20, 621-631

Ettlinger N. (2003) Cultural economic geography and a relational and microspace approach to trusts, rationalities, networks, and chance in collaborative workplaces. Journal of Economic Geography, 3, 145-171

Gann D. M. and Salter A. J. (2000) Innovation in project-based, service-enhanced firms: The construction of complex products and systems. Research Policy, 29, 955-972

Gidado K.I. (1996) Project complexity: The focal point of construction production planning. Construction Management and Economics, 14, 213-225

Gottlieb S. and Storgaard K. (2006) Flexible Strategic Partnership in Danish Construction. SBi

Grabher G. (2002) The Project Ecology of Advertising: Tasks, Talents and Teams. Regional Studies, 36 (3), 245-262

March J. and Simon H. (1958) Organisations. New York: John Wiley

Smith-Doerr L. & Powell W. (2005) Networks and Economic life in Smelser and Swedberg (edt.) “The Handbook of Economic Sociology”. New York: Princeton University Press

The Danish Government (2003) Vækstredegørelse 2003, Vækst med Vilje. Schultz Information

Taylor M. and Asheim B. (2001) The concept of the Firm in Economic Geography. Economic Geography, 77 (4), 315-328

Williamson O. (1985) The Economic Institution of Capitalism: Firms, Markets, Relational Contracting. New York: Free Press

APPLICATION OF PUBLIC PRIVATE PARTNERSHIP (PPP) MODEL IN PROCURING INFRASTRUCTURE PROJECTS IN HONG KONG

Albert P.C. Chan, Patrick T.I. Lam, Daniel W.M. Chan, Esther Cheung*
The Hong Kong Polytechnic University
*Corresponding author: bsesther@polyu.edu.hk

Hong Kong has been one of the early jurisdictions to adopt Public Private Partnership (PPP) model for delivering large public infrastructure projects. The development of this procurement approach in Hong Kong has followed an intricate path. As such, it is believed that there are a number of areas which are interesting to unveil. As part of a comprehensive research study looking at implementing PPPs in Hong Kong, interviews with experienced local industrial practitioners were conducted. Amongst these interviews, seven were launched with past and present Government officials from different relevant local Works and Administrative Departments. This paper presents the analysis of these interviews which helps to answer some of the queries that both academics and the private sector are keen to follow up with. The interview findings show that the retarded adoption of this approach has been due to the public sector being able to afford public infrastructure projects comfortably using taxpayers' monies, since recent budgets have recorded surplus. To bring in private sector finance may not always be the best value for money. Instead observing the success of PPP projects in other jurisdictions has triggered the Government's interest to introduce innovation and efficiency. Therefore it was found that in general, the public sector welcomed this form of procurement. In addition, the Hong Kong SAR Government has been keen to learn from the good experience of other jurisdictions by seeking advice from various consultants and experts. It can be observed that the interviewees exhibited a positive outlook for PPPs and are keen to explore its benefits for the right projects. The findings from this paper are expected to provide a clearer insight into how government officials perceive PPPs, as a result the private sector can gain a clearer understanding of what is expected from them.

KEYWORDS: Public Private Partnerships (PPP), Procurement, Infrastructure Projects, Hong Kong.

INTRODUCTION

Public Private Partnership (PPP) is a procurement approach where the public and private sector join forces to deliver a public service or facility. In this arrangement normally both the public and private sector will contribute their expertise and resources to the project and share the risks involved. The definition of PPP may differ slightly between different jurisdictions, depending on which part of the arrangement the importance is focused on. But in general PPPs can be any agreement where the public and private sectors work together to deliver a public project. PPP is a relatively modern term for this arrangement used only more commonly in the last decade. Previously different variations of the arrangement included Private Finance Initiative (PFI), which is a more familiar term to many people due to its successful development in the United Kingdom (U.K.) during the early nineties (Tieman, 1992). It would not be incorrect to say that the PFI practice developed in the U.K., raised the world's attention to this alternative option for delivering public infrastructure and services. The extent to which PFI could be used and the advantages created were the main drivers attracting other countries to start adopting or improve their practice in PPP. A more specific term used more commonly a decade ago is Build Operate and Transfer (BOT). This arrangement was commonly adopted for transportation projects. This is because transportation projects tend to be larger in size and also because their long physical lives fit well into the procurement mode. Earlier this century, concession was a common form of PPP. These early concessions mainly occurred in Europe (particularly in France) for water projects (Grimsey and Lewis, 2004). Although water projects tend not to be particularly large in project sum, it was noticed early on the advantages of introducing private expertise to deal with tasks that the public sector was probably not as efficient or experienced in carrying out the works. Although a long history if PPPs has been recorded, many jurisdictions are still unclear of how to maximize the benefits and avoid the risks which could occur.

HONG KONG'S PPP EXPERIENCE

Hong Kong is not completely new to the idea of PPP. In actual fact the city was probably one of the first to utilize resources from the private sector. The term PPP may sound revolutionary to Hong Kong, whereas a more familiar term is BOT. The concept of BOT has been used since the late sixties. In September 1969 the construction for the first BOT project in Hong Kong commenced (Mak and Mo, 2005). The Cross Harbour Tunnel (CHT) is a two lane tunnel in each direction. It took only 36 months to complete and was eleven months ahead of schedule. The CHT was an instant success when it came into operation in August 1972. Within three and a half years of operation the Tunnel had collected enough tolls to pay back its construction cost. The Tunnel is probably the most successful BOT project in Hong Kong, and is still one of the most important and profitable pieces of infrastructure locally.

Although Hong Kong has had experience in adopting quite a number of BOT projects, the approach of PPP has never really been studied extensively on a local scale. The traditional practice of these projects was for the government to directly award a concession to the potential bidder. This practice of awarding concessions is common in Hong Kong, but the gestation period spent in formulating the enabling legislation is lengthy.

In recent years the Efficiency Unit of the Hong Kong Special Administrative Region Government has been heavily involved in PPP research. The Government's interest in utilizing PPP is obvious. The approaches that they have taken mainly involve gaining international experience from particularly Europe and Australia. One of the early documents produced by the Efficiency Unit on private sector involvement was a guideline to help governmental bureaux and departments to familiarize with private sector engagement (Efficiency Unit, 2001). These guidelines were published in 2001 and showed the government's interest in adopting the idea of PPP. Only two years later they also produced a comprehensive introductory guide to PPP (Efficiency Unit, 2003). This guide was aimed for the use of the civil service but is also made available for the public's interest to understand the government's approach. After the publication of this report much interest was drawn from the public due to the possibility of the increased business opportunities available. More recently, the Efficiency Unit published two more guidelines on PPP (Efficiency Unit, 2007; 2008). The first edition shows how more knowledge on the issues of PPP have been learnt, it also identifies areas of concern to local practitioners as well as civil servants, and it tries to provide some insights into these areas. The second edition is much more specific on how to establish a PPP project. The guideline is aimed at coaching civil servants on how to conduct a PPP project by looking at the business case, dealing with the private sector, managing the risks, funding and payment issues, managing performance etc.

THE RESEARCH FRAMEWORK

The findings presented in this paper are part of an on-going research project looking at developing a best practice framework for implementing PPPs in Hong Kong. As part of the data collection, interviews were conducted with PPP experts from the public sector in Hong Kong.

Design of Interview Questions

Utilizing in-depth literature findings, interview questions linking up to the project objectives were derived. The following questions were derived for the interviewees:

1. Have you conducted any research looking at local case studies? And if so, could you share your insights?
2. How would you compare PPP with traditional procurement methods?
3. Which type of project do you feel is best suited to use PPP?
4. What do you feel are the key performance indicators in a PPP project?
5. In general, what do you think are the critical success factors leading to successful PPP projects?
6. Does your organization have any in-house guidance/practice notes?

Selecting Respondents

The target respondents of the interviews were practitioners with experience in PPP of senior level and authority who have had experience acting for the government. Amongst the seven interviewees, two were from Administration Departments (one of the interviewees previously represented a Works Department), three were from Works Departments (one of which previously represented an Administration Department and the other also holds a position at a local institute), two of the interviewees were from Non Governmental Organizations (NGO) (both had previously acted for different Works Departments). The interviewees selected ranged from a variety of different roles within the Government. Table 1 shows details of these interviewees.

Table 1 List of Interviewees from the Public sector in Hong Kong

No.	Position of Interviewee	Organization of Interviewee
PU1	Assistant Director	Administration Department
PU2	Permanent Secretary	Administration Department (previously Works Department)
PU3	Director	Works Department (previously Administration Department)
PU4	Senior Director	Works Department
PU5	Senior Quantity Surveyor	Works Department / Local Professional Institute
PU6	Executive Board Member	NGO (previously Works Department)
PU7	Executive Director	NGO (previously Works Department)

THE PUBLIC SECTOR'S PERSPECTIVE ON PPP

1. Have you conducted any research looking at local case studies? And if so, could you share your insights?

Interviewee PU 1 is an Assistant Director of a public administrative department. His department has been incredibly active in conducting PPP research and hence he was interviewed for his expert knowledge in the area. Interviewee PU1 mentioned that the department had already produced a guideline back in 2003 and the second edition would be produced by the first quarter of 2007. He added that the new bilingual guideline would include information collected from overseas and will also look into the local problems and the success factors for PPP. In addition their department has also carried out internal case studies on local projects.

Interviewee PU2 had recently started his post at an administrative department, before this he had spent a long time working at a works department. Hence the discussion was heavily based on his experience at the works department. He did not go into detail on whether there have been any case studies conducted within his previous department, but instead he introduced how asset management can also be regarded as a form of PPP, and also how it has been implemented successfully in his previous department for maintenance works. He also added how this form of arrangement has been successfully carried out for asset management of buildings in Melbourne, Australia.

On the contrary to Interviewee PU2, Interviewee PU3 had previously worked in an administrative department but only recently changed to a position in a works department. He suggested that:

"Apart from looking at the experience of Australia and U.K., it is also worth taking a look at South Africa and Philippines. Both of these places are new in adopting PPP and have done quite well."

He added that during his previous position he had:

"…………… conducted a study and a technical circular was published."

Interviewee PU4 is a Senior Director of a local works department. He explained how their PPP model is in the form of Design Build and Operate (DBO), and how it was based on the model of another works department in Hong Kong. He shared that his department:

"…………… has employed consultants to advise on procurement using the DBO method…………… The consultancies of these projects have carried out studies investigating DBO strategies."

Interviewee PU5 is a Senior Quantity Surveyor working for a local works department (responsible for project management of public building projects) and also an office bearer of a local professional body. Referring to the department he works for, he explained that no studies have been carried out within their department and that they have:

"…………… not taking the most active role in PPP projects. The client's departments (as they are responsible for operation) and the Finance Bureau (as they are the payers) would be in a better position to pursue PPP."

Referring to the work conducted at the professional body, Interviewee PU5 explained that:

"…………… we focused very much on the financial structure and risk management…………… There should also be a clear risk allocation and the risks should be associated with the potential return. In addition, there should be a clear timetable…………… From international practice we discovered new terms such as the Public Sector Comparator and Special Purpose Vehicle…………… the risks should be allocated to the party who is most able to handle them."

Interviewee PU6 is an Executive Board Member of a NGO. He explained how it would be inconvenient to comment on the works department he had previously worked for, but he was willing to share some insights into the topic of PPP from a personal level.

Interviewee PU7 is currently the Executive Director of a NGO. Previously he had worked in a governmental works department for many years before his retirement. In the interview conducted with him he shared his knowledge and experience on PPP from his previous position. Interviewee PU7 explained that he had personally not conducted any research studies in the area of PPP, but suggests that:

"…………… there is also a form of PPP in buildings such as the home ownership scheme PSPS……………"

Interviewee PU7 was referring to Private Sector Participation Scheme (PSPS) that he had previously been involved with in his previous employment. Through PSPS, good quality residential apartments were financed, designed and built by private developers by allocating land to them on a subsidized basis. The completed apartments were marketed to medium-income buyers as a form of affordable housing.

2. How would you compare PPP with traditional procurement methods?

Interviewee PU 1 explained that:

"There is longer lead time to start up a project using PPP."

And also for PPP projects:

"Need to construct a public sector comparator."

Interviewee PU1 further explained why Hong Kong has tended to procure PPP projects traditionally rather than by PPP:

"There is no drive from the top or the treasury because the Hong Kong Government is not in shortage of money. Whereas in almost every jurisdiction that has successfully introduced PPP, they have a shortage of capital funding for infrastructure, new projects, maintenance or re-provisioning. Therefore the incentives are not the same and the Hong Kong Government has other alternatives."

Interviewee PU2 described that:

"Under the traditional practice, a works order would be needed for any works required, whatever the cost. This created a large amount of documentation which has now been replaced by PDAs under the new arrangement. The works department now acts as a supervisor's role."

For a more accurate analysis he added:

"A public sector comparator should be utilized."

Interviewee PU3 believed that it would be more appropriate to consider which method the project requires:

"Whether a procurement approach is appropriate to particular project would depend on the nature and characteristic of the project."

Unfortunately Interviewee PU3 has also realized that:

"Our colleagues may not necessarily adopt this selection method. They tend to prefer the usual practice for which standard forms of contract are available."

Interviewee PU4 described that for PPP projects:

"…………… they will identify the concession period and the payment arrangements. In a traditional approach, we will pay the contractor on a monthly basis during the construction stage.

Also, in PPP projects Interviewee PU4 described that:

"Contractors will submit construction and operation prices in their tenders. The nature of PPP or DBO is to allow more flexibility at all angles for tenderers so that they can maximize their expertise whether it be in terms of financial, technical or managerial…………… These projects involve rigorous procedures."

Comparing traditional methods to PPP, Interviewee PU5 explained:

"…………… in a PPP arrangement the Government will have an observation but not a solid project idea, and here is where the PPP arrangement can add value to the project…………… I think most people will also agree that PPP projects are developed faster than those procured by the traditional approach."

Interviewee PU6 believed that:

"The suitability of adopting PPP depends on the project itself. The project must be financially stable."

When asked whether the PPP arrangement is best when the government is the end user, Interviewee PU6 agreed. He also added:

"In a traditional procurement method the government will finance the facility or service themselves."

Interviewee PU6 also believed:

"Firstly they may not have the money for public facilities or services and they do not want to borrow to subsidize these. The second reason is that even if the government does have money they may want to spend it somewhere else…………… The second advantage of PPP is efficiency. But efficiency is also related to finance."

In addition Interviewee PU6 added that:

"PPP is a lot more complex compared to traditional procurement methods hence the cost is also much larger."

Interviewee PU7 explained that:

"There are no projects that are exactly the same. If there is a project that involves the public and private sector, and also PPP is believed to be the most suitable to achieve success for that project then it should be used."

He also added that for the public sector they:

"Need to consider what the end product will be."

3. Which type of project do you feel is best suited to use PPP?

Interviewee PU 1 believed that for PPP projects to work:

"It does not matter whether income comes direct from the end user or the government or a combination of them, as long as there is a link of payment to performance."

Interviewee PU2 believed that:

"Each project is unique so it depends."

Interviewee PU3 informed that:

"xxx quoted that the Shatin Water Treatment Works project is a project with prospect of being a PPP…………… Other suitable projects will depend on whether they can be financially viable taking into account the risks associated with the project…………… In Hong Kong, we need to consider value for money."

Interviewee PU4 felt that in order to procure by PPP:

"………. the projects needed to involve a large operating element…………. We will consider if the project performance can be measured easily. "

Interviewee PU5 described:

"Unsuitable PPP projects are ones that have no economic case."

PU6 believed that the projects most suitable to use PPP:

"…………. are those that involve a high operation cost…………. economically attractive to the private sector and if anyone would be interested…………. Some projects may not be economically feasible alone, but the government could support it with subsidy if necessary."

Also Interviewee PU6 raised an example of a successful PPP project in Hong Kong:

"MTRC has developed property above their stations to subsidize the underground construction for over 20 years. This has been a successful case and an effective arrangement."

Interviewee PU7 believed that:

"Housing projects have been shown to be successful"

When further asked if smaller projects would be suitable for PPP, Interviewee PU7 used the PSPS as an example of success and added:

"Depends if there are any mutual benefits for the public and private sector."

