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PO Box 219
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Dr Simon Smith
School of Engineering
Alexander Graham Bell Building
Edinburgh, EH9 3JL
simon.smith@ed.ac.uk

ARCOM Declaration:
The papers in these proceedings were double refereed by members of the scientific committee in a process that involved detailed reading of the papers, reporting of comments to authors, modifications of papers by authors and re-evaluation of re-submitted papers to ensure quality of content.

FOREWORD

Welcome to Edinburgh for the 28th edition of the Association of Researchers in Construction Management's annual conference. This year's conference promises to be one of the biggest yet, and returns to Scotland's capital for the second time, having first been hosted by Heriot-Watt University in 2004; and to Scotland for the third time after Glasgow in 2000.

This year's conference call attracted a huge amount of interest. 329 abstracts were submitted in February, which resulted in 181 full papers. This has been further reduced to 134 final accepted papers, all of which appear in full in these proceedings. This is one of the highest number of papers that an ARCOM conference has seen and is testament to the popularity, quality and importance of this annual showcase of the best research in international construction management research, particularly at a time of financial difficulty for so many delegates. It is possibly also a reflection of the popularity of our host city for 2012. The Scottish capital needs little to persuade us to visit its mix of Georgian and Medieval streets and our location for the conference itself, at the foot of the Salisbury Crags and Arthur's Seat; opposite the Holyrood Parliament and next to the Queen's Park and Holyrood Palace will hopefully inspire enlightened debate!

In recent years ARCOM, and the ARCOM conference, have grown to become an internationally significant institution. The committee has recognised this yet has steadfastly refused to attempt to cash in on this popularity; rather we have tried to increase the quality of the papers presented. Thus we maintain quite strict standards of academic quality and rigour in our review process. This is impossible without the efforts of its Scientific Committee and I must pause to hopefully ensure all delegates are aware of the key role that these 67 people have played in the development and passage of their papers through the review process. It is worth pointing out that a total of 1333 separate reviews were conducted in order that the proceedings appear as they do.

The industry we research is, as ever, facing a great deal of challenges. It has been very hard hit in Europe by the worldwide financial situation with negative growth in the last year in some countries. It is not just construction that has been hit of course, and this downturn is seen in the academic and higher education sectors also. Frustratingly, many academics are unable to fund and thus fully develop the knowledge and understanding in the way they wish to in order to prepare for better times to come. Yet we continue to see progression and changes in the make up of the research presented at our conference. In particular we continue to see a development of understanding of people: the way they behave, the differences in cultures, how they might be treated and protected better and how the diversity of a workforce can be recognised and treated correctly. This must give us hope for the future, that when the world is able to develop its infrastructure and countries that have lain idle for so long can be allowed to grow that its workforce will be better able to deliver. The papers in these proceedings on equality and diversity; on respect for people; on behavioural and cultural differences are a reflection of this and one only needs to look at the table of contents of proceedings from the early '00s to see how trends have changed. These themes have become more prominent.

In recent years the sustainability agenda has rightly affected the way we approach our work and has resulted in a huge increase in research on sustainability theory, low carbon construction, environmental assessment and of energy reduction. The number of papers on sustainability in this year's proceedings is the largest by some margin in comparison to the other themes. 23 papers have been separated out in to two themes: sustainability theory and design issues as well as research on the operation and practice of sustainability implementation. Many works reflect the policy and strategic governmental changes to produce low carbon dwellings and public buildings.

This year we see a new theme on Building Information Modelling and while the large number of abstracts submitted in this area did not, unfortunately, translate to a similar number of accepted final papers, it is clear that there is much work to be done to appreciate the benefits – and uses – of this new technology; and to educate the breadth of the industry on how to exploit and utilise it. I suspect this will be a growing theme for the next few years.

Papers come from a wide variety of sources. This year, over twenty countries are represented with a vast number of papers coming out of PhD and postgraduate research. ARCOM is proud to nurture this talent and it is also very gratifying to see that a large number of experienced academics number among the registered delegates. I am hoping that the long ARCOM tradition of support and encouragement of early career researchers continues in the debate and discussion, in both lecture room and social arenas of this conference.

There are eight paper prizes to be awarded this year. Three are ARCOM's own awards, commemorating past chairs and committee members Rod Howes, Paul Townsend and David Langford. Five awards are funded by our sponsors: CIOB, RICS and publishers Wiley-Blackwell and Taylor & Francis. The late Prof. Dave Langford is also remembered by the Second Annual Langford Lecture, this year delivered by Aletha Holborough from University of Westminster.

It goes without saying that a conference of this nature needs a lot of support and work behind the scenes and a note of thanks must as always go to the main ARCOM committee in addition to the scientific committee mentioned above. Particularly thanks to Paul Chan, Ani Raiden and Stephen Gruneberg for managing our debate and keynote speaker sessions. I'd like to offer thanks and appreciation to Will Hughes for his support and advice on academic, editorial and many other issues. And last but not least a sincere nod to our new Conference Secretary, Dominic Ahiaga-Dagbui whom most of you will already know from his numerous email communications.

Go forward and enjoy. Engage in debate, make new friends, renew old acquaintances, advance and further our field and have a good time doing so!

Dr Simon D Smith, University of Edinburgh, UK
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OFFSITE CONSTRUCTION

RE-ENGINEERING THE CONSTRUCTION SUPPLY CHAIN: TRANSFERRING ON-SITE ACTIVITY, OFF-SITE

Stuart Tennant[1], Michael McCarney[2] and Michael K.L. Tong[2]

[1] *School of the Built Environment, Heriot-Watt University, Edinburgh, EH14 4AS, UK.*

[2] *School of Engineering and Built Environment, Glasgow Caledonian University, Glasgow, G4 0BA, UK*

Interest in supply chain management theory and practice in UK construction has grown considerably over the past decade. In parallel, a number of other key industry initiatives have also gained momentum. A notable development has been the increasing modularization of the construction process. The theoretical merits of off-site manufacture in construction are well documented and include reported benefits in production, scheduling and quality improvements. However, the impact of modularization on the governance and membership of the construction supply chain are less well-known. In an effort to connect supply chain management theory with modern methods of construction (MMC), the research investigates the potential impact transferring on-site activity, off-site will have on the supply chain. This is a conceptual paper based primarily on a review of supply chain management and MMC literature. Drawing on supply chain management theory and practice, the significance of an increasingly modular-orientated supply chain in construction is explored and evaluated. Secondary data is provided via anecdotal evidence gathered from a number of construction site visits and discussions with a cross-section of industry stakeholders. The adoption of modular construction and subsequent transfer of traditional on-site construction activities off-site is likely to necessitate a re-engineering of current construction supply chain management practice. In contrast to the commercially biased supply networks reflective of long-established working practices, off-site modular construction is likely to engender supply chain relationships that are increasingly socially as well as technologically bound and influenced by changes to the power dynamics. The literature highlights many business related opportunities, however the transfer of traditional construction activities upstream is not without risk. In conclusion, the research provides a conceptual grounding for further investigation of modular construction and the potential impact on the management and structure of construction supply chains.

Keywords: supply chain management, power, trust, relationships.

[1] S.Tennant@hw.ac.uk

[2] M.McCarney@gcu.ac.uk

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INTRODUCTION

Transferring traditional on-site construction activity, off-site is both complex and potentially problematical. Many factors individually and collectively combine to impede the adoption of off-site modern methods of construction (MMC) including economic conditions, technological developments, historical influences and industry routine. Despite these challenges, increasing industry receptiveness for MMC continues to be largely motivated by the promise of productivity and performance improvements. The merits of off-site construction are well-documented (Goodier and Gibb, 2007) and may range from production benefits, programme benefits and manufacturing benefits (Doran and Giannakis, 2011). In contrast to the well documented productivity and performance benefits of contemporary construction processes, the scope and impact of MMC on the governance and membership of the construction supply chain are less well-known. This research seeks to explore the potential impact MMC and in particular modular construction will have on the governance and structure of traditional construction supply chains.

Supply chain management remains pivotal within arguments to improve the productivity and performance of organizations and continues to receive significant academic and industry attention (O'Brien *et al.* 2009, Pryke, 2009). Indeed, supply chain management has been drawn upon, connected with and frequently used as a lens with which to explore multiple research questions (Green *et al.* 2005). Within the context of the UK construction industry, aspirations of improved productivity and performance have been pursued for over sixty years (Murray and Langford, 2003). Supply chain management has previously been argued to be instrumental in delivering these aspirations (Egan, 1998, Egan, 2002). Notwithstanding repeated attempts to develop and diffuse concepts of supply chain management, construction, improvements in project productivity and organizational performance remain largely speculative. As a result, there still exists significant scope for supply chain development and improvement, especially when connected with parallel productivity initiatives, such as off-site manufacturing and MMC.