4. What do you feel are the key performance indicators in a PPP project?

For the key performance indicators, again Interviewee PU 1 believed that would be related to the:

"………….link between performance and payment…………."

Interviewee PU2 described that:

"The success can be measured in terms of the resources reduced in terms of money and people."

The interview with Interviewee PU3 did not touch on the key performance indicators.

Interviewee PU4 believed that:

"There are two things. The first is the Public Sector Comparator (PSC) which will be used to confirm whether the DBO approach is cost effective. The second are the KPIs which will be used to measure the contractor's performance and will be project specific."

The traditional key performance indicators for projects were named by Interviewee PU5:

"Three objectives need to be considered, i.e. cost, time and quality."

He also felt importantly that:

"A Due Diligence Audit can be used to measure the consortium's performance."

The key performance indicators according to Interviewee PU6 include:

"Time, cost and risk management."

And Interviewee PU7 added:

"………….. the project must be profitable for the private sector, time more efficient and general public acceptance."

5. In general, what do you think are the critical success factors leading to successful PPP projects?

Interviewee PU 1 suggested:

"In Hong Kong, the projects that have succeeded there has been someone acting as the champion………….."

In addition he warned that:

"My personal thought is that for capital value below 300 million Hong Kong dollars you may need to think carefully."

Interviewee PU2 described that:

"There are three key ingredients for PPP: 1) Supervisory level should have a correct mindset for adopting PPP; 2) The organizational papers and contract are prepared correctly; and 3) The roles of each party need to be well defined and they must be willing to work together."

He added that:

"The procurement method must be a transparent process."

And also:

"The project should be small to begin with so that it is not too complicated. The project must be well defined………….. A plan needs to be set for how the project will be shown to the public. Public participation is vital for social acceptance. Partnering spirit is needed.

Interviewee PU3 mentioned that:

"For a PFI project to be successful, the risk assessment must be done well. The risk allocation component is the most important."

Interviewee PU4 suggested that the critical success factor for PPP was the same as the suitability for PPP:

"………… the projects needed to involve a large operating element."

Interviewee PU5 named the critical success factors for PPP to be:

"1) There must be development potential; 2) Ability to clearly specify requirements of the Government; and 3) Appropriate risk allocation which is dependent on contract conditions."

He also added:

"The key was to inform the general public what PPP actually was and how these facilities procured by PPP would be looked after. Apart from the risks, political problems are also important to consider."

The critical success factors according to Interviewee PU6 include:
"The project must be economically viable. The risk must be manageable for the investor. Risk is related to cost. Social factors are important to affecting the success of a project."

Interviewee PU7 described:
"Both parties must share the same goal, mutual benefits must be perceived, the arrangement must be fair, responsibilities clear and an easy to implement mechanism."

In addition Interviewee PU7 added:
"The process must be transparent for the public to understand and accept."

6. Does your organization have any in-house guidance/practice notes?

As mentioned earlier in the interview the department of interviewee PU1 has several guidelines on PPP accessible from their website for public viewing. During the interview, interviewee PU1 also raised a few other areas of concern that should be considered for PPP projects. He mentioned that:
"Staffing is an issue particularly if there is an existing facility or service that is thinking of moving into the private sector."
And that:
"There is no standard staff transfer mechanism or scheme."
Hence:
"Therefore the lack of a standard mechanism discourages departments from considering a PPP proposal if the staff transfer arrangement is required."
Interviewee PU1 further explained that:
"Traditionally departments do not need to handle the sole responsibility of a large project but using the PPP method they would have to, therefore it is understandable that departments are reluctant to change their normal practice of procurement."

In other countries that first started to adopt PPP, the financial drive has often been a large motivator, but for Hong Kong Interviewee PU2 explained:
"PPP in Hong Kong is not for the finance but instead to increase efficiency."

He also shared his feelings towards other parties affecting PPP projects:
"In Hong Kong it appears there is too much respect given to minorities in the society. Also, the media often inaccurately reports."

Interviewee PU3 shared similar views as Interviewee PU2 on Hong Kong's financial situation:
"…………… there is no need for external capital finance for Hong Kong Government…………… Therefore if the Government is to bring in the private sector they must demonstrate that efficiency and productivity improvement could lower the cost by 30%."
He shared that for conducting PPP projects the government also has some reference materials for their staff:

"There is no mechanical method, but there are some available guidelines…………… One has been developed for D&B."

In addition he added that:

"There are some detailed guidelines in Australia, the Philippines and South Africa."

When asked whether Interviewee PU4 had any internal guidelines for PPP, he informed that:

"We refer to the Efficiency Unit PPP guide book, the Environmental Protection Department practice and international practices."

Interviewee PU5 referred to a booklet and conference proceedings produced by his institute, in addition he highlighted that for the Western Kowloon Cultural District project in Hong Kong:

"The Government had been heavily criticized for it, as the public believed that the Government had handed over the development right to a single developer and the Government would not admit that it was a development project."

Problems raised by Interviewee PU6 include:

"For existing facilities it is not to do with the project itself but the employees. For facilities that change from being public to private, there is also much opposition from the existing employees and unions. It will become a political and social problem…………… For WKCD the general public believes that it is an excuse for property development."

Some debate has been going on about whether specific PPP legislation is necessary, Interviewee PU6 shared his views:

"There is no need for legislation unless the facility is receiving payment from the general public."

As Interviewee PU6 no longer works at the department he served, he felt it was inappropriate to pass us information but provided some further contacts instead.

Interviewee PU7's organisation has not produced any in-house materials but he raised another problem which has been regularly discussed:

"There has been argumentation about whether this project involved too much profit for the private party."

CONCLUSIONS

This paper has presented the findings of seven interviews conducted with past and present government officials with experience in PPP projects and research. It was found that the project itself was important in determining which procurement method should be adopted. A public sector comparator could also be used to determine the method most appropriate for the project. The procurement process of PPP projects tend to take a lot longer but there is the advantage of incorporating the private sector's expertise. Projects that are suitable for the PPP method include those that have a high operating element and cost. Also suitable PPP projects are those that have a good economic case. The key performance indicators of a PPP project are mainly related to the cost, time and risk.

There are a number of critical success factors for PPP projects: there must be an appropriate risk allocation, adequate information to the general public, clear specifications defined, the project must not be too complicated, there must be a partnering spirit between the parties, and the project must have an economic case. Some of the interviewees felt that the Hong Kong government is more than capable to fund public work projects, but instead they would like to adopt PPP for the added advantages of bringing in the private sector such as increasing efficiency. Finally, the Hong Kong government should ensure that PPPs are not conducted for the private sector to make large profits.

A follow-up empirical questionnaire survey to solicit various opinions on the key issues regarding the application of PPP model from those project team members who had gained hands-on experience in participating in PPP projects had also been launched between October and December of 2007 in both Hong Kong and Mainland China. The major survey findings including the perceived benefits, potential obstacles, critical success factors, key risk factors and their treatment of adopting PPP models will be collated and disseminated towards the research community and construction industry through subsequent refereed publications in the form of journal articles and conference presentations.

ACKNOWLEDGEMENTS

The work described in this paper was fully supported by a grant from the Research Grants Council of the Hong Kong Special Administrative Region, China (RGC Project No. PolyU 5114/05E). Sincere thanks goes to those industrial practitioners, who have kindly participated in the interviews reported in this paper.

REFERENCES

Efficiency_Unit. (2001). *Serving the Community by Using the Private Sector*. June 2001, Hong Kong Special Administrative Region Government.

Efficiency_Unit. (2003). *Serving the Community By Using the Private Sector - An Introductory Guide to Public Private Partnerships (PPPs)*. August 2003, Hong Kong Special Administrative Region Government.

Efficiency_Unit. (2007). *Serving the Community By Using the Private Sector Policy and Practice (Second Edition),* January 2007.

Efficiency Unit (2008). *Serving the Community By Using the Private Sector - An Introductory Guide to Public Private Partnerships (PPPs) (Second Edition),* March 2008, The Hong Kong Special Administrative Region Government.

Grimsey, D. and Lewis, M. K. (2004). *Public Private Partnerships: The Worldwide Revolution in Infrastructure Provision and Project Finance* (First ed.). Cheltenham, U.K.

Mak, C. K., & Mo, S. (2005, 22 February). *Some Aspects of the PPP Approach to Transport Infrastructure Development in Hong Kong.* Paper presented at the Public Private Partnerships - Opportunities and Challenges, Hong Kong.

Tieman, R. (2003, 24th November). A Revolution in Public Procurement:UK's Private Finance Initiative. *Finance Times,* 4.

A METHODOLOGY TO ASSESS THE PERFORMANCE OF PPPS COMPARED TO OTHER PROCUREMENT METHODS IN AUSTRALIA

Peter Raisbeck
Faculty of Architecture, Building and Planning, The University of Melbourne
raisbeck@unimelb.edu.au
Associate Professor Colin Duffield
Faculty of Dept. of Civil and Environmental Engineering, The University of Melbourne,
Michael Lawrisky
Allen Consulting Group, Melbourne Australia

Estimating cost and risks in Australian capital projects is often characterised by optimism bias—the tendency to be overly optimistic about planned actions—and insufficient historical data on which to base decisions. In this situation strategic decision making is hampered by the fact that any historical project data is distributed across Australian states and not readily available to decision makers. The methodology developed here is an attempt to overcome some of these issues and to develop techniques which compare the time and cost performance of diverse projects procured by different methods. This is important in relation to the debates that have surrounded the PPP model in Australia.

These debates are complicated by the fact that across Australia there is currently a plethora of procurement decision methodologies in use by government. Different Australian states use different processes and criteria to assess how best to design, construct, deliver and then operate new projects. The policy documents which guide these processes also differ markedly between these states and different states will have a range of different procurement paths, including Public-Private Partnerships (PPPs) to select from. However, no single database of project outcomes for public infrastructure exists across Australian jurisdictions.

For these reasons this paper sets out a methodology for assessing and comparing different procurement methods including PPPs. This is important because PPPs have attracted a great deal of debate about their worth. The methodology expounded here is based on a consideration of previous studies, time and cost metrics, project size and the relative complexity of different project types. Whilst this methodology could clearly be developed further, it is a significant advance on conclusions about procurement performance solely related to small sample sets and case study approaches.

KEYWORDS: PPPs, Benchmarking methodology, procurement, time and cost outcomes.

INTRODUCTION

Empirical research into PPPs in comparison to other methods of procurement is important because in Australia, State and Commonwealth Infrastructure Plans project spending of over $320 billion over the next decade, which could easily become $400 billion. Estimates of the size of the Australian PPP market vary. In 2004 the National PPP Forum estimated that at that time, over $9 billion in PPP projects were already contracted. This comprised over $4 billion in PPP projects currently in the market and over $5.5 billion of projects being considered for delivery as PPPs. According to the *Financial Times* the Australian market comprised $9 billion of projects between 2000 and 2006, and is expected to grow to $100 billion in the next ten years (Minder, 2006). However, such levels would not be achieved unless the market share of PPPs rises significantly. In order to achieve the $100 billion level of PPP projects foreshadowed by the *Financial Times*, it would therefore be necessary for Australian PPPs to capture a 25 percent share of the overall infrastructure market, compared with their current share, which lies in the vicinity of 10-15 percent of total government procurement.

The Australian PPP market, whilst not as large as the UK's PFI market, is already among the most sophisticated PPP markets in the world. It is a market which continues to evolve. In its initial phase the project finance techniques and instruments were developed for BOT and BOOT projects and then adapted to build transport infrastructure. Most of these projects were contracted in the market up to 2000, and completed before 2005. As discussed below a number of the evaluations of the efficiency of Australia's PPP market is based on these projects. However, in the second phase and third phases of development in this market social infrastructure projects are beginning to widen their dominance of the market in numerical terms. These projects are diverse and include hospitals and schools involving significant facilities management over the economic life of the asset.

Previous research on performance measurement

Initial Australian research into the PPP market tended to endorse enthusiastically the PPP model, which was seen as a development of the BOT and BOOT infrastructure projects of the 1980s. The project finance techniques used to quarantine risk in these projects are now seen as precursors to the current cohort of PPP projects (Gann, 2005, p.572). Global growth in PPP markets has been matched by a corresponding rise in PPP research across a number of fields, including public policy and governance, construction management and economics, innovation theory and project management. In the present study we limit consideration to the UK, whose Public Finance Initiative (PFI) has had a considerable influence on the Australian PPP market, and on Australian research

UK performance outcome research

In the UK, which has been at the forefront of development of the PPP procurement framework, there has been a large body of research on PPPs. The research that is most relevant to the methodology applied in the present study is that carried out by Mott MacDonald (Mott MacDonald, 2002). The study focussed on measuring the relative degree of 'optimism bias' associated with Traditional procurement. 'Optimism bias' was defined as the percentage differential between the estimated works duration or capex cost at the 'Strategic Outline Case' (SOC) or 'Outline Business Case' (OBC) and Works Completion (WC). Given that the UK's PPP projects had relatively neutral 'optimism bias', the table shows that for 'non-standard buildings, for example, the capex estimate for Traditionally procured projects suffered between 4 percent and 51 percent 'optimism bias'.

Another study that appeared in the UK soon after the Mott MacDonald study was by the UK National Audit Office (2003). The NAO compared the results of its 2002 Census on PFI Projects with the 1996 Procurement Survey for Traditionally procured projects. The NAO found that 76% of PFI projects were completed on time, and 78% were completed on budget. By contrast, for Traditional procurement only 30% of projects were completed on time and only 27% were completed on budget. Evidence of value for money (VFM) calculations undertaken by the NAO was summarised by Allen (2001, p.30-33). There have also been a number of UK reports and academic studies that have looked at satisfaction levels and performance of PPPs. Cambridge Economic Policy Associates (2005) reported to the Scottish Executive that Scottish PPPs were generally performing well. An academic study by Kakabadse et al (2007, p.61) concluded that the 'emerging evidence is favourably inclined towards PFI' in the UK schools sector. However, a study sponsored by the UK Association of Chartered Certified Accountants (ACCA, 2004) provided a negative view of PFI projects in the roads and hospitals sectors.

Arguably, the UK PFI seems to have been generally successful relative to what might have happened under conventional public procurement. Projects are delivered on time and on budget a significantly higher percentage of the time. Pollitt (2005, p. 226) raised the prospect that the full benefits of PPPs were not confined to PPP projects, but extended to Traditional procurement as a 'vehicle for learning'. Pollitt (2005, p. 227) also felt it was important that the benefits of the PFI were not disproportionately captured by the private sector, but was confident that financial windfalls to private investors could be addressed via 'appropriately specified contracts'. The relatively higher bid costs of PPPs have often been commented on. Allen (2001 p.34) reported on the Adam Smith Institute's (1996) study, which concluded that tender costs expressed as a percentage of total costs were in the region of 3 percent for PPPs, and just under 1 percent for Traditional procurement. For the purposes of making value for money assessments, the results of the Mott MacDonald study have been interpreted as requiring that an addition to cost estimates under the Traditional procurement alternative (the Public Sector Comparator, or PSC) be made in the range given by the table.

In a critique of the Mott MacDonald (MM) and UK NAO results, Unison (2005) outlined a number of methodological problems that it considered were biasing the empirical findings in favour of PPPs. These methodological issues were as follows: Transparency – The Mott MacDonald and NAO sampling methodology was not described. Population analysis – The populations from which the PPP and Traditional samples were not described. Representative ness of samples – There was no detailed description of how representative the samples were of the PPP and traditional populations. Consistency and relevance of time period - Some Mott MacDonald traditional projects were drawn from an earlier period, which pre-dated the procurement reforms of 1999. Relative complexity selection bias – A greater proportion of Traditional projects were 'non-standard', and therefore involved a higher degree of complexity than PFI (PPP) projects.

Another criticism of both Mott MacDonald concerned the issue of measurement bias. According to Unison, Mott MacDonald measured PFI (PPP) projects from the later time of the full business case (FBC), and traditional projects from the strategic outline case (SOC) or outline business case (OBC), which came earlier, and were therefore likely to involve greater time and cost uncertainty. We have outlined these methodological issues here because the present study's methodology has undertaken to address each of them. Whilst not intending to provide a defence of the Mott MacDonald and UK NAO methodologies, we would note that the Mott MacDonald study did point out that its results showed an improvement (i.e. considerable lessening of optimism bias) over time, and that is why it provided a significant range for its estimate of the relative optimism bias of Traditional projects.

Australian research on PPP performance

The empirical research agenda on PPPs has been dominated by researchers who have generally tackled specific issues and employed case study approaches. For example, there have been several case studies or sectoral analyses of PPPs, including: English (2005) – case study of the Latrobe Hospital; Brown (2005) - analysis of a number of toll road agreements; and Hodge (2005, p.319-323) - review of the Melbourne City Link and Sydney's M2 Road. More comprehensive empirical analysis of PPPs has been confined to studies undertaken or commissioned by governments, most notably the UK Government. In Australia, this absence of empirical data has been linked to transparency and accountability issues. For example, Hodge (2005, p.327) considered that "The absence of any rigorous and transparent evaluations of Australasian PPPs represents a significant accountability shortfall, and we are left relying on only a few pieces of empirical evidence when attempting to make up the accountability jigsaw." Because of the lack of empirical evidence this has allowed some researchers to argue that PPPs have also been associated with (or seen as a proxy for) privatisation programs (Hodge, 2004) that encourage private providers to supply public services at the expense of public organisations themselves (Hodge, 2007).

The Fitzgerald Report (Fitzgerald, 2004) reviewed the *Partnerships Victoria* process for the Victorian Treasurer. The report investigated 8 case studies of PPP projects that had been undertaken within the ambit of the Partnerships Victoria framework since its inception in 2000. Fitzgerald reported that at the time they were entered into, on a weighted average, and using the then prevailing discount rate, the saving attributed to the PPPs was 9 percent relative to the respective risk adjusted Public Sector Comparators (PSCs). However, it was noted that this *ex ante* estimate of the benefit was sensitive to the discount rate applied and factors such as the valuation of the risk transfer achieved in the contracts. Hence, it was not an analysis of what was actually achieved by PPPs as opposed to other methods of procurement.

In general, it can be said that Australian academic research has tended to focus on non-empirical methods that often discuss case studies in relation to aspects of PPP contracting or operation. Very little research has focused on the linkages between concepts of procurement innovation, public interest, risk and what has actually been delivered to the Australian public. Again, as noted by Hodge (2005, p.323), 'there has been no comprehensive evaluation of Australia's PPPs thus far'. In both Australia and in the British PPP market, much of the research has been framed from either an economic policy perspective, or from a contracting and procurement perspective. Economic policy debates have seen claims and counterclaims emerge between PPP proponents and detractors. In contrast, the procurement-based research has tended to avoid these debates and has focused on understanding PPPs as a new form of procurement.

Proposed methodology

Given the above issues in relation to PPP performance research our focus in this study was to construct a methodology for evaluating the Australian PPP market (and by implication, the Traditional procurement route) using the most up-to-date data available in the public domain. To achieve this we set out to compare the project time and cost outcomes observed in the PPP market, with those projects delivered by governments via Traditional procurement methods. It was our aim to provide an accurate snapshot of Australia's evolving PPP market. Rather than extrapolating from, and generalising the results of a few PPP successes or failures based on a small number of case studies gathered from small populations of selected projects, our aim from the outset was to apply a rigorous methodological approach. Originally, we had the objective of selecting matched pairs of PPP and Traditional projects. However, as the research project progressed we found that each project is a customised solution, and no two projects are exactly alike with respect to such indicators as location, size, type and value. This ruled out the matched pairs approach, as determining a ‘matched pair’ would have required the exercise of considerable subjectivity.

In formulating our research methodology to compare the performance of PPPs in other alternative procurement approaches, we kept in mind the recent criticisms levelled at the methodologies applied in the UK studies that have been discussed earlier. In particular, in formulating our detailed research methodology we were mindful that the different project pools we constructed for comparison were not biased by the inclusion of (previously known) overly successful, or underperforming traditional projects. Similarly, we have not sought to bias the selected project pools by excluding unsuccessful PPP projects. We have not selected projects that were atypical and not representative of each procurement method. We have not biased our research findings by comparing different baselines between the two procurement methods. Nor have we biased our research findings by comparing different timelines between the two procurement methods. We have provided a high degree of transparency in relation to the data and sources applied, so that the research could be fully replicated by others.

Cognizant of criticisms that have been levelled at previous studies, we were careful not to build into our research methodology any particular bias. Given the focus of academic research on PPP projects, it was important that a methodology was developed, in the first instance, to represent the current state of the Australian PPP market. For this reason we chose to compare projects that had been contracted into the PPP market, and whose construction had been completed. We did not see any methodological value in excluding or including projects that were seen as either Traditional/PPP successes or failures. The selection criteria that we employed were designed to best reflect Australia’s current PPP market alongside a pool of broadly comparable projects procured by other methods. Our particular selection criteria are set out as follows:

Criterion 1

Australian governments have significantly changed and improved their PPP policies since about 20007 and thus it is sensible to focus on PPP projects that have been arranged and procured using the current style of policies. Thus, we have focused the sample projects to be those primarily undertaken since 2000.

Criterion 2

Largely completed projects which allow realistic comparisons to be made between forms of delivery for the capital component of projects (capex) of all, or a majority, of the associated costs needed to be brought to account. This includes preliminary works, detailed design, project management, procurement (possibly including construction) and completion costs such as settlement of any contractual disputes. We concentrated on completed or largely completed projects so that all or the majority of costs would be brought to account in most projects. All projects included data for at least one of the project stages 1 and 2 (denoted ‘partial data’ in Appendix C) with a majority of projects having ‘full data’ (i.e. data for all stages and the ‘Full Period’).

Criterion 3

Projects with a significant capex budget. PPP projects are generally only appropriate for large and significant projects due to the added requirement of arranging private finance as a part of the project. It is therefore appropriate to adopt a minimum project budget for projects included in the sample to ensure comparisons between Traditional and PPP procurements are meaningful. We envisage that we will select projects with a capex $20 million or greater.

Criterion 4

Similar number of PPP projects to other projects in each pool. The total number of PPP projects that have been completed using current policies is relatively small. A full sample of these PPP projects was sought, and a similar number of traditionally procured projects was chosen to broadly match this sample.

Criterion 5

Projects of similar complexity. There can be a wide differential between the relative complexities of particular projects, for example 'iconic' buildings versus 'normal' office facilities and new developments on clear sites ('greenfields') versus refurbishments and/or upgrade projects ('brownfields'). Having prioritised projects using criteria 1 to 3, Traditional projects were selected on the basis of criteria 4 and 5, where the number of potential Traditional projects was large (e.g. road).

Project milestones

Various periods (stages 1, 2 and 3, and the Full Period) have been calculated in order to provide alternative perspectives on the procurement process, which might be defined differently by different parties. Our interest has also been to examine whether consistent trends can be seen irrespective of the definition of milestones and stages. In order to address alternative views, cost and time data were obtained at four different milestones in a project, and four different periods were identified. The time and cost data were normalised in order to yield percentage performance relative to the target at each successive milestone or stage. It may be expected that as these stages progressed closer to the final outcome, more information will be known about a project, and outcomes will be closer to those anticipated.

In order to measure normalised performance, we define four milestones in a typical procurement project, which are as follows:

1. Original Approval – original approval of the project.

2. Budget Approval – approval of final budget prior to going to contract.

3. Contractual Commitment – situation on signing of contracts.

4. Actual Final – actual outcome of the project.

Project stages

Using the four project milestones identified above, we defined the Full Project and three periods in the project lifecycle for analysis, i.e. four different periods over which the relative performance of PPPs and Traditional procurement approaches could be measured and compared.

These four periods were:

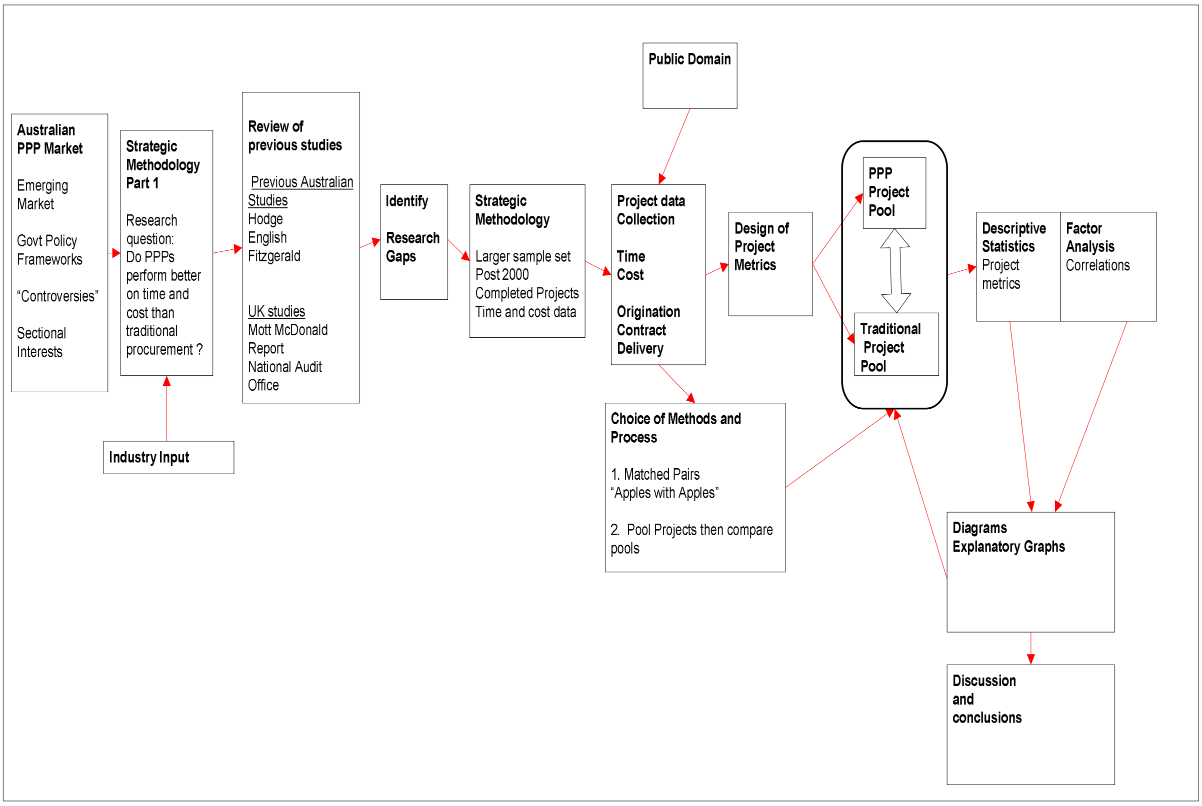
1. Full Project Original Approval to Actual Final;

2. Stage 1 Original Approval to Contractual Commitment;

3. Stage 2 Budget Approval to Actual Final; and

4. Stage 3 Contractual Commitment to Actual Final.

Figure 1: Diagram of the Methodology



Discussion: beyond time and cost performance measures

Whilst the above methodology goes some way to begin to assess the performance of PPPs against other procurement methods there is still a range of issues that require addressing in PPP research in Australia.

Benchmarking Issues

Public infrastructure projects may be either economic infrastructure such as roads or social infrastructure such as courts, hospitals or schools. Often data for individual projects may include both qualitative measures such as critical success factors and quantitative measures such as time and cost data for each project. For these reasons benchmarking data between projects is difficult.

Risk identification and allocation

Risk components between different projects differ and for decision makers risk identification and allocation at the inception of a project is often an art rather than a science. These risks include design, construction and commissioning risk, operating risks, market risks, integration and co-ordination risks, force majeure risks and political risks such as those related to industrial relations and changes in government policies. Often the identification of these risks may only emerge during a project's construction. For example, projects currently under way may not fully take into account policy approaches, currently under development. For example, any new Australian Government policies focused on national emissions accounting leading to a carbon trading scheme.

Value for Money issues

VfM is by no means an exact science. If VfM is defined as "the optimum combination of whole-life costs and fitness for purpose to meet user requirement" (HM Treasury 2003) then decision making is complex because of the need to consider whole-of-life costs, design issues and user requirements. Again different states in Australia have different methods and policies for assessing VfM. Both NSW and Victoria use a Public Sector Comparator (PSC). The PSC is a decision tool which compares the cost of undertaking a project between the public and private sectors. However, the 2006 NSW government report into Public Private Partnerships stated that "NSW operates with a less detailed policy on its PSC than other jurisdictions." (NSW, 2006).

Financing decisions

Unravelling financial market risks from other project risks such as design and construction risks is important if strategic decision making is to be improved. Clearly Governments can borrow to provide public infrastructure at a lower cost of capital than the private sector. This is because there is no weighted cost of equity in government financed projects. Because of this governments have been seen to deliver public infrastructure at a cheaper or "risk free" rate of capital. This has sometimes been mistakenly associated with the idea that governments manage projects free of all other project risks. This has prompted a public debate whether these other risks can be better managed by the private sector or not. However, without firm data on outcomes, project risks and the value added by private sector involvement in public projects, this debate will continue.

Service Delivery choices

Governments must now enter into complex contractual agreements including facilities management agreements. Contractors are often required to manage and deliver services and integrated solutions under these arrangements which they did not traditionally deliver (Gann, 2005). Often in these arrangements it is not clear how commercial risks are allocated between the parties to these contracts. Designing these contracts and performance monitoring is important if ongoing service delivery is to be adequate but this is difficult to forecast until a project becomes operational.

CONCLUSION

Empirical research into PPPs in comparison to other methods of procurement is important because in Australia State and Commonwealth Infrastructure Plans plan spending of over $320 billion over the next decade, which could easily become $400 billion. In general, it can be said that Australian academic research has tended to focus on non-empirical methods that often discuss case studies in relation to aspects of PPP contracting or operation. In both Australia and in the British PPP market, much of the research has been framed from either an economic policy perspective, or from a contracting and procurement perspective.

Consequently, economic policy debates have seen claims and counterclaims emerge between PPP proponents and detractors.

Much of the previous work evaluating the PPP model in both Australia and internationally is now dated, as the maturity and sophistication of the market has evolved. This is also true of the UK results obtained by Mott MacDonald and the UK National Audit Office. In Australia most research, even some of the most current research, relates to PPP projects that were completed prior to 2004, and has concentrated on physical infrastructure such as toll roads, rather than social infrastructure, and were often based on a limited sample of case studies.

What is forgotten in criticisms of the PPP model is that if there has been an accountability shortfall, it has been disproportionately shared by Traditional procurement. In Australia there is no transparent research that investigates the efficacy and VFM credentials of Traditional procurement, and no sense of whether performance has been improving over time, as has been suggested in the UK by the Mott MacDonald and other studies.

Nonetheless, we expect this market to continue to develop, and for PPPs also to continue to engage in the ongoing operation of water and energy infrastructure related to Australia's future sustainability needs. In this paper we provide a review of the evolution of the market and a snapshot of its current state. More importantly we suggest a methodology that will enable an assessment of the performance outcomes for assessing the more recent social infrastructure projects that have come to dominate this market.

REFERENCES

Akintola, A., Beck, M.,. and Hardcastle, C. eds. (2003) Public-private partnerships : managing risks and opportunities, : Blackwell Science, Malden MA.

Akintoye, A., and Hardcastle, C. et al. (2003) Achieving best value in private finance initiative project procurement. Construction Management and Economics, 21, 461-470.

Akintoye A, Bing Li, Edwards P. J. and Hardcastle C. (2005) Critical success factors for PPP/PFI projects in the UK construction industry. Construction Management and Economics, 23, 459–471.

Australian Capital Territory (December, 2002), Statement of the Objective and Principles for the Private Provision of Public Infrastructure.

Campagnac, E. (2007) From Construction to Services: The Client Interface and the Changes in Project And Services Governance in PPP. CME 25 Conference, 16th-18th July, 2007 Reading, England.

Carrillo, P. Robinson, H. Anumba, C. Bouchlaghem, N. (2006). A Knowledge Transfer Framework: the PFI context. Construction Management and Economics, 24/10, pp. 1045-1056

Commonwealth of Australia (June, 2000), Australian Government Policy Principles for the use of Public Private Partnerships.