Off-site manufacturing and MMC are similarly argued to be instrumental in the delivery of productivity and performance benefits (Venables *et al.* 2004). Despite growing popularity for modularization of the construction process, off-site manufacture coupled with on-site assembly is not a new concept (Pan *et al.* 2008). Post Second World War construction was an enthusiastic sponsor of industrialized systems building and in particular prefabrication. Contrary to the initial optimism, serious product failures arguably left an indelible and consequently negative mark on the safety and build quality of industrialized systems (Green, 2011).

The ensuing lack of MMC investment and development has gone largely unchallenged over many decades, especially within the non-housing sectors. Despite increasing and compelling arguments in favour of MMC, industry implementation has been at best, circumspect. In an effort to connect supply chain management theory with MMC practice, this research investigates the potential impact transferring on-site activity, off-site will have on construction supply chains. Given the largely fanciful notions of construction project end-to-end service and product delivery, the focus of attention is primarily the supply side of the commercial dyad between the main construction contractor and second-tier construction sub-contractors and suppliers.

This paper is presented in a conventional format. Following a brief overview of MMC, a contextually sensitive interpretation of supply chain management in

construction is presented. The research strategy is explained and the research methods adopted are made clear. The findings and discussion section explore the largely theoretical debate concerning the commercial power and corporate leverage linked with the transfer of traditional on-site construction activities, off-site. The paper concludes with some reflections and identifies future research avenues.

MODERN METHODS OF CONSTRUCTION (MMC)

Reference to MMC was first coined by the newly elected Labour Government circa 1997. The prime driver for industry change was a political resolution to build low-cost affordable housing. The term, MMC in the main but not exclusively denotes the use of off-site systems of construction. Off-site prefabrication of building components ready for on-site assembly is an alternative approach to traditional on-site construction methods that will theoretically reduce the timescale for house building activities. In contrast to the political origins of MMC, the term has now been used in most sectors of the construction industry. Consequently, MMC is frequently used interchangeably with alternative expressions such as off-site construction, off-site manufacturing, prefabrication, industrialisation and modular construction.

Despite the growing popularity of MMC, a definitive definition remains elusive. In an effort to provide a greater degree of clarity, Ross *et al.* (2006) offer the following five classifications: 1/ off-site manufactured - volumetric, 2/ off-site manufactured - panellised, 3/ off-site manufactured - hybrid, 4/ off-site manufactured - sub-assemblies and components and 5/ non-off-site manufactured MMC. The five discrete categories of MMC identified by Ross *et al.* (2006) are worthy of individual analysis however this research will focus primarily on concepts of volumetric construction, commonly referred to as modular construction. According to Gibb (1999 p.8), modular construction may be described as "a unit, or units that form a whole building or part of a building in terms of full enclosure and structural needs". A typical example of modular construction would be a complete bathroom pod or plant room (Gibb, 2001).

Improving the productivity and performance of the construction process has been a recurrent topic of interest that has lead to lively debate; this was evident by the publication of the UK government report ‘Rethinking Construction’ chaired by Sir John Egan. Egan (1998) championed the cause for greater integration of supply chains, component standardisation and off-site methods of construction. The report however, neglected the opportunity to endorse the increasing importance of alternative modes of supply chain governance with variant forms of off-site construction.

It is widely recognized that the UK construction industry remains largely traditional and conformist in its outlook. As a result of both history and routine, the diffusion of innovation and subsequent industry transformation to MMC may be difficult to alter. However, findings from a recent study by Nadim and Goulding (2010) suggest off-site methods of construction is likely to dominate construction technology for the foreseeable future. Notwithstanding growing awareness of the potential benefits, adoption of MMC is not automatically assured.

In a review of constraints likely to impede the uptake of modular forms of construction, Blismas *et al.* (2005) identify three discrete categories: namely, site constraints, process constraints and procurement constraints. First, site constraint refers to restricted or limited space available for facilitating the construction process, for example storage on a construction site. This category of constraint is largely reflective of city-centre or gap development where the building footprint occupies a

significant percentage of the total available land. Second, process constraints identify the limited capacity of suppliers. A shortage of available products from local suppliers may impact upon projected costs and reduce expected construction efficiencies. Third, procurement constraints relate to practitioner knowledge and understanding of novel methods of commercial exchange. Alternative procurement routes may be required to address anomalies associated with traditional forms of contract founded largely on pro-market, anti-trust approach to the construction process. It could be interpreted from the site, process and procurement constraints identified that management of the supply chain will have a considerable influence on the future uptake of modular forms of off-site construction. Central to the debate is greater integration between all stakeholders involved in modular construction both during manufacture and incorporation on site, thus forming longer-term and commercially enduring alliances.

POWER AND RELATIONSHIP MANAGEMENT APPROACHES

According to Cox and Ireland (2002), by understanding the resources that augment and diminish the relative power of both buyers and suppliers in specific exchange relationships, it is possible for practitioners to know what the objective circumstance is facing the parties in the relationship. This understanding provides buyers and suppliers the knowledge of the most appropriate relationship management approach available to them. The power matrix (Figure 1) could be used as a starting point to understand the objective position in the relationship. It is based on the premise that all buyer and supplier relationships are predicated on the relative utility and relative scarcity of the resources that are exchanged between the two parties (Cox *et al.* 2000).

Buyer Power Attributes Relative to Supplier		
HIGH	BUYER DOMINANCE (>)	INTER-DEPENDENCE (=)
LOW	INDEPENDENCE (0)	SUPPLIER DOMINANCE (<)
	LOW	**HIGH**
	Supplier Power Attributes Relative to Buyer	

Figure 1: The Power Matrix (Source: Cox et al. 2000).

The power perspective on buyer and supplier relationship management implies that the relative power of the buyer and supplier is the determining factor in the operational and commercial outcome in any transaction. This school of thought challenges the unquestioning use of collaborative approaches as it contradicts common-sense logic of economic theory. This logic asserts that the maintenance of perfectly competitive supply markets, with low barriers to entry, low switching costs

and limited information asymmetries ensures that suppliers innovate and pass value to buyers (Cox, 1999).

Given the fact that both buyers and suppliers are free to pursue symmetrical or asymmetrical relationship management styles with one another to achieve their respective business objectives reinforces the argument that there can be no single 'best practice' approach to relationship management (Cox and Ireland, 2006). In essence, integrated supply chain management, partnering, relationship marketing and the like may be regarded as a 'best practice' approach for organisations under certain circumstances but highly unlikely to be 'best practice' in all external sourcing situations. Therefore, practitioners have to first understand the way in which buyers can work with any supplier and the scope of their activities within a supply chain.

The discussion of power in buyer-supplier relationships provides a useful starting point prior to considering the power structures within the entire supply chain. In the construction industry, the dyad between the client and the main contractor is also affected by the relationship that the main contractor has with its subcontractor and suppliers. There is a need for understanding the extended network of dyadic power relationships in order for appropriate relationship management strategies to be developed and is referred to as the 'power regime' (Cox *et al.* 2000, Cox and Ireland, 2006). Only by understanding the structure of power within the network as a whole is it possible to understand the feasibility and desirability of introducing reactive arm's length or proactive collaborative relationship strategies for the buyer and supplier.

Another issue that needs to be questioned is the notion where both parties fully achieve their ideal goals and referred to as a 'win-win'. This ideal is not feasible in practice because of the incommensurability of the objective commercial interests of both parties. This is the central paradox of all relationship management approaches between buyers and suppliers (Cox, 2004). This implies that it possible for buyers and suppliers to achieve operationally and commercially all or something of what they value ideally but difficult for both parties to do so simultaneously. There are three 'mutuality' outcomes in which long-term collaboration relationships between buyers and suppliers are sustainable. These are win for the buyer/partial win for the supplier; partial win for both the buyer and supplier; and win for the supplier and partial win for the buyer.

Although neither party would wish to operate in a 'lose-lose' arrangement, one-off business relationships do not require the maintenance of a relationship so a 'lose' outcome is not an issue for the winner. The implication of this is that the promotion of a widespread use of collaborative approaches may not be desirable or sensible. If there is no necessity for operational continuity then opportunism may be more beneficial for one party than to pursue the collaboration. This may explain the traditional common occurrence of the main contractor behaving opportunistically in dealings with subcontractors because of their wide availability due to low barriers to entry.