Corry, D. (2004) New Labour and PPPs. in eds. A. Ghobadian et. al., Public-private partnerships: policy and experience. Palgrave Macmillan, Houndmills, England; New York, N.Y, 24-36.

Das, Sushi. & Costa, G (2000) 'Huge Upgrade For Spencer Street Station' The Age, 29 February 2000.

Demirag, I. Dubnick, M. Iqbal Khadaroo, M. (2004) A Framework for Examining Accountability and Value for Money in the UK's Private Finance initiative, The Journal of Corporate Citizenship, 15, 63.

Dixon, T., Pottinger G and Jordan, A. (2005) Lessons from the private finance initiative in the UK Benefits, problems and critical success factors. Journal of Property Investment & Finance, 23/5, 412-423.

Duffield, C. F. (2001). An evaluation framework for privately funded infrastructure projects in Australia. PhD thesis Department of Civil and Environmental Engineering. Melbourne, Australia, The University of Melbourne.

Duffield, C. F. and Clifton C. J. (2007) Combining finance and design innovation to develop winning proposals. Unpublished paper.

English, Linda and James Guthrie (2003), 'Driving privately financed projects in Australia: what makes them tick?' Accounting, Auditing and Accountability Journal, 16/3, pp.493-511.

English, Linda, (2005), "Using public-private partnerships to deliver social infrastructure: the Australian experience", pp.290-304 in Graeme Hodge and Carsten Greve (Eds.) The Challenge of Public-Private Partnerships: Learning from International Experience, Edward Elgar, Cheltenham, UK, and Northampton, MA, USA.

Fitzgerald, P. (2004). Review of Partnerships Victoria provided infrastructure: Final report to the Treasurer. Growth Solutions Group, Melbourne.

Grimsey, D., Lewis, M. K. The governance of contractual relationships in public-private partnerships. The Journal of Corporate Citizenship Autumn 2004 15, p. 91

Gruneberg, S., Hughes W., and Ancell D. (2007) Risk under performance-based contracting in the UK construction sector. Construction Management and Economics 25, 691–699

Hodge, Graeme, (2005), "Public-private partnerships: the Australasian experience with physical infrastructure", pp.305-331 in Graeme Hodge and Carsten Greve (Eds.) The Challenge of Public-Private Partnerships: Learning from International Experience, Edward Elgar, Cheltenham, UK, and Northampton, MA, USA.

Hodge, Graeme (2007), "Public-Private Partnerships: An International Performance Review", Public Administration Review, Vol. 67, No. 3, May/June, pp.545-558.

Gann, D. and Salter, A., (2000) Innovation in project-based, service enhanced firms; the construction of complex products and systems. Research Policy 29 pp. 955-972.

Gann, D, Brady T, Davies A, (2005) Can integrated solutions business models work in construction. Building Research and Information, 33/6, pp. 571-579.

Grimsey, D.and Lewis M. K., (2002). Evaluating the risks of public private partnerships for infrastructure projects. International Journal of Project Management 20/2. pp. 107-118.

Grimsey, D., Lewis, M. K. The governance of contractual relationships in public-private partnerships. The Journal of Corporate Citizenship Autumn 2004 i15, p91

Ho, Ping S. Model for Financial Renegotiation in Public-Private Partnership Projects and Its Policy Implications: Game Theoretic View. Journal Of Construction Engineering and Management, July 2006, 679

Jaafari, A. (2001) Management of risks, uncertainties and opportunities on projects: time for a fundamental shift. International Journal of Project Management 19, pp. 89-101.

Kieran, S. (2007) Research in Design. Journal of Architectural Education, 61/1, pp. 27-31.

Klaasen, Ina T. (2007) A scientific approach to urban and regional design: research by design. Journal of Design Research, 5/4 pp. 1569-1551.

KPMG, (2007) Building for Prosperity: Exploring the prospects for Public Private Partnerships in the Asia Pacific.

Leiringer, R. (2006) Technological Innovation in PPPs: incentives, opportunities and actions. Construction Management and Economics 24, 301-308.

Majamaa, W. (2005) Evaluation of proposals for PPP projects from the perspective of a group of rational consumers. 11th Joint CIB International Symposium June 13-16, 2005 Helsinki.

McGeorge, D., Marcus J., Cadman K., and Chen S., E. (2007), Implications for Design and Build contractors bidding in Public-Private-Partnership Consortiums: an Australian perspective, Working Paper, School of Architecture and Built Environment, Faculty of Engineering and Built Environment, The University of Newcastle.

Masterman, J. W. E. (2002) Introduction to building procurement systems. Spon Press, London ; New York 2nd.ed.

Pitt, M., Collins N., and Walls, W. The private finance initiative and value for money. Journal of Property Investment & Finance Vol. 24 No. 4, 2006 pp. 363-373

New South Wales Treasury (2001, 2006), Working with Government: Guidelines for Privately Financed Projects, (originally 2001) revised December 2006.

Millar, Royce and Moynihan, Stephen, (2006) “Major projects fail to harness precious resource.” The Age, September 30, 2006

Quiggin, J., (2007), “Beware the PPP pitfalls”, Australian Financial Review, p.70.

Raisbeck, P. (2006), PPP financing, architectural design, and risk mitigation in Melbourne’s Southern Cross Station project. Joint International Symposium of CIB Working Commissions W55/W65/W86 Construction in the XXI century: Local and global challenges, Rome 18-20 October 2006.

Partnerships Victoria (July, 2003), Use of Discount Rates in the Partnership Victoria Process, Technical Note.

Satyanarayana N. Kalidindi and Thomas A V. (2003) Private sector participation road projects in India: assessment and allocation of critical risks eds. Akintola Akintoye, Matthias Beck and Cliff Hardcastle in Public-private partnerships: managing risks and opportunities Malden, MA : Blackwell Science.

Victorian Treasury (June 2000) Partnerships Victoria.

Zhang, X (2005) Criteria for Selecting the Private-sector Partner in Public-Private Partnerships Journal of Construction Engineering and Management, 631.

PARTNER SELECTION CRITERIA FOR PARTICIPATION-BASED COOPERATION

Vrieling, Leone
Eindhoven University of Technology

Favié, Ruben
Eindhoven University of Technology
r.favie@bwk.tue.nl

Kranendonk, Piet
AT Osborne
pkr@atosborne.nl

Maas, Ger
Eindhoven University of Technology
g.j.maas@bwk.tue.nl

The Dutch construction industry is under pressure. In order to answer the expectations set by society, innovations are necessary. The industry stands in need of clients and contractors who find common objectives and work in participation-based cooperation (such as partnering or alliance) in order to stimulate innovation development. On paper, public clients strive for innovative cooperation with their contractors. Yet, many clients and contractors still try to realise their conflicting objectives, which leads to difficulties in the relationship and counteract innovation. Underlying this lack of support for participation-based cooperation is the inadequate knowledge on the criteria public clients must and may set in order to select a suitable partner. This study describes and analyses the selection of a partner for participation-based cooperation by a public client. Criteria for partner selection were assessed with a literature review in relation to participation-based cooperation. A hierarchical case study on five project alliances verified these criteria. The study shows that public clients have to reconsider the specification phase in the tendering process. The research indicates that certain additional criteria must be set if the selection of a partner is to succeed. In particular, criteria concerning the potential employees in the participation-based relationship are necessary. It is recognized by the Regieraad Bouw that public clients need wise applications in order to make clear decisions in the tendering process. The result of this study is a practical set of criteria, which can simplify the selection of a suitable partner and which can contribute to the support of participation-based cooperation in the Dutch construction industry.

KEYWORDS: cooperation, tender, criteria, public client.

1. INTRODUCTION

Clients in the Dutch construction industry hardly ever possess the skills and knowledge needed to realize a project single-handed. They are ignorant of the opportunities and risks involving construction projects and therefore unable to cope with this. In order to complement their capability deficiencies, they search for a partner. Every relationship between a client and a contractor is based on some form of cooperation. However, various levels of cooperation can be distinguished based on the alignment of objectives [1]. Thompson and Sanders also argue that this alignment of objectives is proportionate to the surplus value of the project. According to Thompson and Sanders, cooperation can be divided in four stages, represents new levels of alignment (see figure 1).

In the majority of relationships in the construction industry, legal protection of one's own interests and objectives is the main priority. This competitive mind-set leads to conflicts, deceleration and increasing costs. Competitive based cooperation is the underlying condition of the issues in the current construction industry [2].

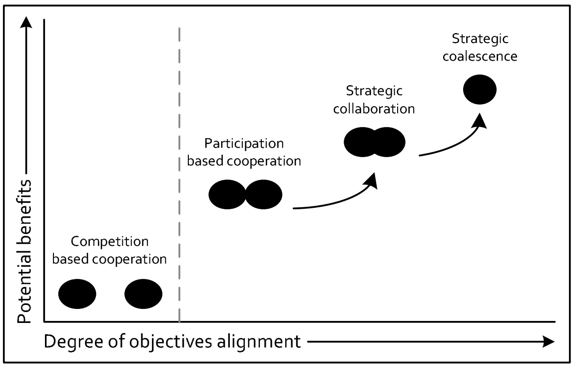


Figure 1 Levels of cooperation (based on Thomson and Sanders, 1998)

As shown in figure 1, on the opposite of competition-based cooperation stands participation-based cooperation (such as partnering or alliance). Participation-based cooperation means a relationship between an active attending client and contractor who share the work and decision making for a project in which compromises lead to common objectives and in addition create surplus value. The common objectives lead to advantages in the relationship, resulting in project benefits such as time and cost reduction and increase of quality.

The government forms one of the largest professional clients in the Dutch construction industry. Private parties are their partners in mostly competitive based relationships. Innovations are necessary to anticipate the increasing pressure set by society. The industry stands in need of clients and contractors who find joint interests and work in participation-based cooperation in order to stimulate innovation development. The Dutch government supports this proposal. On paper, public clients strive for innovative cooperation with their contractors. Yet, most current projects are executed in relationships based on competition. Therefore, a shift from competition-based to participation-based cooperation is necessary. Both strategic collaboration and coalescence, which are based on a high level of common objectives, are currently one bridge too far.

According to Woerkum [2] successful participation-based cooperation requires a suitable project, involvement of suitable organizations and a well organized relationship. Much has been written on the assessment of projects and the composition of the relationships. The lack of support for participation-based cooperation by public clients lies therefore in the assessment of organizations. Many researchers [3 – 6] argue that participation-based cooperation will not succeed without trust between the partners. Unfortunately, public clients can and may not use this as a criterion during the tendering process. It is unclear to public clients which criteria they must and may set in order to select a suitable partner. Therefore, according to the Regieraad Bouw [7] and Blokker [8], public clients experience difficulties in the partner selection process. The following example endorses this finding.

Example: Diversion Aalsmeer – Uithoorn, N201. On the project N201 the public client, Province Noord-Holland, had the intention to form a participation-based cooperation (a project alliance). Preceding the tendering process, questions concerning the partner selection process, such as: how do we select the partner? and how do we make the decision transparent and objective?, arose. As a result of absent answers, Province Noord-Holland decided to put out a contract for a generally used competitive based cooperation hoping to switch to participation after tendering. [9]

As stated before, many researchers identify critical success factors of participation-based cooperation. In contrast with the success factors, little researchers provide information on criteria for such cooperation. Most of the provided criteria are focussed on the suitability of the project in the field of criteria to assess the organizations involved, studies get stuck in vague descriptions. Woerkum [2] for example names corporate culture and trust as the only factors that influence the suitability of an organization for participation-based cooperation. Koolwijk en Geraedts [2] identify three factors: affinity with the level of cooperation, accepting the approach and procedures and the innovative attitude of the partner. All factors are difficult to interpret for the public client.

The main question that arises is as follows: which criteria should be used in order to select a suitable partner for participation-based cooperation? This study expands on the current literature on the subject by converting the critical success factors into clear criteria. Next to that, criteria are formulated which prevent the relational problems between client and contractor in the current Dutch construction industry. This set of criteria is tested on five Dutch, experimental cases of participation-based cooperation. Finally, the criteria are shown in a practical model, which can simplify the selection of a suitable partner and which can contribute to the practice of participation-based cooperation.

2. METHODOLOGY

2.1 Research questions

In order to come to a recommendation on the improvement of the partner selection process for participation-based cooperation, by formulating the necessary criteria to select a suitable partner, three research questions has to be answered.

The first question is as follows: which requirements are demanded off the partners in the construction industry, forming a, participation-based, relationship? An extensive review of the literature dealing with participation-based cooperation is necessary. This type of desk research was considered appropriate for the investigation as quantitative studies have been executed on both the relational problems between client and contractor in the current Dutch construction industry as well as the critical success factors of participation-based cooperation. Focus of the study lies in the terms cooperation, inter-organizational relationships, (project) partnering ands (project) alliances. From this, requirements on the involved organizations are identified.

The next research question is put as follows: in the current Dutch construction industry, which elements of cooperation are paid attention to in participation-based cooperation projects? An in-depth study on the experimental, participation-based relationships between client and contractor in the Dutch construction industry was needed. The small number of samples and the in-depth in stead of wide focus leads to the case study as fitting research strategy. Specifically a compared case study, which is executed hierarchically.

The case study design was based on the theory of Yin [10]. The study included the analysis of criteria set in five project alliances, the experimental participation-based relationships in the Dutch construction industry. Yin [10], Verschuren and Doorewaard [11] argue that in order to increase the reliability and validity of the results, data of different sources had to be used, which is called converging evidence (figure 2). This case study research contains interviews with involved people (clients and/or consultants), set selection and tendering protocols and results from evaluations. Observations have not been made the analysis of actual behaviour is not part of the aim.

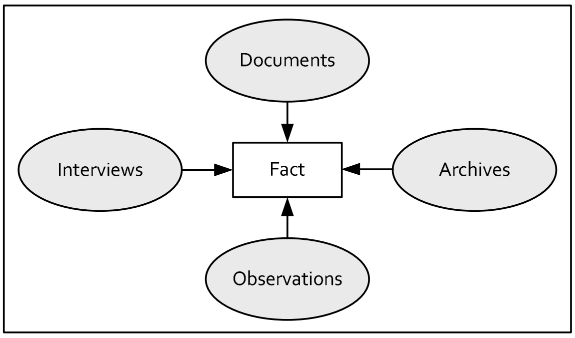


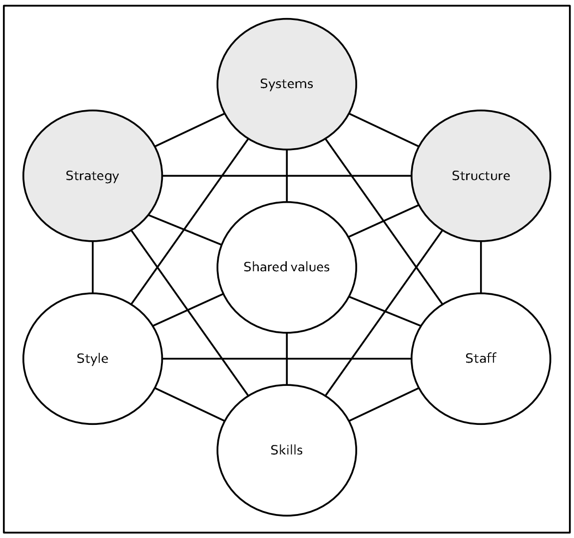
Figure 2 Converging evidence (Yin [10])

The last question is as follows: ideally, which criteria should a public client set in order to select a suitable partner for participation-based cooperation? The aim of this question is to formulate the necessary criteria by processing the results from the literature study and the case study. This set of criteria that resulted from the literature study is tested on the five Dutch, experimental cases of participation-based cooperation. Finally, the criteria are shown in a practical model, which can simplify the selection of a suitable partner and which can contribute to the practice of participation-based cooperation.

2.2 7S-framework

The necessary shift from competition-based to participation-based cooperation requires changes in the working-method of an organization. Several change management models exist, providing a scope for the analysis and improvement of the organization and its performance with regard to both internal and external factors.

This study focuses on the suitability of an organization for participation-based cooperation. The management model needed to provide a fitting scope for the research integrally assesses organizations and focuses only at the internal organization. The 7S-framework provides the scope for this study. Other management models pay considerable attention to external factors such as competitive organizations, customers and society. However, this research focuses on the internal suitability for a level of cooperation.



Figuur 3 7S-framework [12], [13]

The 7S-framework describes seven aspects of an organization (see figure 3):

- Strategy, the aim set by the management and the way to achieve this.
- Systems, the formal en informal procedures, regulations and agreements.
- Structure, the design of the organization, in the area of hierarchy, coordination, etc.
- Staff, the characteristics of the employees.
- Skills, the characteristic competences.
- Style, the behaviour of management and employees.
- Shared values, the social values within the organization.

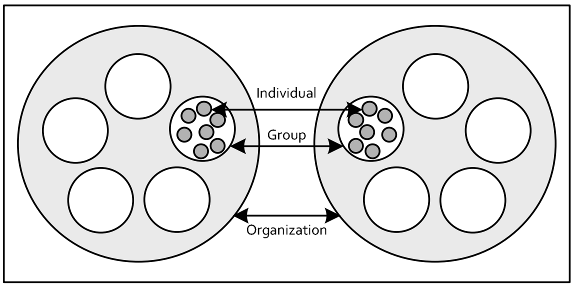


Figure 4 Levels of scale within organization [14]

The behaviour of employees is influenced by factors from three different levels of scale: the level of the organization as a whole, of the group and of the individual [14] (figure 4). The success of participation-based cooperation depends on the behaviour of the people involved. This behaviour is influenced by the three organizational scales.

The organizational aspects are important on all scales. Decisions taken by the management of the organization as a whole influence the work floor and lead by the key figures. Taken participation-based cooperation in account, the organizational aspects are analysed on the scale they influence directly (see table 1).

Table 1 Organizational aspect by scale

Scale	**Organizational aspect**
Organization	Strategy
	Structure
Group	Skills
	Shared values
	Style
	Systems
Individual	Staff

3. RESULTS

3.1 Criteria literature study

The literature study focussed on the relational problems between client and contractor in the current Dutch construction industry and the critical success factors of participation-based cooperation.

Tables 2 - 5 present the results of the analysis. The relational problems, stated by the client as well as the contractor, are shown in table 2. Part of these problems is overcome by the common objectives based on compromises which are part of participation-based cooperation. In order to prevent the other relational problems from happening, the organization should possess a number of specific qualities, as stated in the second column. The third column shows the organizational aspect from the 7S-framework the qualities fall under. This in order to have a fixed classification during the entire research project. Which will be elaborated on later.

Table 3 shows a comparison between the success factors of five different quantitative studies. Ten success factors of participation-based cooperation can be indicated. These are critical for the development of the intended participation-based relationship. These success factors are vague descriptions of organizational elements, and difficult to interpret for the public client.

Table 4 identifies the qualities required for the development of the identified success factors. All the required qualities to prevent the relational problems and to develop the success factors, should be taken into account assessing organizations on their suitability for participation-based cooperation. Table 5 gives an overview of these qualities, classified into the organizational aspects by scale.

Table 2 Relational problems Dutch construction industry [15]

Relational problem	**Quality that overcomes the relational problem**	**7S-aspect**
Differences in interpretation	Clear and equal communication	Systems
Indolence	Integrity	Style
Circumstances beyond control	*Not attribute to someone*	-
Miscommunication	Effective communication	Systems
Alterations in personnel	Stable organization and project team	Structure
Non-performance	*Overcome by common objective*	-
Poor adjustment	Cooperation skills	Staff
Missing chemistry	Capable key figures	Staff
	Trust	Staff
Deliberate deception	*Overcome by common objective*	-
Abuse	*Overcome by common objective*	-

Table 3 Comparison critical success factors quantitative studies

Factors	**Sarkar [16]**	**Chan [17]**	**Cheung [18]**	**Chan [19]**	**Beach [20][1]**	**Frequency**	
Mutual trust	1		1	1	6	9	Success factor
Common objectives	1	1		1	6	9	Success factor
Equality	1	1		1	6	9	Success factor
Management support		1			7	8	Success factor
Improve performance	1			1	5	7	Success factor
Commitment	1	1	1	1	2	6	Success factor
Effective communication			1		4	5	Success factor
Conflict resolution	1		1	1	3	6	Success factor
Financial objective	1		1	1	2	5	Success factor
Interdependency	1	1	1	1	0	4	Success factor
Compatibility	1				0	1	Low frequency
Focus on quality			1		0	1	Low frequency
Experience		1			0	1	Low frequency
General attitude		1			0	1	Low frequency

[1] Beach analyzed 8 different sources.

Table 4 Critical success factors participation-based cooperation

Success factor	**Quality underlying success factor**	**7S-aspect**
Mutual trust	Integrity	Style
	Capable people involved	Staff
	Positive shared experience	Staff
	Cooperation skills	Staff
	Positive attitude conflict resolution	Style
	Effective communication	Systems
Common objectives	*Overcome by common objective*	-
Equality	Proportionate effort and reward	Systems
Management support	Cooperation part of strategy	Strategy
Improve performance	Awareness of aims organizations	Shared values
Commitment	Complementary resources	Skills
	Common objective	-
Effective communication	Direct communication between people	Systems
	Communication on different levels	Systems
Conflict resolution	Positive attitude conflict resolution	Style
Financial objective	*Overcome by common objective*	-
Interdependency	Complementary resources	Skills

Table 5 Overview on literature of required qualities in order for participation-based cooperation to succeed

Scale	7s-aspect	Quality	Interest
Organization	Strategy	Cooperation part of strategy	Management support
	Structure	Stable compilation personnel	No alterations personnel
Group	Skills	Concerned employees complementary knowledge	Interdependency, commitment, common objective
		Concerned employees complementary skills	
		Concerned employees complementary management attitude	
	Shared values	Concerned employees aware of the partners aims	Improve performance
	Style	Concerned employees act integer	No indolence, conflict resolution, trust
		Concerned employees positive attitude conflict resolution	
	Systems	Direct communication between people	Effective communication, no differences in interpretation, trust
		Communication on different levels	
		Proportionate effort and reward	Equality
Individual	Staff	Direct communication between people	Capability key figures, trust
		Communication on different levels	Trust
		Key figures cooperation skills	Adjustment, trust

3.2 Criteria case study

The case study successively analyzed five project alliances: the Betuweroute section Sliedrecht – Gorinchem (Waardse Alliantie), the A2 junction Hooggelegen, the diversion of the N201 at section Aalsmeer – Uithoorn, the redevelopment of the Oostergasfabriek and additional developments on the campus of Maastricht University. The case study research concentrated on three topics: criteria to assess the suitability of the organization as a whole (prequalification), criteria to assess the suitability of the group and individuals (tendering) and criteria considered after evaluating the projects. Table 6 shows an overview of required qualities by scale according to the case study in order for this participation-based cooperation to succeed.

4. DISCUSSION

This study focuses on the Dutch construction industry. The literature about the success factors of participation-based cooperation is mainly originating from the United Stated, the United Kingdom and Australia. The results from the research on competition-based cooperation in these countries are more inferior than the Dutch construction industry. Therefore, some factors concerning the relationship between client and contractor mentioned in these sources, are possibly less important in Dutch participation-based relationships than in the publishing countries.

Also in contrast to the counties mentioned before is the number of participation-based relationships. In the Dutch industry, only a few, experimental projects can be found. Because of the experimental nature of the projects, these projects have different characteristics. Because of the unequal preconditions, these new projects are not a full representative of participation-based cooperation between public client and private contractor. None of the less, with the results of this study, mentioned in section 3 a well found as, answer on the main question of this study can be obtained. In order to form an answer on the question ´which criteria should be set in order to select a suitable partner for participation-based cooperation?´ the necessary qualities of an organization following the literature study were tested on those following the five Dutch, experimental cases. Table 7 shows the comparison between the literature study and the case study.

4.1 Level of organization as a whole

Strategy

Participation-based cooperation is a structural instrument in gaining objectives. Cooperation is part of the strategy. This is set by the management of the organization. In order to obtain their support for the relationship, the intended cooperation should be part of the organizational strategy. Both the literature and the cases name this quality.

Tabel 6 Overview on case study of required qualities in order for participation-based cooperation to succeed

Scale	**7s-aspect**	**Quality**	**Interest**	**Freq.**
Organization	Strategy	Management support	Positive influence negotiation	5
Group	Skills	Insight in risks participation-based relationship	Capability persons concerned	1
		Concerned people equal knowledge on cost management	Insight in financial advantage	1
	Shared values	Concerned employees aware of values parties	Best for project/value for money	2
	Style	Mutual respect between concerned people	Integrity	1
		Concerned employees share responsibilities	Improve performance	1
Individual	Staff	Key figures positive attitude cooperation	Commitment	3
		Key figures have competences and experience	Capability key figures	2
		Key figures have confidence in relationship	Commitment	1
		Former positive experience between key figures	Trust	1
		Key figures experience with type of cooperation	Support type of cooperation	1
		Key figures cooperation skills	Adjustment, trust	1

Table 7 Comparison qualities literature study and case study

Scale	7s-aspect	Quality literature study	Quality case study
Organization	Strategy	Cooperation part of strategy	Management support
	Structure	Stable compilation personnel	-
Group	Skills	Concerned employees complementary: Knowledge Skills Management attitude	Concerned people : Equal knowledge on cost management Insight in risks participation-based relationship
	Shared values	Concerned employees aware partners aims	Concerned employees aware of values parties
	Style	Concerned employees act integer	Mutual respect between concerned people
		Concerned employees positive attitude conflict resolution	Concerned employees share responsibilities
	Systems	Direct communication between people	-
		Communication on different levels	-
		Proportionate effort and reward	-
Individual	Staff	Direct communication between people	Key figures have competences and experience
		Communication on different levels	Former positive experience between key figures
			Key figures experience with type of cooperation
		Key figures cooperation skills	Key figures cooperation skills
		-	Key figures positive attitude cooperation
		-	Key figures have confidence in relationship

Structure

In literature, clients as well as contractors indicate alterations in personnel as a relational problem [15]. In order to comply with this quality, organizations need to be able to put in fixed personnel. Although in the cases alterations in personnel is not mentioned, it will be taken into the set necessary criteria. Deceleration of the process is often due to an instable organisation, this quality is important in participation-based cooperation.

4.2 Level of group

Skills

In order to develop participation-based relationship, the involved group of employees from the client and contractor should possess complementary competences. This creates interdependency between the parties, which leads to a concerned attitude. Logically, the cases describe more detailed qualities then the literature, as every project has specific needs.

Shared values

In current, competition-based relationships, the involved group of employees lack awareness of the partners aims, any form of dialogue is absent. This understanding of each others interests is part of the necessary shift from competition-based to participation-based cooperation and to improve the achievements. Both the literature and the cases name this quality.

Style

To prevent relational problems and develop success factors such as trust and conflict resolution the client as well as the contractor should act integer and adopt a positive attitude in conflict situations. Both the literature and the cases name this quality.

Systems

In project teams, communication and reward systems focussed on the intended cooperation are formulated. Literature show that is important for the group of employees to have experience with different type of systems. Effective communication and a proportionate effort and reward have a priority. In the cases, effective communication is mentioned as a requirement for the key figure, although experience show that it is important for all persons involved. It stimulates the cooperation. Reward systems are not mentioned in the cases. In project alliances, reward systems are set in the contract. In these cases, extra criteria in this area are not necessary. Because not all participation-based relationships have these systems in the contract, the reward system is put into the set criteria.

4.3 Level of individual

Staff

People make or break cooperation. In order to develop the necessary success factors, the key figures in a participation-based relationship have to be capable. Next to that a shared positive experience stimulates the increase of trust. But most important, the key figures should have cooperation capabilities.

Table 8 summarizes the crucial set criteria in order to select a suitable partner for participation-based cooperation. In spite of the improvement of the partner selection process, this is no guarantee for a successful participation-based relationship. The chemistry between the persons involved still plays a major role in the success of cooperation. This is an inexplicable quality, that as such can not form a criterion. The model forms a scope, set by the public client, in order to influence the selection of people involved but does not assure success.

5. CONCLUSIONS

In current, competitive based relationships, cooperation is considered an incidental solution; participation takes place only when necessary. In participation-based relationships, cooperation is a strategic choice to increase project success. In order to succeed, suitable partners should be concerned.

In order to select a suitable partner, public clients set partner selection criteria. The criteria generally set by competitive based cooperation are focussed on the organization as a whole. This study indicates that certain additional criteria must be set if the selection of a partner for participation-based cooperation is to succeed. In particular criteria focussed on the people concerning the participation-based cooperation are necessary. This study expands on the current literature on the subject by providing clear criteria for Dutch public clients in order to select a suitable partner (table 8) and converting this into a practical model. To obtain this, current literature on cooperation is tested on experimental Dutch cases. Only a few Dutch participation-based cases are finished. The relationship between the used criteria and points of interest and the relationship between the client and the contractor during the project is an interesting continuation of this study. With this, the actual connection between this set criteria and cooperative success can be demonstrated.

Table 8 Set partner selection criteria participation-based cooperation

Scale	**7s-aspect**	**Necessary quality**
Organization	Strategy	Cooperation part of strategy organization
	Structure	Stable compilation personnel in organization
Group	Skills	Concerned employees complementary knowledge
		Concerned employees complementary skills
		Concerned employees complementary management attitude
		Concerned employees insight in risks participation-based relationship
	Shared values	Concerned employees aware of values of both parties
	Style	Concerned employees act integer
		Concerned employees positive attitude conflict resolution
	Systems	Direct communication between people
		Communication on different levels
		Proportionate effort and reward
Individual	Staff	Key figures have competences and experience
		Former positive experience between key figures
		Key figures experience with type of cooperation
		Key figures cooperation skills
		Key figures positive attitude cooperation

REFERENCES

[1] Thompson, P. J. en Sanders, R. (1998). Partnering Continuum. *Journal of Management in Engineering*. 14 (5) ,pp. 72 – 78.

[2] Koolwijk, J. S. J. en Geraedts, R. P. (2006) *Projectalliantie: procesinnovatie bij complexe bouwprojecten.* Delft VSSD

[3] Barrett, P. (2000). Systems and relationships for construction quality. International *Journal of Quality & Reliability Management.* 17 (4/5), pp 377 – 392.

[4] Black, C., Akintoye, A. en Fitzgerald, E. (2000). An analysis of success factors and benefits of partnering in construction. International *Journal of Project Management.* 18 (1), pp. 423 – 434.

[5] Chan, A. P. C., et al. (2004). Exploring critical success factors for partnering in construction projects. *Journal of Construction Engineering and Management,* 130 (2), pp. 188 – 198.

[6] Smid, G., Bijlsma-Frankema, K. en Bernaert, G. (2007). Innovaties en vertrouwen in netwerken: een verdiepende casestudy. *Tijdschrift voor Management en Organisatie.* mei/augustus (3/4).

[7] Regieraad Bouw (2005). *Samenvatting van PPS werkdiner 23 november 2005* [online versie]. Gouda: Regieraad Bouw.
Available: www.regieraadbouw.nl [19 September 2007]

[8] Blokker, H. (2006). *Kansen voor innovatie binnen de bouwsector, verslag van de 'Toekomstwijzer Bouw 2006'* [online versie]. Syntens: Nieuwegein.
Available: www.onri.nl [10 September 2007]

[9] Staveren, J. van. (2006). Alliantiecontract bij omlegging N201 Omlegging Aalsmeer – Uithoorn. *Cobouw*. 31 mei 2006.

[10] Yin, R. K. (2003). *Case study research: design and methods*. Londen: Sage.

[11] Verschuren, P. en Doorewaard, H. (2000). *Het ontwerpen van een onderzoek*. Utrecht: Lemma

[12] Pascale, R. T. en Athos, A. G. (1982). *De filosofie van het Japanse management: een bewezen methode voor een succesvol beleid voor het gehele bedrijfsleven*. Amsterdam: Omega Boek.

[13] Peters, T. J. en Waterman Jr. R. H. (1984) *Excellente ondernemingen: kenmerken van succesvol managemen*t. Utrecht: Veen

[14] Weber, A. A. (2002). *Gedrag, de basis van management: individu, groep en organisatie*. Arnhem: Uitgeverij MBES

[15] Laan, A. T. en Sijpersma, R. (2006). *Bouwen op vertrouwen*. Amsterdam: Economisch Instituut voor de Bouwnijverheid.