RESEARCH STRATEGY

This is a conceptual paper. The research strategy is not to hypothesize and test a theory but to explore the opportunities and challenges connected with a modularization of the supply chain and the transfer of traditional on-site construction activity, off-site. Whilst it is acknowledged that the construction industry is both diverse and complex, a number of research parameters have been introduced. The primary focus of attention is the organizational interface between the main

construction contractors and their second tier construction sub-contractors and/or suppliers. In addition, the potential influence and subsequent impact of other construction stakeholders, for example the construction client is acknowledged and where appropriate commentary is provided. The research is not without limitations and assumption. Notable exclusions from the discussion are construction activity outside the UK, house building and builders merchants.

Research Method

The research method relies primarily on a literature review. Drawing specifically on supply chain management theory and practice and examples of off-site manufacture, the significance of an increasingly modular-orientated supply chain in construction is explored and evaluated. Secondary data is provided via anecdotal evidence gathered from a number of construction site visits and discussions with a cross-section of industry stakeholders. These include discussions with senior construction managers from first tier construction contractors and second tier construction sub-contractors and/or suppliers.

DISCUSSION

The economic exchange of construction services and products does not occur in a vacuum. Consequently, many factors impact individually and collectively on the commercial decision-making process. The discussion that follows draws particular attention to two key factors. First, the organizational interface between the main construction contractor and construction suppliers specializing in the provision of construction technologies collectively labelled as modern methods of construction (MMC). Second, the re-engineering of the construction supply chain and associated positions of power and trust.

Organizational Interface

The theoretical merits of off-site manufacture and MMC are well documented (Doran and Giannakis, 2011). Over the past decade construction clients have been seen as the main protagonists for MMC. However, it could be argued that main construction contractors also have a notable role to play. The adoption or rejection of MMC for main construction contractors is a choice among alternatives, inextricably linked with wider business interests, project objectives, commercial risk and management of uncertainty. Consequently when afforded the choice between traditional on-site operations or increasing implementation of off-site MMC, the non-adoption of MMC may be an instrumentally rational response to managing power and anti-trust relations.

Consequently, construction industry adoption of MMC is not a decision based solely on technological capacity and capability. On the contrary, central to industry adoption and utilization of MMC is the management of the organizational interface between the client, main contractor and the MMC supplier. Given the power and relationship management approaches outlined by Cox *et al.* (2000), a shift towards a manufactured product base would arguably alter the traditional relational dynamics of the construction supply chain. Introducing ever-increasing technological specialization and standardization in to the manufacturing and supply network arguably limits the choice of capable suppliers available to the main contractor. The rise in prominence of highly ‘specialist’ sub-contractors offering products and services that are both beneficial and simultaneously scarce generates a commercial power shift within the supply dyad that construction main contractors may find unnerving and clients, problematic.

Given industry experience of endemic insolvency (Chevin, 2010), main construction contractors and clients are justifiably cautious. Recent research suggests one in ten large construction organizations are dependent upon high-risk suppliers (CIOB, 2012), a disquieting trend that raises growing questions of supply chain insecurity and exposure to commercial risk. A recent site visit to a major NHS hospital development confirmed this concern. The senior project manager was keen to explain that if a plumbing organization went in to liquidation, they could be replaced with minimum disruption. On the contrary, if a specialist supplier of bathroom pods went in to liquidation, then operational consequences for the project in terms of cost, time and specification would be substantial. Given the choice, main contractors may take a business-orientated decision to negate the opportunity to promote MMC in favour of well-established, low-risk and readily available construction trades.

In terms of supply chain governance, the lower the technical development and specialization, the lower the risk and commercial commitment of the main contractor. Conversely, the higher the technical development and specialization associated with the product or service (for example bathroom pods), the greater the commercial interdependency. Managing varying degrees of service or product specialization is arguably a central concern when adopting MMC. For some, recognition of increasing levels of specialization and project standardization requires resourceful management and a potential re-engineering of the construction supply chain governance structure.

Re-engineering the Construction Supply Chain

The notion of re-engineering the construction supply chain is not intended as a panacea for poor construction productivity and performance. The construction industry, like many other sectors is capable of supporting alternative forms of commercial exchange (Miles and Snow, 1986). However, MMC complete with ever-increasing levels of technological innovation and complexity arguably necessitates relational management and organizational integration some may consider atypical of the construction sector.

An alternative to traditional, arm's length contracting is a hybrid mode of governance. Neither a market nor hierarchy, a hybrid mode of governance (network or clan) reflects risk-sharing both parties willingly undertake and governance mechanisms put in place to resolve inherent contractual imprecision. In short, "trust supplants power as the key concept" (Williamson, 2008 p.10). For example, if considerable project risk resides with the supplier of specialist modular units then the unit cost to the construction contractor and the client will be greater than if the risk resided primarily with the construction contractor. Conversely, if the risk is absorbed by the construction contractor the unit cost would arguably come down but at the potential expense of commercial power and leverage. The balance of the commercial exchange however may be countered if the construction contractor can incentivise longer-term relations via guarantees of regular demand and volume. Given the trading challenges facing the supply-side of the MMC market, the specialist supplier would find it difficult to sever commercial ties with the buyer (Cox *et al.* 2006). The resultant collegiality of the commercial exchange alleviates the inherent risk associated with MMC and may provide a cost effective way to pilot innovative construction methods.

Building on Cox *et al.*'s (2000) power regimes and Williamson's (1975) concept of transactional cost economics (TCE), the technology of transacting (Williamson, 1996) and interpretation of supply chain management (Williamson, 2008); a correlation between varying degrees of MMC development and specialization and alternative

supply chain governance structures may be projected (Figure 2). If technical development and specialization (s) is negligible (s = 0), a buy option via pro-market governance of the supply chain may provide the optimum performance outcome. Due to the homogeneous nature and ample availability of the commodity there is very little commercial incentive to cultivate long-term relationships (Gruneberg and Ive, 2000). Alternatively, if technical development and specialization is very high (s = 1), a make option via an organizational hierarchy may provide the optimum solution given that substantial levels of specialized investment are difficult to support via a market mode of governance (Zenger and Hesterly, 1997). If technical development and specialisation is neither zero nor one (0 < s < 1) then a hybrid mode of governance either a supply network or clan may provide the commercial agility and relational flexibility (Powell, 1990, Ouchi, 1980) to accommodate varying degrees of specialization and product standardization frequently associated with MMC.

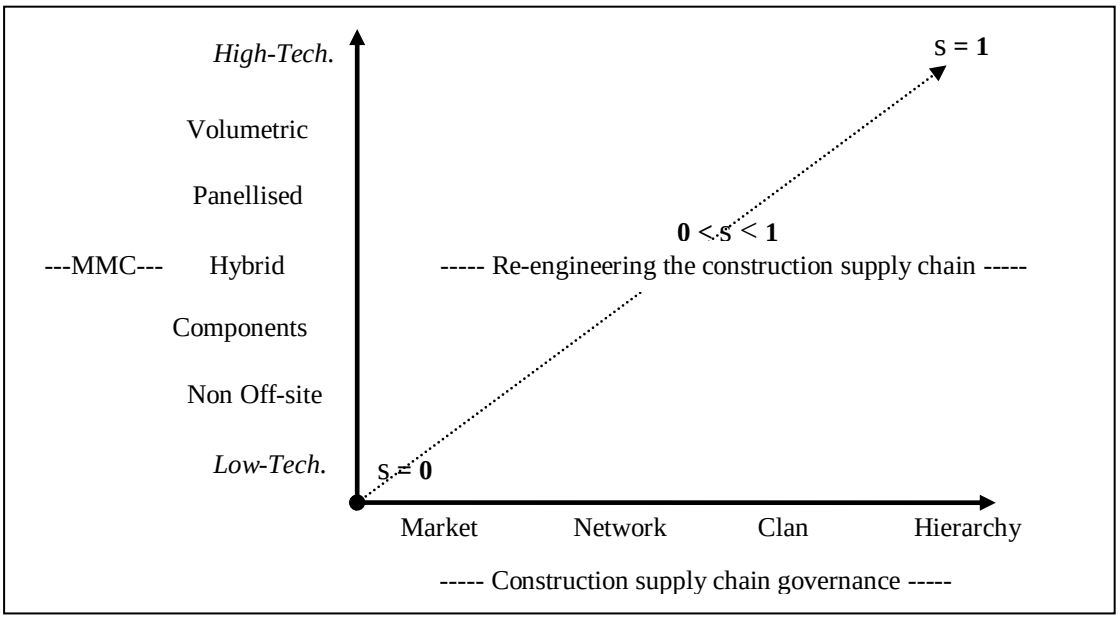

Figure 2: Re-engineering the construction supply chain

In contrast to much of the prevailing literature, the promotion and implementation of MMC needs to be explored from research perspectives other than technological. Developing a research agenda drawing on multiple theories of innovation, diffusion and organizational institutionalism is likely to portray an insightful and alternative prescription of MMC and industry interest regarding transferring on-site activity, off-site. Construction innovation, diffusion and organizational institutionalism and by extension mechanisms of institutional change are inextricability linked (Redmond, 2003). Given that you cannot have one without the other(s), re-engineering supply chain management practice rooted in the institutional assumptions of pro-market trading and by extension supply chain governance, is likely to prove difficult.

CONCLUSIONS

The imminent challenge for MMC is not primarily technological. On the contrary, the technological capability and capacity for modular construction is both advanced and viable. The challenge for MMC is trust. Construction management inability or intransigence to re-engineer the supply chain governance structure to accommodate commercial relations that are increasingly economically, socially as well as

technologically bound may ultimately impede the adoption and subsequent implementation of MMC.

The constant interplay between power and trust in the majority of construction transactions provoke both parties to remain guarded of the commercial motives driving the relationship. There arguably exists a Pareto optimal, where the rewards of the buyer cannot be increased without reducing the rewards of the supplier and vice versa. Given the prerequisite for equilibrium within the economic transaction of construction goods and services, supply chain relationships governed by trust remain largely fanciful. Repeated failure to supplant power with trust may have far-reaching consequences for a construction industry keen to exploit the productivity and performance benefits of MMC.

In the absence of trust, provisional lessons from the construction industry (Buildoffsite, 2009) suggest a 'make' option via a hierarchical organizational structure may provide the optimum governance solution to the design and off-site manufacture associated with MMC. However, a hierarchical form of supply chain governance replacing price and trust with authority and competition and collaboration with bureaucracy is not without limits. Consequently, the implications and limitations of alternative modes of supply chain governance (market, network, clan and hierarchy) and MMC need to be studied and better understood from multiple perspectives including innovation, diffusion and institutional change. Otherwise, non-adoption of MMC may provide a persuasive and 'risk-adverse' solution.

ACKNOWLEDGEMENT

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BARRIERS AND DRIVERS FOR INCREASED USE OF OFF-SITE BRIDGE CONSTRUCTION IN SWEDEN

Johan Larsson[1] and Peter Simonsson [2]

[1] *Dept. of Civil, Environmental and Natural Resources Engineering, Luleå University of Technology, 971 87 Luleå, Sweden.*

[2] *Swedish Transport Administration, Sundsbacken 2, 971 23 Luleå, Sweden.*

There is great pressure to change the civil engineering industry in Sweden, which is said not to follow efficiency growth other manufacturing sectors are achieving. This increases a demand for innovative construction methods and a growing industrialised thinking for sustainable construction. By implementing off-site manufacturing (OSM) into bridge construction, client satisfaction can increase, bridges can be constructed faster using less resource, and more bridges for the same invested capital can be realised. A questionnaire survey and a workshop have been undertaken partly to identify benefits and drawbacks for OSM in bridge construction and partly to study if OSM satisfies the client better than on-site construction. The outcome shows that drivers of OSM meet client needs better than on-site construction alternatives. Time, cost and working environment are large drivers, correlating well with previous surveys undertaken. However, quality, as in other surveys tend to stand out as a driver, is a barrier in comparison with on-site construction. This opinion may be due to both the generally negative views for OSM bridges in Sweden and also due to previous bad experiences. Despite these negative views, results show that the hypothesis of OSM being a better alternative for satisfying the client is true. To increase its market share, barriers like reduced quality and not aesthetically pleasing must be overcome. OSM bridges are to date a rare feature in Sweden, but by display the drivers, it could become a common construction method in Sweden.

Keywords: off-site manufacturing (OSM), bridge construction, client needs, barriers, drivers.

INTRODUCTION

Today there is a lot of talk about the demand of change within the Swedish civil engineering to become more industrialised. Like in many countries (Egan 1998, Blismas & Wakefield 2007), Swedish construction industry has been linked with inefficiency and not meeting client needs. To be able to implement new methods and techniques, a whole new approach involving all actors have to be implemented (Simonsson 2011). Off-site manufacturing (OSM) and standardisation are seen as large parts of industrialisation in Sweden. According to Eriksson *et al.* (2011) and

[1] johan.p.larsson@ltu.se

Larsson, J and Simonsson P. (2012) Barriers and drivers for increased use of off-site bridge construction in Sweden *In*: Smith, S.D (Ed) *Procs 28th Annual ARCOM Conference*, 3-5 September 2012, Edinburgh, UK, Association of Researchers in Construction Management, 751-761.

Olander *et al.* (2011) the benefits for industrialisation is increased productivity, leading to time and cost reduction. Barriers include conservatism, strict codes and unsuitable contracts. Several productivity studies, e.g. (Horman and Kenley 2005, Mossman 2009) identify that wasteful activities stands for between 50-65% of available construction time. OSM is seen as a method to reduce waste and complexity related to on-site construction (Tam *et al.* 2006, Ballard and Arbulu 2004).

Much has been written on drivers and barriers of OSM in general; nevertheless little emphasis of this construction method within bridge construction exists. OSM bridges can be seen as Non-volumetric preassembly products that are produced in a factory and then only installed into their final position at the construction site (Gibb & Isack 2003). These OSM bridge units can consist of beams and slabs but also prefabricated reinforcement cages and left formwork. Bridges in Sweden are to date most often on-site constructed, while OSM bridges are a common feature in other countries e.g. the Netherlands, Denmark, Poland and the United States, to name but a few. By highlighting the drivers and barriers with this construction method, the use of OSM within Swedish bridge construction could become more common as in other countries.

In this research, benefits and drawbacks are product related and only become drivers and barriers if these factors are important for the client. Hence, drivers and barriers are important factors to satisfy client needs.

To investigate if OSM is satisfying client needs better than on-site construction and also to highlight barriers and drivers for OSM a comprehensive survey has been completed. To complement important results from the survey a workshop has been undertaken. In spring 2010, a new Swedish authority (Swedish Transport Administration) was formed with the task to develop an effective and sustainable transport system. The authority has, from the government, been given the task of creating conditions for increased productivity within the industry. This should be done through conveying a larger responsibility to the actors on the market e.g. contractors and designers. STA is responsible for the construction, operation and maintenance of public roads and railways including bridges. Because of this transformation, the opportunity to change Swedish bridge construction is today larger than ever. It is easier to define client satisfaction within bridge construction compared to e.g. house construction, because only one major client exists operating under strict codes (Eurocodes).

Consequently, this paper aims to answer the following research question: Is client satisfaction increased by implementing more OSM into Swedish bridge construction?

OSM RESEARCH

General

OSM has in general been recognised as a vital element for improving construction in terms of efficiency and productivity (Blismas & Wakefield 2007). Drivers often associated with OSM are time, quality, cost and health and safety (H&S) related (Blismas *et al.* 2006, Gibb & Isack 2003). Perceived drivers and barriers of OSM are well documented (Blismas *et al.* 2006, Gibb & Isack 2003, Nadim & Goulding 2011). OSM and its' benefits are poorly understood by many involved, consequently a reluctance of using it is widely spread (Pasquire & Gibb 2002, CIRIA 2000).

Barriers for increased use of OSM are mostly process, value, conservatism and knowledge related (Blismas *et al.* 2005). A major drawback is that design of the structure has to be established early in the projects lifecycle because of the long

supply-chain associated with OSM. A more complete understanding of the process and cooperation throughout the whole supply-chain are two major issues needed to be understood regarding OSM (Pan and Sidwell 2011 and Gann 1996). According to Nadim and Goulding (2009), both academia and practitioners agree that communication skills, teamwork and problem solving plays major part in increasing the uptake of OSM. Construction industry is more focused on initial construction cost rather than value, hindering OSM to be equitably evaluated (Blismas *et al.* 2006, Pasquire & Gibb 2002). Previous OSM research regarding drivers and barriers is summarised in Table 1.