[16] Sarkar, M. M, Aulakh, P. S. en Cavusgil, A. T. (1998). The strategic role of relational bonding in interorganizational collaborations: an empirical study of the global Construction industry. *Journal of International Management.* 4 (2), pp. 85 – 107.

[17] Chan, A. P. C., Chan, D. W. M. en Ho, K. S. K. (2003). Partnering in Construction: Critical Study of Problems for Implementation. *Journal of Management in Engineering.* 19 (3), pp. 126 – 135.

[18] Cheung, S., et al. (2003). Behavioural aspects in Construction partnering. International *Journal of Project Management.* 21 (5), pp. 333 – 343.

[19] Chan, A. P. C., et al. (2004). Exploring critical success factors for partnering in construction projects. Journal of Construction Engineering and Management, 130 (2), pp. 188 – 198.

[20] Beach, R., Webster, M. en Campbell, K. M.(2005). An evaluation of partnership development in the construction industry. International *Journal of Project Management.* 25 (8), pp. 611 – 62

CONSTRUCTION SKILLS DEVELOPMENT IN THE UK: TRANSITIONING BETWEEN THE FORMAL AND INFORMAL

Paul W Chan
Northumbria University, Newcastle upon Tyne, UK
paul.chan@unn.ac.uk

Robert C Moehler
Northumbria University, Newcastle upon Tyne, UK
robert.moehler@unn.ac.uk

Research reported here is part of a wider study that seeks to examine the practices involved in encouraging and enabling employers to engage with the skills development agenda. A series of exploratory interviews and ethnographic observations reveal potential disconnections between skills policies at the governmental level and what actually happens in employer practices regarding skills development. On the one hand, the formal education and training system focuses on such targets as the attainment of narrowly-defined occupational standards, levels of competence, and quantitative performance measures like completion rates. On the other hand, the socialised concept of skills development takes place informally at the workplace through on-the-job training and mentoring relationships between senior and junior employees. Both the formal and informal systems appear to co-exist alongside each other, although tensions are mounting in terms of confidence that employers and the wider industry place on the efficacy of the formal system.

Keywords: informality, skills development practices, skills policy, training and education.

INTRODUCTION

The UK construction industry faces an enduring problem of skills shortages. ConstructionSkills, one of the Sector Skills Council for Construction that has a remit of addressing skills needs for the UK construction industry, recently forecasted an annual average requirement of around 88,000 new entrants a year to meet expected workloads from 2008 – 2012 (ConstructionSkills, 2008). At the same time, first year entrants into vocational training courses in 2006 – 2007 stands at around 40,000 (Department of Business Enterprise and Regulatory Reform, BERR, 2007). Thus, this suggests that supply of skilled labour into the industry is inadequate to meet current and future demand. Furthermore, the industry has a reputation of a lacklustre approach towards investment in skills training and development. Using the National Vocational Qualifications framework (Grugulis, 2003b) as a barometer for instance, only a third of the British construction workforce is trained to a rudimentary Level 2 or higher, which is unsurprising given the median annual training days per full-time equivalent employee of merely 1 day (BERR, 2007).

The extant literature on skills has often been critical about employers' apparent unwillingness to engage in the skills development agenda. To redress this, the high-profile Leitch (2006) review has recently called for a shift towards demand-led skills provision insisting on greater involvement of employers in raising skills levels. Notwithstanding the laudable nature of such policies, little is currently known as to how employers can usefully achieve this (Chan and Moehler, 2007). As this paper unfolds, it is argued that the underlying problem is not about how employers can be engaged in skills development, but why they are currently not engaging in the first place. We contend that the institutions responsible for steering skills development through skills policies and provision should bear part of the blame. These institutions representing the formal system of skills development remain somewhat disconnected from what is essentially needed by industry (employers and employees). Consequently, employers that try to cope with the skills shortages resort to such informal practices as on-the-job training and mentoring. It is suggested that because of the lack of clarity of, and confidence on, the formal system of skills development, employers are reluctant to engage in the formal discourse of the institutions tasked to deliver on skills. To help support this observation, we first review theoretical perspectives of skills and examine the role of employers and institutions in skills development. Thereafter, we discuss the context of ongoing research that investigates skills development practices in the North East of England and present some preliminary findings from its exploratory phase. We conclude by calling for more research into a deeper understanding of dynamic relationship between formal and informal systems of skills development in resolving the UK construction skills shortages.

THEORETICAL PERSPECTIVES OF SKILLS

The economic benefits of skills are well-acknowledged. Becker (1964, 1993) who popularised the concept of human capital in recent times maintained that there is overwhelming evidence that connects human capital investment through training and education with rising personal income. However, as Grugulis (2003a) points out, “the longstanding consensus that skills are ‘good things’ […] and the evidence that they can advantage every participant in the employment relationship have not been matched by a widespread adoption of high skills routes to competitiveness. Despite the existence of exemplary practice, extensive exhortations and official interventions, most jobs in Britain demand few skills. (p. 7)”. Even workers with degree qualifications are not guaranteed that their higher-level skills would be put to good use at the workplace with the growth of what Blenkinsopp and Scurry (2007) term as GRINGOs (graduates in non-graduate occupations).

If skills are a ‘good thing’, why is the rhetoric detached from the reality of training and education investment? Construction researchers have offered a number of explanations for this phenomenon. The central argument tends to revolve around the nature of the industry. The construction industry is often used as a barometer of economic performance, and therefore exposed to the vulnerabilities of economic cycles of boom and bust. Given such uncertainties, firms are less likely to engage in skills training and development, which requires a longer-term view (see MacKenzie *et al.*, 2000). Furthermore, the industry epitomises the pinnacle of flexible organisation and its deeply entrenched reliance on self-employment (Harvey, 2001) and contingent labour (Forde and MacKenzie, 2007) reduces the industry’s propensity to train. Together with the difficulty in attracting new entrants into the industry resulting from its poor public image, the industry inevitably reports a low average training investment of around one-person-day per year (BERR, 2007).

Then there is the added complication of the (ever expanding) definition of skills. Drawing on Cockburn’s (1983) writings, Grugulis (2003a, 2004) proffered three perspectives of skill: “there is the skill that resides in the man himself, accumulated over time, each new experience adding something to a total ability. There is the skill demanded by the job, which may or may not match the skill in the worker. And there is the political definition of skill: that which a group of workers or a trade union can successfully defend against the challenge of employers and of other groups of workers (Cockburn, 1983: 113; cf. Grugulis, 2003a: 4)". Accordingly, the first relates to the conventional economic perspective of human capital, and the latter two would be governed by more sociological lens (Grugulis, 2004). These varied perspectives of skills suggest that skills can mean different things to different people, as Clarke (1992) observed, "[…] whilst training creates skills, these skills have different values for the worker who owns, sells, employs and attempts to conserve them than for the builder *(employer)* who buys and consumes them (p. 6)".

Following on from this, there is the question as to who should be responsible for paying skills development. Becker's (1964) seminal paper led to a huge body of work contributing to this debate; consequently resulting in the distinction between firm-specific skills and skills that are completely general (Bloom *et al.*, 2004). It follows logically therefore that the investment of firm-specific skills should lie within the remit of firms and that the state through its education system should provide for the general skills since an increase in worker productivity should in theory benefit the economy as a whole. However, commentators have argued that this dichotomy is far too simplistic, hence the answer as to who should pay for what skills less straightforward.

Distinctions between firm-specific and general skills can also be less helpful in reality. Groen (2006) observed that as a market expands and becomes more competitive, there is a corresponding shift of employer emphasis towards generic skills; thereby reinforcing the idea that employers are inclined to abdicate from the responsibility of investing in skills development (Dainty *et al.*, 2005). Thus, the shifting employer preference towards general skills lends further support to the de-skilling (Braverman, 1974) of firm-specific skills. Grugulis *et al.* (2004), for instance, argued that the growing desire of employers to focus on generic skills offers on the one hand a false sense of upskilling among the workers and on the other virtually no benefit of wage premium. Becker's (1964) belief that investment in human capital would reap benefits of greater productive capacity and wage growth would stand to be tested. In fact, recent evidence in the UK construction industry showed little correlation between skills levels and wage rates (Clarke and Herrmann, 2004). Moreover, the economic perspective of human capital emphasises human resources as an economic factor of production and potentially plays down the human benefits that can be accrued through development, reiterating the distinction between hard and soft human resources management (Druker *et al.*, 1996).

Grugulis (2004) later added that the concentration on generic skills meant moving "the focus of attention away from the workplace and those who manage it, onto schools, colleges and universities, all of which have failed, it is alleged, to have imbued their students with the appropriate skills (p. 12)", thus 'outsourcing' the responsibility of failing to achieve high-commitment, high performance knowledge economy away from the realm of management. Indeed, Beckingsdale and Dulaimi (1997) observed that skills training and development is rarely seen as a core business activity among construction companies. Researchers like Bell *et al.* (2002) also support this observation as they note that companies tend to approach such initiatives as Investors in People as a badge-collecting public relations exercise.

Role of employers and institutions in skills development: two sides of the same coin

Much of the literature on skills has painted a very bleak picture regarding the involvement of employers in skills development. Contemporarily, however, sympathetic commentators have suggested that construction companies have to juggle between the short-term need for profitability and the long-term employee interests of skills development. Raidén and Dainty (2006) used the phrase 'chaordic organisation' to describe how construction companies deal constantly with both the chaotic business environment and the orderly, strategic planning of skills. Raidén and Dainty (2006) argued that employers desire to engage in the practice of skills development, but do so within a competitive business environment. Employers often require the support of public institutions in upskilling the workforce.

Such support necessitates a strong vocational education and training (VET) system. For Clarke and Winch (2004), this means educational philosophy that embeds strong theoretical underpinning in schools, colleges and universities, work experience provided by employers and opportunities for simulation of work processes. This is only possible through a deeper social partnership between the education system and industry, and it is precisely this partnership that Leitch (2006) felt his proposal for employment and skills boards could facilitate in moving the UK economy to a higher skills level.

However, institutions need to be strong, and its strength goes beyond adjusting organisational structures. In the UK, however, Broadberry and O'Mahony (2004) argued that institutional structures have weakened since the Second World War which resulted in the erosion of much-needed intermediate skills. The UK government has realised the importance of intermediate skills in closing the productivity gap with its main competitors (Leitch, 2006), although dominant policy is still geared towards encouraging a greater proportion of school leavers into higher education. Broadberry and O'Mahony (2004) suggested taking a leaf out of German institutions, which remained strongly supportive of maintaining a healthy balance of intermediate and higher-level skills, a view shared by many others. Clarke and Herrmann (2004) showed how differences in institutional structures between the UK and Germany accounted for a more productive German construction industry.

Nonetheless, relatively few studies have been undertaken to examine how institutions can effectively support and encourage employers to engage in skills development. The efficacy of public institutions in formulating appropriate skills policies and enforcing skills provision is arguably crucial in terms of inspiring confidence among employers (and employees) of the formal system of skills development. A corollary of the inadequacy of public institutions is a greater reliance on informal approaches to skills development at the workplace, which might be insufficient to plug the problem of skills shortages. To find support for this, a study is currently being undertaken in the North East of England to examine interactions between public institutions and employers in delivering skills development for the regional construction industry. The study seeks answers to a number of research questions, including: who develops skills for whom, how are these skills being developed, what skills matter, and on what basis are decisions made regarding skills development. The next section will briefly outline work done to date and discuss early findings emerging from this exploratory phase.

METHODOLOGY

Within the confines of the paper, the methodology for the exploratory phase of the research is outlined (please see Chan and Moehler, 2007 for a detailed explanation of the research methodology adopted for the overarching study). To date, a series of 22 in-depth (semi-structured) interviews have been carried out with managerial staff from a range of stakeholder groups, including governmental institutions (e.g. local authority) and agencies (e.g. JobCentre Plus, Learning and Skills Council, Regional Development Agency), quangos (e.g. Regional Skills Partnership), training providers and colleges, employers, trade unions and professional associations. Furthermore, 11 focus group interviews were undertaken with operational staff within employer organisations, auditing networks and professional networks. Additionally, participant observations were done in two case study organisations - a private training organisation and a civil engineering and plant hire company - to get a rich insight into how skills development takes place in practice. The participant observations meant that the researcher attended 24 meetings and observed 8 trainees going through the skills development process over a period of 40 days. The interviews and ethnographic research enabled the research team to make sense of how the various organisations interacted with one another in relation to skills development in UK construction.

PRELIMINARY FINDINGS AND DISCUSSION

The most striking finding relates to the plethora of organisations that claim to have some involvement with skills in construction. Early on in the study, a desktop search was undertaken of organisations in the North East of England that have made a reference (however tenuous) to having a connection with skills in construction. This yielded a 7-page list of organisations, and the number seems to be growing organically. Notwithstanding the myriad of organisations (a selection of which is depicted in Figure 1), a number of key organisations can be identified. For instance, the Learning and Skills Council (LSC), together with Jobcentre Plus (part of the Government's Department of Work and Pensions) are crucial in terms of implementing the government's skills policies and administering funding regimes. At the same time, a number of organisations including *inter alia* the Construction Industry Council (CIC), Confederation of British Industry (CBI), the Federation of Small Businesses (FSB) and the Federation of Master Builders (FMB) provide a voice for industry that can powerfully steer the formulation of government skills policies. Educationalists are also represented either through individual educational institutions (e.g. Universities) or through such networks of institutions as the Centre of Vocational Excellence (CoVE) for construction. And the list goes on. Amidst all these organisations, Business Link is an independent agency that offers support to broker the relationship between employers (demand) and education and training providers (supply), and more crucially funding regimes.

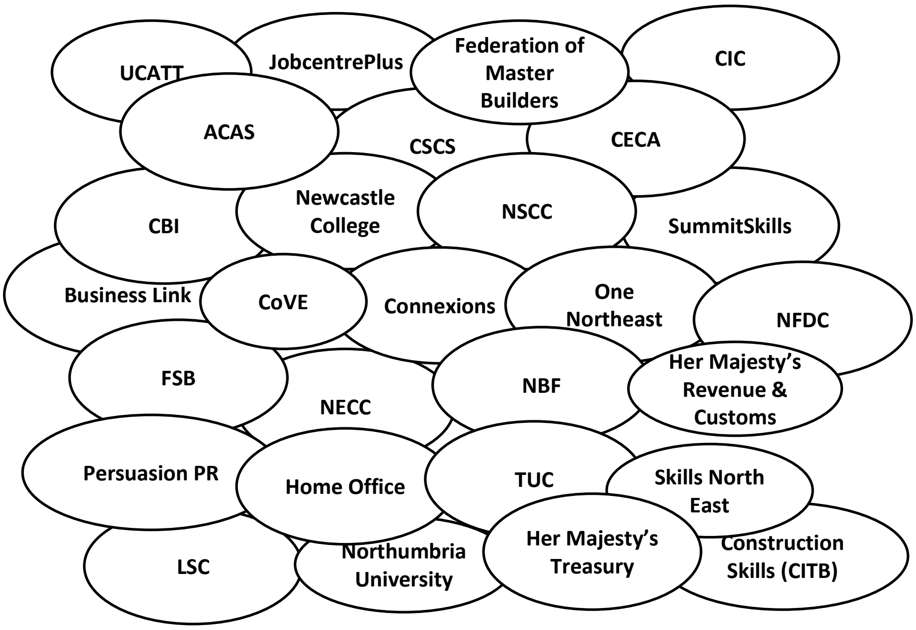


Figure 1: Myriad of organisations involved with skills in construction in the North East of England

The exploratory phase of this research has taken a year to complete. Within this time, it was observed that organisations involved in skills constantly evolve and grow. Even the government department that is charged with formulating skills policy (then Department for Education and Skills, DfES) have split to become the Department of Innovation, Universities and Skills (DIUS), and Department for Children, Families and Schools (DCFS). To exacerbate the situation, the diversity of the sector meant that six Sector Skills Councils are charged with coordination of skills development for the construction industry. These include Construction Skills, Summit Skills (for building services engineering), Asset Skills (for housing, property and facilities management), Energy and Utilities Skills, Proskills (for materials, products and manufacturing) and LANTRA (for environmental and land-based sector). Together with the Engineering Construction Industry Training Board (ECITB), these sector skills councils form part of the Built Environment Skills Alliance. Needless to say, there is immense confusion as to who drives skills development from a policy-making perspective. It is therefore unsurprising that employers interviewed during the exploratory phase have expressed dissatisfaction with the lack of clear answers given by Business Link.