OSM bridge

Research within off-site bridge construction often involves case studies of a specific project or concept, not surveys and interviews which often are included in general OSM research. Concerns associated with bridge construction is often the same as for general construction, but one specific area for bridges is traffic disruption which often has to be considered (NCHRP 2003). Case studies are often performed on prefabricated bridge concepts and reducing traffic disruption is often highlighted as the major driver (Freeby 2005, Russell *et al.* 2005). OSM are often evaluated on the assumption that they reduce traffic disruption in comparison to on-site construction.

Other documented drivers for prefabricated bridges are; improved H&S, improved constructability, increased quality, reduced environmental impact and lower life-cycle costs. These are correlating well with drivers for OSM in general (Gibb and Isack 2003). OSM bridge research seldom discusses drawbacks, but only highlights the benefits that are available (Freeby 2005, Federal Highway Administration 2006, Russell *et al.* 2005). Insufficient attention has to date been devoted to explore what barriers and drawbacks that exist for OSM bridge construction and how this construction method satisfies client needs, see Table 1.

QUESTIONNAIRE SURVEY AND WORKSHOP

A comprehensive questionnaire survey has been undertaken to form the foundation for this research. The respondents include contractors, consultants/designers, OSM suppliers and clients. For a complete summary of respondents and their experiences of on-site and OSM, see Table 2. Questionnaire forms where sent to the respondents by email and completed surveys where sent back by return email, making it possible to reach numerous respondents at the same time. 159 questionnaire forms where sent out, with 66 answering respondents which makes the respondent rate approximately 42%. The number of respondents is not sufficient for the results to be statistically significant. The survey and workshop contains qualitative elements which support the quantitative results, making it possible to draw conclusions.

Table 1: Research summary of drivers and barriers for off-site manufacturing

General OSM	**Research method**	Quality	Predictalility/Consistency	Fewer defects	Cost	Initial cost	Life-cycle cost	Value for money	Profitability	Time	Minimize on-site operations	Minimize construction delays	Traffic disruption	Process	Reduce waste	Cooperation	Codes	Lead-time	Design fixed early	Present process and management	Health & Safety	Environment	Productivity	Constructability	Fewer people involved	Need of skilled workers	Suitable evaluation tools	Negativism/Conservatism	Lack of knowledge	Few available suppliers
Blismas et al. (2005)	S									D				B				B		B							B		B	B
Blismas et al. (2006)	C																										B			
Blismas & Wakef. (2007)	W, C, I		D		D	B				D				D	D		B	B	B	B	D	D				D		B	B	
Gibb & Isack (2003)	I	D			D					D	D			D				B	B				D		D		B			
Goodier & Gibb (2001)	L, S, W	D				B				D																	B	B		
Pasquire & Gibb (2002)	I	D	D	D	D			D	D	D											D	D	D				B			
Tam et al. (2006)	I														D															
Pan & Sidwell (2011)	C				D					D						B														
Olander et al. (2011)	L, C				D											D	B			B			D					B		
Eriksson et al. (2011)	I				D					D													D				B	B		
OSM bridge																														
Russell et al. (2005)	C	D					D						D								D	D		D						
Freeby (2005)	C	D					D						D								D	D		D						
Fed High. Adm. (2006)	C					D				D																				
NCHRP (2003)	L	D			D	B				D		D	D								D									
Summary		6D	2D	1D	7D	1D 3B	2D	1D	1D	9D	1D	1D	3D	2D 1B	2D	1D 1B	2B	3B	2B	3B	5D	4D	4D	2D	1D	1D	6B	4B	2B	1B

D=driver, B=barrier, S=survey, C=case study, I=interview, W=workshop, L=literature review

Table 2: Experience of the respondents from the questionnaire survey

Roll (Resp. num.)	**Contractor (27)**			**Client (21)**			**Designer (13)**			**OSM suppl. (5)**		
Experience (Years)	<1	1-5	>5	<1	1-5	>5	<1	1-5	>5	<1	1-5	>5
Construction	0%	7%	93%	0%	0%	100%	0%	0%	100%	0%	20%	80%
On-site	4%	11%	85%	10%	10%	80%	0%	0%	100%	20%	40%	40%
Off-site	41%	22%	47%	29%	23%	48%	24%	38%	38%	0%	40%	60%

The survey was kept as short as possible containing a total of 25 questions, hence a too comprehensive survey increases the risk of losing respondents and the answers tend to contain less thoughtful answers (Holme & Solvang 1991). The questionnaire were discussed and debated with several persons, both practitioners and academics, before distribution, in order to minimize misunderstandings and leading questions. Leading questions and loaded formulations could otherwise greatly influence the answers (Andersson 1985). The research is inductive meaning that the survey was undertaken before theory around the topic where studied.

The survey formulated most questions with structured responses through a five-point scale making it easy to answer and to compile the material. Most questions allow respondents to provide comments in addition to the structured response options, making the answers more rich (Bergman & Wärneryd 1982). Topics for the survey were selected to give an overview of the industry today and what is expected of the future including questions about; different contract forms, early involvement from different actors, development of the industry in Sweden, OSM, standardization, on-site construction, industrialised thinking and important factors for bridge construction.

To complement results from the survey, a workshop involving contractors, clients and OSM suppliers has been undertaken. Participants were selected based on experience and influence opportunity for the development of the industry, making it possible for the outcome to be passed out to the rest of the industry. Four groups were formed to discuss five specific questions during the workshop; industrialisation, client/customer satisfaction, cooperation, uniqueness of the construction industry and reluctance to change. The topics were chosen based on problems for sustainable development identified in the undertaken questionnaire survey.

RESULT AND ANALYSIS

According to the survey, all participants are convinced that bridge construction in Sweden has to become more efficient and effective in the future. Involved actors tend to blame low productivity and lack of development on thoughts that the industry in some way is unique and therefore, impossible to change. Other causes for lack of development are according to the survey; strict rules and norms, wide spread conservatism and lack of competition with few contractors.

Respondents are disagreeing on the question if bridge construction has become more industrialised the last years. Many respondents are only associating industrialisation with OSM and not with other factors, e.g. processes and standardisation.

Benefits and drawbacks for off-site manufacturing

An overview of the ranked benefits and drawbacks for OSM bridge construction in Sweden, according to the outcome of the survey, shows that time and health and safety (H&S) are the largest benefits. Aesthetic aspects are according to the undertaken questionnaire survey a major drawback, see Figure 1.

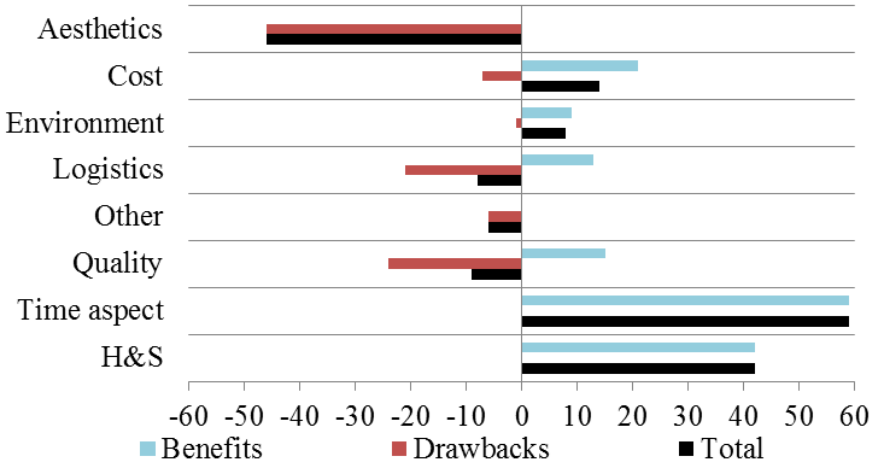

Figure 1: Benefits and drawbacks for OSM. Scores were derived from survey results where respondents could choose up to three factors

Respondents often use words like "ugly" and that all prefabricated bridges look the same. Quality, which often is stated in previous research as a benefit for OSM, is in this survey seen as a negative factor for OSM bridges. Studying this question even deeper, reveals that OSM suppliers are seeing quality as a major benefit but especially clients and designers see quality as a drawback.

Benefits and drawbacks for on-site construction

Two major benefits for on-site construction are aesthetics and quality according to the survey, see Figure 2. Quality which is seen as a minor drawback for OSM bridges is seen as the largest driver for on-site construction. This result does not correspond well with previous undertaken research (Freeby 2005, Blismas & Wakefield 2007, Gibb & Isack 2003).

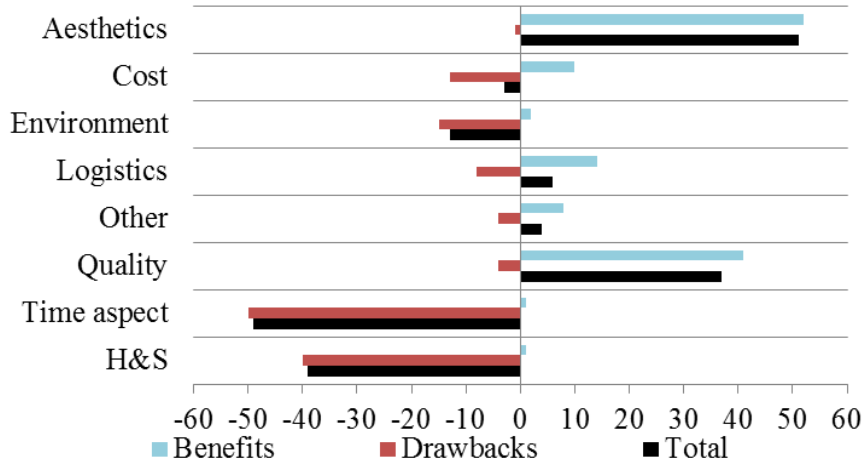

Figure 2: Benefits and drawbacks for on-site construction. Scores were derived from survey results where respondents could choose up to three factors

Client satisfaction

Factors with the greatest importance when constructing a bridge in Sweden, is according to the questionnaire survey quality and cost, see Figure 3. Time is less important for contractors and consultants, but instead these actors seem to think aesthetic aspects are very important. The total score is correlating well with what clients seem to think are important factors. Quality, cost, time and H&S are the four

most important factors for satisfying client needs when constructing a bridge. This result correlates well with previous survey undertaken about OSM in general. Hence, these four could be seen as drivers or barriers for the different construction methods.

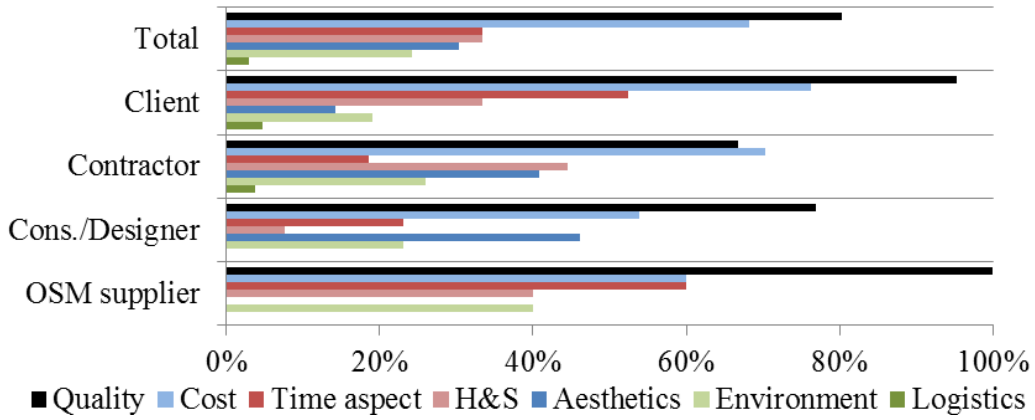

Figure 3: Most important factors for bridge construction. Scores were derived from survey results where respondents could choose up to three factors

By taking the benefit scores for the four most important factors out of Figure 1 and Figure 2, and multiplying these with the total importance for each factor, Figure 3, the drivers and barriers for the construction methods are revealed, see Figure 4. By making a radar diagram of the scores obtained shows that OSM is satisfying client needs better than traditional on-site construction, see Figure 4. The sum for OSM drivers are 60 while the same number for on-site construction is 40. Quality is, according to the radar diagram, the largest barrier for OSM, while time, cost and H&S are drivers for increased use of OSM within bridge construction in Sweden.

	Quality	Cost	Time	H&S
Benefits for OSM	15	21	59	42
Benefits for On-site	41	10	1	1
Importance of factor	0,80	0,7	0,3	0,33
Drivers for OSM	12	14	20	14
Drivers for On-site	33	7	0	0

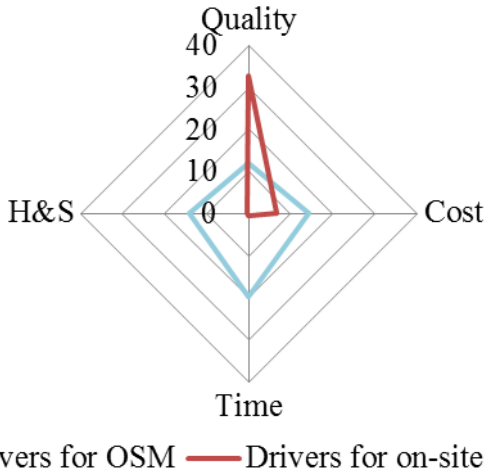

Figure 4: Construction methods most suitable for satisfying the client needs

Structures suitable for OSM and standardisation

Bridges in Sweden will, according to the questionnaire survey, in the future consist of a combination of on-site construction and OSM, see Figure 5. Clients and OSM suppliers are more positive to OSM than contractors and consultants. According to the survey, differences between the two construction methods are mostly time, quality and aesthetics related, but also flexibility and process are frequently mentioned. Design has to be set earlier in an OSM project, hence OSM is less flexible and changes are more difficult to deal with at the construction site.

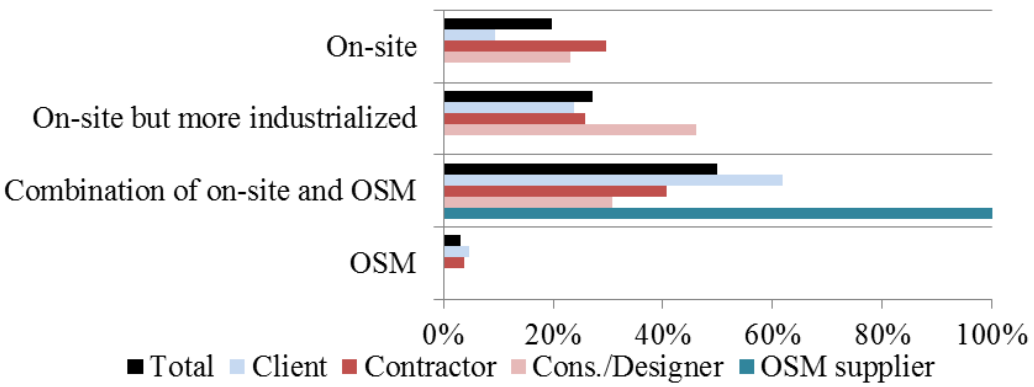

Figure 5: Future construction methods for bridges in Sweden

94% of all respondents think that it is possible to standardise bridges or at least parts of bridge structures. Almost 50% of all respondents think that the superstructure of bridges benefits most of OSM and standardisation. Hence, OSM superstructures have been tested in Sweden and abroad with satisfying results. 33% of all respondents believe that the superstructure is the bridge structure that demands most working hours on-site, probably contributing to the positive approach for OSM.

Workshop discussion

To complement the survey results, a workshop has been undertaken. A summary of the three most important questions for this research from the workshop can be seen in Table 2. The first question is about industrialised thinking and what elements that are involved in it. One aim with industrialised thinking is to increase the customer satisfaction. Hence, second question is about what elements that are associated with customer satisfaction, in this case the customer is the user of the bridges. The industry is said to be change reluctant and that involved actors often are conservative. Third question deals with components that could facilitate for possible changes.

Table 2: Summary of the three most important questions from the workshop

Elements associated with industrialised thinking	
Processes	OSM
Standardisation	Traceability
Elements associated with customer satisfaction	
Satisfying a need	Shortened construction time
Information about disruption	Minimise traffic disruption during construction
Elements that facilitate for changes	
Must be able to see profit of changes	Focusing on value when peforming the procurement
Understanding of the process	More available time in the beginning of the project
Positive and involved clients	Increased understanding and respect for people

OSM is a major part of an industrialisation of construction in general, but also for bridge construction. A standardised product is in need of a standardised process to be as efficient and effective as possible to construct. Standardised work and standardised products are of great importance to be able to gain advantages associated with repeatability. For that to be possible, similarities between projects have to be recognised and utilised. Working with continuous improvements and seeing the whole value chain is, according to all group discussions, an important part of an industrialised thinking. Cooperation between involved actors and creating clear communication channels are necessary to increase the client satisfaction. By letting

involved actors fully understand what the changes is all about and that it takes to time to change a whole industry is of great importance to be able to get everyone on-board.