The ever-increasing number of organisations involved in skills development also gives rise to growing bureaucratisation of the formal education and training system. So, for instance, whereas the DfES would formerly be charged with formulating and implementing skills policies, this is now undertaken by DIUS and DCFS. Such bureaucratisation leads to frustration by anyone who wishes to engage with the skills development agenda on two counts. First, in making decisions about how best to invest in skills development, one would have to navigate through additional layers of information. Second, increasing bureaucratisation adds to administrative burden on employers who wish to gain access to funding regimes. This can be highly inefficient because resources that could be allocated to development of skills are now channelled towards such activities as form-filling and second-guessing shifts in government policies. This has been recognised in the governance literature as depoliticisation of the role of government, where governments do less in terms of actual provision whilst retaining power to control the system (Burnham, 2001).

In controlling the system, the efficiency agenda appeared to be the prevailing concern for the government agencies interviewed. Skills development practices are desirable insofar as they are cost-effective to do so. On the one hand, government skills policies espouse the need to upskill the workforce beyond Level 2 (Leitch, 2006), whilst this is not matched with funding availability on the other. Elsewhere, we have argued that funding regimes can influence skills development behaviour; as such, there is the danger that skills development takes place in areas not connected with what really needs to be done (Moehler *et al.*, 2008). So, despite discontent with the qualifications framework and criticisms of the rudimentary standard of Level 2 training (Grugulis, 2003b), because full funding is available for Level 2 training, education and training providers are likely to flourish in such provision. Employers who are able to access such funding will be seen to be engaging in skills development, whilst others will simply look elsewhere to meet their skills shortages.

We have come across a number of examples of how some employers particularly small to medium sized firms (SMEs) have actually sought solutions from outside the formal education and training system. Some of these examples have been acknowledged in the literature including recruitment of retired time-served crafts labour to act as mentors for younger unskilled/semi-skilled employees and on-the-job training and improvisation (IFF, 2003). Another employer who became increasingly frustrated in navigating the complexity of the British system actually paid for his workforce to undertake traditional crafts training in France. Indeed, from our observations, it was noted that there is a contrast between the demands of the formal and informal system of skills development. Formally, policy-makers and public institutions are concerned with such issues as high completion rates, the eradication of unemployment and the perpetuation of key skills and Level 2 agenda. Consequently, there is an obsession with quantitative measurement of performance, and greater emphasis placed on outputs rather than outcomes. On the contrary, employers are more interested in sustaining harmonious working at the workplace and juggling skills development needs of their workforce with the pressures of maintaining order books and delivering projects on time (Raidén and Dainty, 2006). For employers, the qualifications framework and the quantitative outputs of completion rates and Level 2 competence make relatively little sense when compared to qualitative outcomes of getting the job done.

The literature has often derided employers for 'fit for purpose' approach to skills definition and development. Grugulis (2007), for instance contrasted between accepted wisdom of what constitutes skills and what employers desire: "Technical and professional expertise may be the produce of politics and consensus, but it is generally agreed by professional bodies, educationalists or experienced and expert workers […] Soft skills, in marked contrast to this, are defined by the employer who also specifies how they should be demonstrated and the means by which they may be assessed (p. 89)." Yet, the employers we interviewed were in fact concerned with the technical and professional skills, which they cannot seem to get satisfaction from the education and training system. Instead, the employers we interviewed are increasingly pushed into seeking ways outside the formal system to develop the skills of their workforce to achieve technical proficiency, which they consider to be what's best for their clients. Therefore, disconnected agendas between the formal and informal requirements of skills development can be observed in our research to date, and these are illustrated in Figure 2.

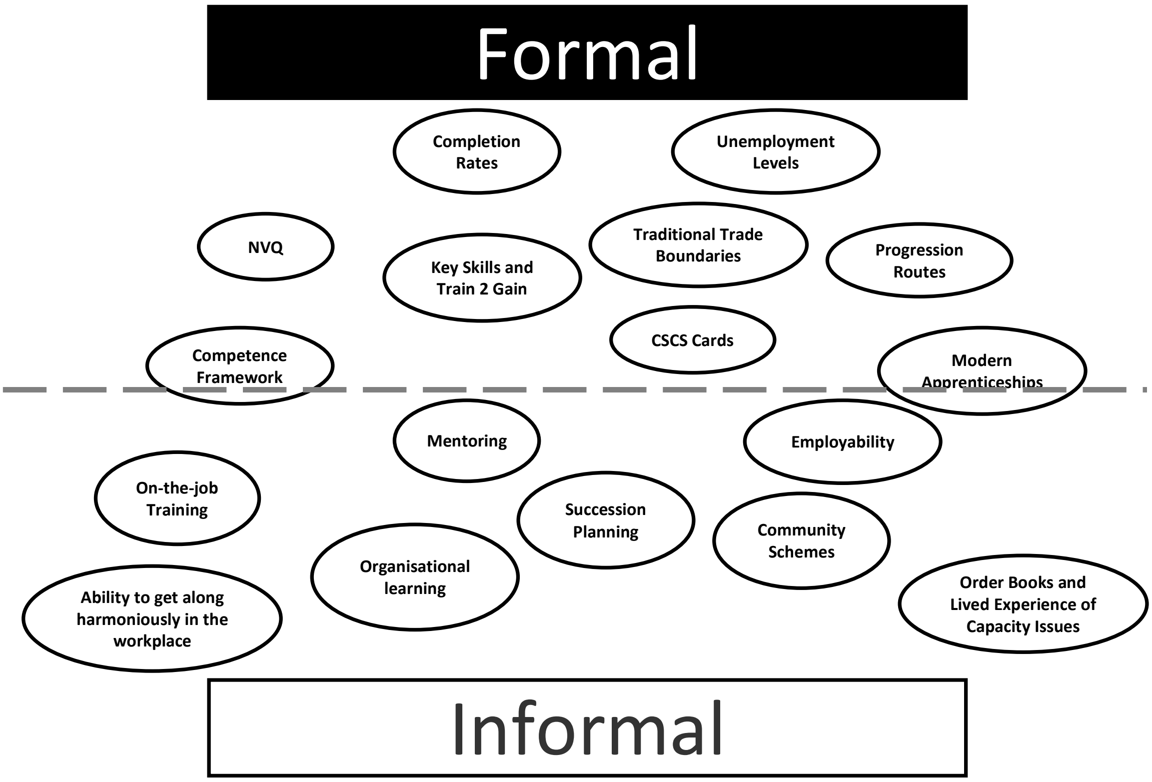


Figure 2: Disconnected agendas between formal and informal requirements of skills development

Such disconnections arise because of different emphases and priorities that are *institutionalised* within each system. On the one hand, the formal system is driven by funding allocation by central government, which in turn leads to the close monitoring of such quantitative measures as number of qualifications achieved and completion/retention rates. The success of the formal system tends to be determined by fulfilment of these targets, which often drive behaviour of those that benefit from government funding (e.g. government agencies, educational institutions, third-party brokerage services). Employer engagement often occurs with employer representation (e.g. the CBI, FSB etc.) rather than employers themselves. Employers, especially the SMEs who lack resource capacity to train, often find it difficult to access government funding for skills development, and are anyway more concerned with how the (quality of) skills can help ensure the continuity of production. As a result of the inadequacy of the VET system, these employers will look elsewhere to meet the skills gaps and shortages. These could include informal skills development at the workplace, or even accessing skills from abroad through migrant worker employment.

CONCLUSIONS

The concept of skills will always remain a contentious area of policy-making since its definition and impacts continue to be contested. Of course, the government through its institutions and policies can help provide greater clarity and support to industry in any endeavour to upskill the workforce. However, the UK is increasingly characterised by a growing number of (fragmented, even fractured) government institutions and agencies in promoting the skills development agenda. Notwithstanding the laudable attempts of the Leitch (2006) review, the old adage of the mind being strong but the flesh being weak rings true. It has been observed that the plethora of organisations involved in skills development adds to increasing bureaucratisation, which in turn leads to greater administrative burden on the part of employers and growing frustration and confusion of what the formal education and training system can offer. The result is a detachment between the agendas of the formal system determined by quantitative performance measures of completion rates and achievement in competence and the informal, socialised system at the workplace where employers simply want their workforce to get the job done to the client's requirements. The disconnection of agendas is reflected in employers' confusion of the qualifications framework and what this represents. As a result, some employers find themselves having to 'go it alone' and seek for solutions elsewhere. The idea that employers do not engage with skills development is potentially a red herring. Unless the formal system recognises what truly needs to be developed, skills development will continue to be met informally at the workplace. The challenge for the future then is to seek answers to the question as to how the formal system can cater for informal skills development practices at the workplace, rather than to simply demand for employer engagement.

REFERENCES

Becker, G. (1964; 1993) *Human capital: a theoretical and empirical analysis, with special reference to education*. 3rd Ed. Chicago: University of Chicago Press.

Beckingsdale, T. and Dulaimi, M. F. (1997) *The Investors in People standard in UK construction organisations*. CIOB construction papers, 9 – 13.

Bell, E., Taylor, S. and Thorpe, R. (2002) A step in the right direction? Investors in People and the learning organisation. *British journal of management*, **13**, 161 – 171.

Blenkinsopp, J. and Scurry, T. (2007) "Hey GRINGO!" the HR challenge of graduates in non-graduate occupations. *Personnel review*, **36**(4), 623 – 637.

Bloom, N., Conway, N., Mole, K., Möslein, K., Neely, A. and Frost, C. (2004) *Solving the Skills Gap: Summary Report from a CIHE/AIM Management Research Forum*. London: AIM.

Braverman, H. (1974) *Labour and Monopoly Capitalism*, MRP.

Broadberry, S. and O'Mahony, M. (2004) Britain's productivity gap with the United States and Europe: a historical perspective, *National Institute Economic Review*, **189**, 72 – 85.

Burnham, P. (2001) New Labour and the politics of depoliticisation. *British journal of politics and international relations*, **3**(2), 127 – 149.

Chan, P. and Moehler, R. (2007) Developing a 'road-map' to facilitate employers' role in engaging with the skills development agenda. *In*: Boyd, D. (Ed.) *Proceedings of the twenty-third ARCOM conference*, 3 – 5 September 2007, Belfast, UK, Association of Researchers in Construction Management, 409 – 419.

Clarke, L. (1992) *The building labour process: problems of skills, training and employment in the British construction industry in the 1980s*. Occasional Paper No. 50, CIOB, Englemere.

Clarke, L. and Herrmann, G. (2004) Cost vs. production: disparities in social housing construction in Britain and Germany. *Construction management and economics*, **22**, 521 – 532.

Clarke, L. and Winch, C. (2004) Apprenticeship and applied theoretical knowledge. *Educational Philosophy and Theory*, **36**(5), 509–21.

Cockburn, C. (1983) *Brothers: male dominance and technological change*. London: Pluto Press.

Construction Skills (2008) *Blueprint for UK construction skills 2008 to 2012*. Kings Lynn: Construction Skills.

Dainty, A. R. J., Ison, S. G. and Root, D. S. (2005) Averting the construction skills crisis: a regional approach. *Local Economy*, **20**(1), 79–89.

Department of Business Enterprise and Regulatory Reform (2007) *Construction statistics 2007*. London: BERR.

Druker, J., White, G., Hegewisch, A. and Mayne, L. (1996) Between hard and soft HRM: human resource management in the construction industry. Construction management and economics, **14**, 405 – 416.

Forde, C. and MacKenzie, R. (2007) Getting the mix right? The use of labour contract alternatives in UK construction. *Personnel review*, **36**(4), 549 – 563.

Groen, J. A. (2006) Occupation-specific human capital and local labour markets. *Oxford economic papers*, **58**(4), 722 – 741.

Grugulis, I. (2003a) Putting skills to work: learning and employment at the start of the century. *Human resource management journal*, **13**(2), 3 – 12.

Grugulis, I. (2003b) The contribution of National Vocational Qualifications to the growth of skills in the UK. *British Journal of Industrial Relations*, **41**(3), 457–75.

Grugulis, I., Vincent, S. and Hebson, G. (2003) The rise of the 'network organisation' and the decline of discretion. *Human Resource Management Journal*, **13**(2), 45–59.

Grugulis, I., Warhurst, C. and Keep, E. (2004) What's happening to 'skill'? *In*: Warhurst, C., Keep, E. and Grugulis, I. (Eds.) *The skills that matter*. Hampshire: Palgrave Macmillan. pp. 1 – 19.

Grugulis, I. (2007) *Skills, training and human resource development*. Hampshire: Palgrave Macmillan.

Harvey, M. (2001) *Undermining construction: the corrosive effects of false self-employment*. London: The Institute of Employment Rights.

IFF Research (2003) *The effect of employment status on investment in training*. CITB and Department for Education and Skills (DfES).

Leitch, A. (2006) *Prosperity for all in the global economy: work class skills*. Final report. December. Norwich: HMSO.

Mackenzie, S., Kilpatrick, A. R. and Akintoye, A. (2000) UK construction skills shortage response strategies and an analysis of industry perceptions. *Construction management and economics*, **18**, 853 – 862.

Moehler, R., Chan, P. and Greenwood, D. (2008) The interorganisational influences on construction skills development in the UK. *In*: Dainty, A. R. J. (Ed.) *The twenty-fourth ARCOM conference*, 1 – 3 September 2008, Cardiff, UK, Association of Researchers in Construction Management, in press.

Raidén, A. B. and Dainty, A. R. J. (2006) Human resource development in construction organisations: an example of a "chaordic" learning organisation? *The learning organisation*, **13**(1), 63 – 79.

MBA IN CONSTRUCTION AT THE UNIVERSITY OF ZAGREB

Prof. Mariza Katavić, PhD.Econ.
Faculty of Civil Engineering, University of Zagreb, Croatia
mariza@grad.hr

Dražen Bošković, MBACon, CEng.
Civil Engineering Institute of Croatia, Zagreb , Croatia
drazen.boskovic@igh.hr

The MBA in Construction program launched at the University of Zagreb is specially designed and adapted to the specific needs of the construction industry, as “general” MBAs are not always suitable for engineers holding managerial jobs in companies and/or in construction projects. The program is the result of research conducted at the University of Zagreb and in the Croatian construction sector.

The paper presents problems that have emerged during the execution of the program as well as suggestions for its further improvement. How to sustain the continuity of quality university education while taking into account the reality of the lack of time for education is a problem that faces not only students and their future employers, but in the first place university teachers who are expected to pass on knowledge.

KEYWORDS: MBA, construction sector, postgraduate course

INTRODUCTION

One hundred years ago, in 1908, the Harvard Business School was established as the first school for business administration. For decades the MBA qualification was offered only in the US. Later, from the 60-ties, European business schools also started to offer MBAs and MBA programs and curricula have gone a long way and are today taught all around the world. The last fifteen years have seen a massive expansion of providing Master of Business Administration (MBA) degrees around the world, with virtually every university-level business school having one, and some having more than one.

Knowing all this, one may wonder if it makes any sense to start yet another specialised MBA program at the University of Zagreb which, despite its long history of university education (founded 1669), is not a “prestigious” business school from the UK or the USA. To paraphrase Kathawala (et al. 2002), should we have a dilemma? Are we in fact doing students a disservice by offering them an MBA in Construction? Is the MBA a global qualification? Does one size fit all? Should an MBA be offered as a specialization, like our MBA in Construction for example, addressing certain niche markets (e.g. MBA in Health Sector Management, or MBA in Marketing), or should it remain focused on a generalised, all-round curriculum supposedly applicable to everyone?