It is important to conduct long-term thinking regarding changes within this or any industry to recognise the value of changes. In bridge construction it is important not only to focus on initial construction cost but also on, e.g. improved working environment, decreased life-cycle costs and improved quality. Increased understanding of the complete construction process, and not only for the own companies process, is of great importance for the project to be planed correctly and successfully executed.

DISCUSSION & CONCLUSIONS

The presented result from the survey shows that client needs are better fulfilled by using OSM for bridge construction in Sweden. It also provides opinion of how different actors within civil engineering think about OSM and the utilisation of this construction method. Despite that OSM is a rare feature in Sweden, 70% of all questionnaire respondents answer that they holds more than one year of OSM experience. The conclusions are based on one questionnaire survey including 66 respondents. Hence, some limitations in the conclusions can be foreseen. A workshop has been performed to verify some important results from the survey.

Major drivers for OSM within bridge construction in Sweden are time, H&S and cost. Largest drawback for OSM bridges is the aesthetics. Prefabricated bridges are most often associated with unattractive appearance and that they all look the same.

Quality is seen as a major driver for on-site bridges even though this construction method often is linked with unpredictable construction conditions, e.g. weather. By constructing the bridge in a factory, as for OSM, and only assemble it at the construction site, circumstances for obtaining high quality products should increase. This rather unexpected result, for the quality factor, is probably based on past experience and also due to the general resistance and negative view that exists for OSM in Sweden.

If considering the four most important factors for bridge construction according to the questionnaire survey; quality, time, cost and H&S, from a client perspective, these fits better into OSM than traditional on-site construction according to the survey. For OSM to be more common, both client and contractor have to understand the benefits of using it.

Future research will focus on process platforms for bridge construction containing elements like experience feedback loop, this to be able to work with continuous improvements. By having a standardised process, it will be possible to measure how changes are affecting the end product.

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IDENTIFICATION AND REDUCTION OF NON-VALUE ADDING ACTIVITIES IN THE PRECAST CONCRETE CONSTRUCTION PROJECTS IN SINGAPORE

Peng Wu[1], Yingbin Feng[2] and Yun Zhong[3]

[1] *School of Engineering and Built Environment, Central Queensland University, Rockhampton, QLD 4701, Australia*

[2] *School of Computing, Engineering and Mathematics, University of Western Sydney, Penrith NSW 2751, Australia*

[3] *Department of Building, National University of Singapore, 4 Architecture Drive, 117566, Singapore*

Prefabrication systems are believed to have the potential for better environmental performance and have been adopted by the construction industry to meet the challenges posed by global climate change. However, there remains many areas in the prefabrication systems that can be improved in order to reduce carbon emissions, such as site layout, work flow and inventory control. This research therefore aims to identify the non-value adding activities that can be eliminated to reduce carbon emissions in the precast concrete construction projects in Singapore. A weighted factor model comprising 30 contractors in the Singapore construction industry is adopted. Two stages in the precast concrete installation cycle are investigated using the weighted factor model, which are site layout management and delivery management. The results indicate that there are many non-value adding activities in the precast concrete installation cycle that contribute to an increase in the level of carbon emissions, such as large storage area and lack of just-in-time sourcing. The analysis provides good practice guidance and can be used as a checklist for contractors to achieve low-carbon installation. The results will also be useful for regulatory agencies to provide recommendations for the construction industry to reduce carbon emissions.

Keywords: carbon emissions, non-value adding activities, prefabrication, sustainability.

INTRODUCTION

Climate change has emerged as one of the most pressing environmental issues in recent years (Building Research Establishment 2004). The most significant source is carbon emissions, which causes considerable threat to human development, including sea level rises, death of humans and loss of biodiversity (Intergovernmental Panel on Climate Change 2001). Industry and human activities, e.g. fossil fuels consumption,

[1] p.wu@cqu.edu.au

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produce greenhouse gases (GHGs) which affected the composition of the atmosphere. It is believed that human activity is the most significant source of emissions, which is mainly caused by fossil fuel consumption, such as petrol, gas, oil and diesel.

The construction industry contributes to an increase in the level of carbon emissions in many ways (Kruse 2004). For example, the cement section alone accounts for 5% of global man-made carbon emissions (Worrell *et al.* 2001a). The manufacturing of raw materials (e.g., cement and steel) and chemicals have a considerable impact on carbon emissions (Worrell *et al.* 2001b). The transport of raw materials, such as cement, aggregates, and steel, is energy-intensive, particularly for countries like Singapore that heavily rely on the import of raw materials (Wu and Low 2011). The on-site construction of buildings is not always effect and may generate unnecessary carbon emissions (Wu and Low 2012). Precast concrete products are therefore advocated because of their potential benefits towards better environmental performance (e.g., Sanders and Phillipson 2003; Gorgolewski 2005; Tam *et al.* 2006). Many studies have been completed on the improvement that can be made for precast concrete manufacturers (Ballard *et al.* 2003; Ko 2010; Wu and Low 2011). However, it should be noted that the complete life cycle of precast concrete products should also include the installation, operation and demolition. This study therefore aims to take the first step to identify the non-value adding activities in the installation cycle of precast concrete products. The non-value adding activities in site layout management and supply chain management are firstly discussed in this paper.

NON-VALUE ADDING ACTIVITIES AND ENVIRONMENTAL PERFORMANCE

Originating from the Toyota Production System (TPS), the lean concept is the observation that there are two aspects in all production systems: conversions and flows (Koskela 1992). Conversions activities refer to those which actually add value to the product or process. Flow activities refer to non-value adding activities. Only value adding activities are essential to the production process. It is a waste of time and resource to apply improvements to flow activities. The lean concept therefore aims to create an environment where conversion and flow activities are separated and treated differently. Conversion activities are improved while flow activities are eliminated at the same time. Some of the improvement technologies that originate from the lean concept include:

- Just-in-time (JIT): The right parts needed in production reach the assembly line at the time they are needed and only in the amount needed in a flow process (Ohno 1988).
- Total quality control (TQC): The concept refers to three extensions: expanding quality control from production to all departments; expanding quality control from workers to management; and expanding the notion of quality to cover all operations (Shingo 1988).
- Concurrent engineering: It refers to an improved design process characterized by rigorous upfront requirements analysis, incorporating the constraints of subsequent phases into the conceptual phase, and tightening of change control towards the end of design process (Koskela 1992).
- Employee involvement. The organizational goals and personal goals can both be achieved if employees are treated with equity and respect in terms of being involved with decision making, being provided with meaningful jobs and being given the opportunity to learn (Stendel and Desruelle 1992).

Elimination of non-value adding activities has proven to be effective in increasing environmental benefits. Luo *et al.* (2005) found that it could contribute to improve quality and supply chain. Nahmens (2009) found that by applying the concept to a production line, 9 to 6.5 people (labour waste), 12% space (equipment waste) and 10% wallboard (material waste) can be reduced. Miller *et al.* (2010) applied the concept to a small furniture production company and found that it can help the company meet every increasing customer demands while preserving valuable resources. In these studies, wastes, environmental burdens, and environmental deterioration were commonly used as the contributions that can be achieved by applying the concept.

RESEARCH METHODOLOGY

A questionnaire was designed to identify the non-value adding activities in the site layout and delivery management practices. The questionnaire was divided into different sections to include all possible non-value adding activities. In site layout management, the categories of non-value adding activities included: 1.1) construction materials; 1.2) site facilities; 1.3) statutory requirements; 1.4) construction requirements; 1.5) temporary works and services; 1.6) storage area; and 1.7) managing the construction site. Similarly, in delivery management, the categories included: 2.1) damages during transportation; 2.2) selecting precasters; 2.3) just-in-time management; 2.4) other delivery management practices.