According to Purcell (2005), the European MBA market has grown by almost 40 per cent over the last ten years. Examining the UK MBA market, Armstrong (2005) states that there has been a 31 per cent rise in part-time students during the last decade, a 23 per cent rise in distance learning and a 57 per cent rise in full-time student numbers over the same period. Burnson, 2003, reports a "significant rise" in MBA students from Europe going to study in the USA. Ters (2003) reports a significant increase ("several hundred students") in the number of Russian students studying for MBAs at Western business schools. There has also been an "MBA boom" in China Hulme (2004) with 10,000 students enrolled in MBAs in 2001 (contrasting with 100 enrolled students in 1991.).

To conclude, the aims of all MBA programs are very clear - to prepare their graduates for managerial roles, help them gain a better understanding of the industrial and business world and its needs, enrich their skills and provide them with competences relevant to their careers. So there is no doubt that we need the kind of education provided by an MBA. But the best method of delivering knowledge to MBA students is yet to be decided.

MBA IN CONSTRUCTION - DO WE NEED IT ?

When it comes to the construction industry, the MBA programs offering "general managerial training" have to be modified, as they are not completely appropriate for the needs of construction managers. Construction differs fundamentally from all other industries because in a "normal" industry the product changes its place and the production factors (people and machinery) are static. In construction it is the opposite – the product (the site, the building under construction) is static and does not change its place. When the "production process" is finished "the product" stays where it was made, while the production factors (people and machinery) move on to the next location – to the "next product".

For years civil engineers all over the world have been successfully heading building and construction companies and various large-scale projects (dams, nuclear plants, ports, etc). They proved their technical knowledge, skills and expertise while working in different economic and political environments. However, very often they had problems in managing companies and projects (particularly in efficiently managing time and costs/finances), as they had no formal knowledge or training in management and/or project management.

As early as 1949 the founder of modern management Henri Fayol (1949), speaking generally about the knowledge necessary for managerial work, established the correlation between technical and other general (economic, sociological, managerial and other) knowledge for various job positions in the management hierarchy. As one climbs up the managerial ladder the required level of "general knowledge" grows. Every manager knows well that the higher his/her position in the managerial structure is, the less he/she has "to do" with solving technical/professional problems and the more time and energy he/she spends in solving "all the other" problems in the company.

A survey Katavić, Đukan (1989) was carried out among engineers, graduates from the Faculty of Civil Engineering, University of Zagreb (generations from 1955 to 1985), to identify the specific managerial features and "the most important" knowledge and skills for a construction manager. The respondents' evaluations resulted in a rank list of the ten most important skills and knowledge for the construction manager, the first being „command of technical knowledge and professional skills". They firmly expressed the view that ***to be a***

good manager a person must in the first place be a good engineer. They placed the ability to control expenses last of the ten most necessary kinds of knowledge.

In 2001. field research Katavić, Cerić (2002) about the essential knowledge and skills needed by the successful manager in the construction industry was repeated. Respondents ranked ***topmost knowledge in management science*** (analysis, planning, organization, motivation, control)**.** Project management (planning methods, resource management, risk analysis etc.) was considered the second most important knowledge by 91% respondents, and economics came third (accounting, marketing, finances, international economic relations etc.).

Obviously the perception of the manager's functions has changed. Increasingly civil engineers and other technical graduates are becoming aware that they need additional education in the "management field" and the demand for multidisciplinary and interdisciplinary knowledge is growing.

The MBA in Construction given at the University of Zagreb is a program that focuses on construction with the purpose of providing present and future construction managers with knowledge in various non-engineering fields necessary to understand and master complex management processes. Educating civil engineers to be successful managers, as proposed in our program, widens the circle of knowledge "consumers" by providing engineers with new multidisciplinary and interdisciplinary competencies and knowledge.

MBA IN CONSTRUCTION AT THE UNIVERSITY OF ZAGREB

The International MBA in Construction program started in February 2003, as a TEMPUS project. Teachers from Dundee University, Reading University, Salford University, Technische Universität München, American College of Management and Technology from Dubrovnik and University of Ljubljana taught together with colleagues from the University of Zagreb, creating an environment of different business and cultural approaches.

In June 2003 the University of Zagreb Senate approved the program proposed, making MBA in Construction one of the two academically verified business management studies in Croatia and also recognizing it as an international post-graduate study course. The program brings 120 ECTS credits, lasts three teaching semesters and a fourth is set aside for writing a master's thesis Katavić, Matić (2005)

The program consists of three groups of subjects Katavić, Matić (2006):
- general business-management subjects (organisational behaviour and organisation design, business strategy, business ethics, human resource management, decision-making theory, negotiating and business protocol)
- economic subjects with a special accent on construction (business statistics, marketing strategy, international marketing, accountancy and finances)
- construction subjects (project planning and control, project management, legal regulations in construction, building maintenance, environmental protection management).

Two teachers teach each subject, one of them Croatian and the other from a European institution, creating a synergy of knowledge and experience as they demonstrate recent national and international practice. Even when they speak of general subjects, the teachers adapt their lectures to the specific requirements of the construction industry. The material (especially in the group of economic subjects) has also been modified for students of a technical profession, making it easier for them to follow and understand the non-engineering material.

A total of 44 students were enrolled in two generations. Their average age was 32, their average working experience 5 years and 4 months. Most of the students in both generations were male, but each generation had one female student. A prerequisite for enrolment was passing the GMAT (Graduate Management Admission Test)[*].

The system evaluating teacher performance, which also serves for collecting evidence about student preferences and interests when structuring program and subjects, consisted of anonymously grading (using a structured questionnaire) each teacher immediately after a lecture, and grading all the teachers again at the end of a semester. At the end of the third semester, when the students had heard all the lectures and got to know all the teachers, they again graded them and at the same time evaluated the entire program by expressing in a grade their level of satisfaction or dissatisfaction with the scope, quality and manner of delivering knowledge.

The program must constantly be adjusted to follow the expressed needs of the students and teachers, the changes brought about by new professional, scientific and methodological knowledge, and those based on changes in the overall environment.

The first generation of students were taught in weeklong modules of all-day teaching, alternately in Zagreb and at the Post-Graduate Centre in Dubrovnik of Zagreb University. The second generation had all their courses in Dubrovnik. The students' "isolation" and all-day intensive work greatly increased their commitment and allowed them to completely focus on acquiring new knowledge.

Intensive socializing with colleagues and teachers created a background for abundant, direct, formal and informal communication where problems and their solutions are aired, presented and discussed publicly and without hesitation. This led to the development of group synergy, which besides a positive feeling of belonging also achieved group intelligence and group reasoning, thus creating a network of people who think about the problems of Croatian construction in a similar way.

However, the need for long and continuous absence from work that greatly increases study costs (expenses of travelling, accommodation and food) is a kind of drawback for studies planned in this way (especially in the employer's view).

These problems may be related and formulated as a classical managerial assignment – realising a planned objective (studying efficiently and achieving a given high quality of excellence) under conditions of limited resources (time and money).

When discussing limited resources, the following must be borne in mind:

- minimising study costs is a trivial but understandable common goal for all the groups in the process (both students and study management),

[*] www.gmat.org

- another limiting resource is the availability of quality teachers who successfully combine a university and a professional career,
- the number of students who comply with the conditions of enrolment and later also with the demands of the studies is also limited,
- analysing the resource of time is more complex and requires examining not only the time spent immediately on lectures but also the total time that all the participants use until the student passes the examination or writes the final paper,
- and last but not least, postgraduate studies for further scientific training have been abolished and specialist post-graduate studies introduced as a key element of lifelong education.

It is this inter-relationship - quality, time and money - that should be crucial in harmonizing study effectiveness and efficiency. A serious analysis along these lines is also important because the students' previous efficiency (the number who got their master's degree within the given term) was very low. Obviously a correlation must be established between the efficiency of a specific study such as MBA in Construction and the choice of methodology for knowledge transfer.

EVALUATING THE METHODOLOGICAL FORMS OF STUDY

If we start, in addressing this problem, from rationalizing resources, in the first place time, we must consider the introduction of *e-learning* (learning from a distance) as a possible solution. *E-learning* is a radical structural change "from above" and requires the complete re-engineering of classical studies. The most usual reason for structural changes in the system is re-engineering resulting from the introduction of information technology. When studies are re-engineered to accommodate information technologies, then it is not the exchange of information in itself that is decisive but the synergy of contacts and the interactive work and relationships between the participants in the process, in this case of students and teachers, which encourages structural transformation and which is designed to result in certain improvements and advances.

However, it is not yet quite clear whether this is the best way. Professional circles do not yet agree about the desirability of *e-learning* as an extremely flexible method of knowledge transfer. We show below the SWOT-analysis of *e-learning* as demonstrated by Kathawala et al.(2002) We have compared traditional MBA study methods and *e-learning* as a new method. Many elements of the analysis can be generally applied to all *e-learning* methods because they are not specific to MBA programs only.

S – Strengths - comparative advantages of *e-learning* vs. traditional methods

- the global increase in the use of *e-learning* for MBA programs – the main advantage of introducing the new technologies is considered to be the possibility for the mass dissemination of knowledge to dislocated students, combined with rationalisation of absence from work;
- rationalization of teachers' time, who do not have to take frequent trips but can transfer knowledge from any place where they dispose of the necessary equipment;
- easier adaptation to the specific needs of every student.

W – Weaknesses – comparative disadvantages of *e-learning* vs. traditional methods

- terms of enrolment: the possibility that some universities may change enrolment requirements (will they still require GMAT or will some other kinds of knowledge be necessary for enrolment, e.g. knowledge of IT);
- financial aspect: *e-learning* is as a rule cheaper than classical studies, but not in institutions that insist on high-quality programs and teachers;
- institutions that want a top program must invest a lot in equipment (fast computers, the necessary software, technical support for the entire system and, of course, especially for teachers and students);
- quality: one of the main arguments against *e-learning* is the somewhat lower quality of the existing distance MBA studies, because they are not on the quality level of the recognised traditional-method MBA studies.

O - Opportunities – what can institutions do to emphasise the advantages of *e-learning*

- according to some sources, world companies and governments spend about US$40 billion a year on the education of their employees, with growing *e-learning* participation (from US$1.8 billion and 700,000 students in 2000 it grew to US$5.5 billion and 2.2 million students is 2002);
- universities with a weaker tradition have the opportunity of securing a larger part of the MBA *e-learning* market from the peak universities, which decide to introduce new methods only sporadically.

T -Threats - are the warnings that must be taken into account less they become shortcomings that can completely "destroy" the MBA program that uses *e-learning*

- changes in teaching form: there is a great difference between the traditional and virtual teaching of students. The American university teachers' association finds teaching by *e-learning* more time-consuming and intensive for the teacher because an unavoidable and mandatory part of the teaching process includes individual written communication with each student;
- change of data base: traditional data bases, such as books, will give way to new combined data bases, which provide teachers with incomparably greater possibilities of creating coherent study courses;
- change of teaching place: it is a great change to replace a classical classroom with a virtual class in which people communicate by *e-mail* and similar communication tools;
- changes in student characteristics: greater emphasis is placed on ethics (plagiarizing, having others write papers), personal motivation (no one and nothing forces the student to fulfil certain obligations and tasks), self-discipline, organisational and analytical abilities.

One of the main objections to *e-learning* is the lack of personal student-teacher contacts and the non-existence of personal contacts among students. In this sense the research of Ponzurik et al.(2000) shows that various methodological forms can be used to achieve a consistent structure of lectures, however, some educational adaptations are necessary in the case of *e-learning*.

If the above SWOT analysis is applied to our MBA in Construction program several other specific problems/weaknesses appear.
Given that making studies cheaper is an objective acceptable to the students, this will be difficult to realise on the national market because MBA in Construction targets a small population, on the relatively small Croatian market and is held in small groups (maximum 25 students) so the overall effects of a price reduction would be negligible, but work quality might suffer.

At the same time, the measure to which Croatian teachers are ready to accept new technologies is a question, and in this context it is also objectively possible that quality might suffer. It is not unimportant to point out that other specialist university studies show no intention of introducing *e-learning*, so classical teaching should not be rejected without careful consideration. Technology means nothing without a “brain” – it is not possible to teach a computer to lecture well, only a good teacher can do this. Lectures in the form of direct communication are the quintessence of studies, they are their most creative part, the personalisation of knowledge in the creative choice of material, manner of presentation, synthesis of experience and standpoints which can be influenced and which therefore have a motivating and inspiring effect on both associates and students. This effect cannot be achieved in a mechanically-based relationship in a virtual environment. It is therefore certain that the exclusive use of *e-learning* for MBA in Constriction under Croatian conditions would not answer its purpose, at this moment, because it would bring the existing quality into question.

It is completely certain, however, that the future of a program such as MBA in Construction definitely depends on the possibility of finding new ways of knowledge transfer that will require less absence from work. Our target market are young ambitions managers who desire new knowledge and are ready to invest in fulfilling their wishes and needs. Their greatest problem in the realisation of this goal is lack of time, so management studies are faced with the task of finding optimum solutions that will retain and even advance study quality and at the same time shorten the time of absence from work.

CONCLUSION

To summarise, there is no doubt that the classical concept of MBA studies demands a certain degree of re-engineering through a careful and gradual introduction and combination of traditional and new technologies of knowledge transfer, such as for example *e-learning*. However, it is also certain that the time resource should be optimised through structural adaptation based on continuous organic growth, not on sudden leaps.

Part of this adaptation process is the introduction of information technologies geared at creating a fast, efficient and expense-acceptable model of managing the information necessary for the study process, in an environment of full electronic connection. This is relatively easy to achieve and at the same time saves time because it is incomparably easier to follow the flow of information than the flow of physical documents (applications, seminar papers, exams, literature, chosen courses). A prerequisite is creating an IT infrastructure and system of organised approach to and storage of data.
Many world universities have introduced so-called hybrid models of study at some post-graduate level courses (especially specialist studies), which combine traditional methods

(direct contacts between students and teachers) and *e- learning*. One of the options in the further development of MBA in Construction lies along these lines, towards the gradual introduction of *e-learning* in some subjects whose contents and accompanying literature are such as to satisfy the criteria of excellence.

Direct communication between each individual student and teacher, among students and between the students as a group and the teacher must be made possible and simple. This will give communication using information technologies a synergic effect of creating a group intelligence, if not as a substitute, then as a supplement and catalyst for the original communication directly realised during lectures and the formal and informal personal communication between teachers and students. Therefore, what we are looking at is adapting the studies by introducing IT technology as a necessary and desirable first step in the modification and advancement of the existing MBA in Construction programme.

REFERENCES

Armstrong, S., 2005. Postgraduate management education in the UK: lessons from or lessons for the US model?, Academy of Management Learning and Education, 4(2), 229-234.

Burnson, P. (2003), "International business education: shaping future global vision", *World Trade*, No.June, pp.52-4.

Fayol, H. (1949) General and Industrial Management, Pitman Publisher, London

Hulme, V.A. (2004) The MBA boom, The China Business Review, 1, 24-36.
Katavić, M., Đukan, P.(1989) The Civil Engineer as a Manager, 3rd Yugoslav Symposium in Building Organisation, Cavtat, University of Zagreb, 767-779.

Katavić, M., Cerić, A.(2002) In Pursuit of the Perfect Project Manager, 2nd SENET Conference on Project Management, Cavtat, University of Zagreb, 73-85.

Katavić, M., Matić, S.(2005) MBA in Construction, 11th Joint CIB International Symposium, Helsinki, Finland, 328-340.

Katavić, M., Matić, S.(2006) Business Education for Construction Managers, Conference: Contemporary problems in construction, 2-3 June, Subotica, Serbia, 49-58

Kathawala, Y., Abdou, K., Elmuti, D.S., 2002. "The global MBA: a comparative assessment for its future", Journal of European Industrial Training, 26 (1), 14-23.

Nicholls J., Harris J., Morgan E., Clarke K., Sims D., 2002. Marketing higher education: the MBA experience, International Journal of Educational Management, 9 (2), 31-38.

Purcell, J. (2005) Euro MBAs have a unique appeal, Business Education, 1, 13.

Ters, K. (2003) Weighing MBA study: home or abroad?, St. Petersburg Times, 9

Ponzurik, T.G., France, K.R-L., and Cyril, M. (2000) Delivering graduate marketing education: an analysis of face-to face versus distance education . Journal of Marketing education, 22(3),180-187.