Population, samples and sampling method

The questionnaire was distributed to all major contractors in Singapore. According to Building and Construction Authority (2010), the registered contractors in Singapore were classified into seven levels by their financial grade, which are A1, A2, B1, B2, C1, C2 and C3 (A1 being the highest financial grade and C3 being the lowest financial grade). According to the Directory of BCA Registered Contractors and Licensed Builders (Building and Construction Authority 2010), there were 87 contractors within the higher financial grade (A1 and A2), who would frequently be awarded with public housing projects in Singapore. These 87 contractors would therefore form the population of this study. In accordance with the data analysis method, which will be explained below, a minimum of 30 contractors was required in order to conduct the parametric tests to test the significance difference between different non-value adding activities. Convenience sampling method was used to choose the samples from the population. The contractors who were firstly interviewed were requested to provide one or two more contractors who had been involved in precast concrete projects in Singapore. 32 contractors were approached by email and telephone. Because of the complexity of the questionnaire, semistructured interviews were requested with either the site managers or the project managers. A total of 30 responses were received.

Data analysis method

In order to identify the key non-value adding activities, a weighted scoring model was adopted in this research. According to Williams (1993), the risk concept could be broken into the two factors: probability of occurrence (P) and level of impacts (I). The severity of the risk (S) can therefore be described by multiplying the probability of occurrence with its corresponding impact, as shown in the following equation:

$$S = P \times I$$

A five-scale value range was adopted to assess the probability of occurrence of the non-value adding activities in the installation cycle. The range was: (1) very low; (2)

low; (3) medium; (4) high; and (5) very high. Accordingly, the impact on carbon emissions was assessment by a five-scale value range, which was: (1) insignificant; (2) minor; (3) moderate; (4) major; and (5) catastrophic. Paired sample t test was used to test the significance between two different non-value adding activities at a 95% confidence interval. The null hypothesis was that the difference between the two mean values was zero. If the ρ value was less than 0.05, the null hypothesis would be rejected. In other words, the two non-value adding activities compared in the paired sample were significantly different.

SITE LAYOUT MANAGEMENT

According to the results of the survey, as shown in Table 1, the most frequent non-value adding activities in the construction sites where the precast concrete products were used included:

- 1.7.3 Site layout plan is not placed on the notice board for information (2.63)
- 1.1.3 Does not think of the green building materials (2.53)
- 1.7.4 Changes to the site layout plan are not notified immediately (2.47)

The decision regarding the use of green building materials should be made before transportation and installation. Because of its high priority, the use of green building materials was discussed in site layout management. The site layout plan was very important when there are changes in project managers, supervisors and subcontractors during the contract. According to the contractors, green building materials were only used in projects that were targeted for green mark certification. The most commonly used green building materials was the green concrete which was specially manufactured using fly ash or other recycled materials to replace Portland cement. Although the price of such green concrete was slightly higher (S$5 higher per cubic metre for the grade G35 concrete) than the Portland cement concrete, it was seldom used in precast concrete projects unless the projects were targeted for green mark certification. In addition, in precast concrete projects where the green concrete was used, only the minimum requirements in the green mark certification programmes were met. It seems that more incentive schemes from the government should be promoted to encourage the use of more green building materials.

One significant difference between the precast concrete factories and the construction sites was the storage area. Unlike in precast concrete factories where large storage area was provided (Wu and Low 2011), the storage area in the construction sites was relatively small. Contractors placed the order based on a quantity estimation in the following one or two days. However, it should be noted that non-value adding activities such as transferring and singling out activities happened regardless of the size of the storage area. Carbon emissions were emitted no matter which storage type was used.

In addition, the three most important factors that would increase the level of carbon emissions were:

- 1.1.3 Does not think of the green building materials (4.37)
- 1.7.1 Site layout plan is not tested for economic and efficient construction (3.80)
- 1.1.2 Inaccurate estimation of quantities required (3.77)

Contractors agreed that the green building materials were very important if they aimed to achieve low carbon construction. In addition, the site layout should be designed to

support economic and efficient construction, especially for transportation and erection activities which relied on the use of equipment and plants heavily. If a JIT delivery system was adopted in the construction sites, accurate estimation of the quantities of precast concrete products should be focused on. All contractors stated that the quantities could be accurately estimated based on a stable construction schedule.

When considering both the probability and impact, the severity of these non-value adding activities in site layout management is shown in Table 1.

The most important factors included:

- 1.1.3 Does not think of the green building materials (10.83)
- 1.7.1 Site layout plan is not tested for economic and efficient construction (6.93)
- 1.1.1 Improper specifications of the precast concrete products (6.93)
- 1.1.2 Inaccurate estimation of quantities required (6.73)

The contractors agreed on the importance of using green building materials to achieve low carbon construction, as well as the importance of an effective site layout plan to support green construction activities. The specifications of the precast concrete products should be completed at the very start and minimum alterations should be made to the specifications. According to one contractor, changes made from using off-site fabrications to on-site fabrications had happened in the past. Such changes would cause modifications to the site layout plan, as well as the erection method, causing more carbon emissions to be emitted. Five ranking groups were identified, as can be seen from Table 1. When allocating resources (time, human resources and costs) to eliminate the non-value adding activities, the ranking groups that were identified by the paired sample t-tests should be considered. For example, although factor 1.7.1 (Site layout is not tested on economic and efficient construction) had higher severity than factor 1.5.2 (Tower cranes' fully blocked area should be large), these two factors were statistically insignificantly different.

Table 1: Ranking and grouping of non-value adding activities in site layout management

Ranking	Factor No.	Description	Severity		
			AR	Sig. (2-tailed)	SD
1	1.1.3	Does not think of the green building materials	10.83	N/A	4.43
2	1.1.1	Improper specifications of the precast concrete products	6.93	0.0001	3.19
				N/A	
2	1.7.1	Site layout plan is not tested for economic and efficient construction	6.93	1.000	3.15
2	1.1.2	Inaccurate estimation of quantities required	6.73	0.709	2.68
2	1.5.3	Inappropriate design of sitting of static plants	6.10	0.232	1.56
2	1.5.4	Inappropriate design of parking of mobile plants	5.90	0.177	1.86
2	1.5.2	Inappropriate design of tower cranes' fully blocked area should be large	5.63	0.064	1.65
3	1.7.3	Site layout plan is not placed on the notice board for information	5.03	0.010	2.24
				N/A	
3	1.5.1	Inappropriate design of space for access	4.87	0.672	1.94
3	1.3	Does not comply with mandatory statutory requirements	4.77	0.676	2.49
3	1.7.4	Changes to the site layout plan are not notified immediately	4.67	0.317	2.38
3	1.4.4	Does not pay full attention to the use of other equipment and plants	4.60	0.489	2.46
3	1.2	No overall consideration of construction site facilities	4.27	0.156	1.64
3	1.7.2	Site layout plan is not sent to subcontractors and general foreman	4.23	0.056	2.30
4	1.4.2	Does not pay full attention to the office space	3.60	0.011	1.28
				N/A	
4	1.4.5	Does not pay full attention to services required	3.60	0.9999	1.40
4	1.6.3	Over provide storage area – Open store	3.5	0.748	1.28
4	1.4.3	Does not pay full attention to the maximum number of men on site	3.37	0.243	1.47
4	1.6.2	Over provide storage area – Weatherproof store	3.23	0.239	1.36
4	1.6.1	Over provide storage area – Secure store	3.17	0.146	1.26
5	1.4.1	Does not pay full attention to the duration	3.10	0.037	1.18

Notes: AR = Average Rating; SD = Standard Deviation

DELIVERY MANAGEMENT

Similar to the section on site layout management, the non-value adding activities in delivery management were rated by both probability and impact using a five-point scale. The most frequently occurring non-value adding activities in delivery management were:

- 2.2.3 Transportation is not taken into consideration (3.17)
- 2.3.3 No advance order and confirmation order (2.80)

22 contractors (73.33%) stated that transportation was not always a consideration when selecting the precasters (when P=5, P=4 and P=3). The delivery performance of the precasters was very good in the aspects of managing to deliver on time with the right quantity and good quality, as rated by the 22 contractors. It was sometimes the contractors' fault that the delivery vehicles were left idling due to site congestion. The two-order system derived from the JIT delivery system and as proposed by Tommelein and Li (1999) was sometimes not adopted by contractors who believed that one order would be good enough because of the small quantity ordered every time.

However, it should be noted that the two-order system would also help the precasters to deal with changes. It was not only the contractor who could benefit from this system. On the other hand, a few factors which did not frequently happen in delivery management included:

- 2.3.4 Insufficient data exchange with the precasters (1.50)
- 2.3.1 Demand fluctuations (1.60)
- 2.4.1 No accurate delivery notes (1.67)

The data exchange between the precasters and the contractors seemed to be sufficient. The contractors were not facing demand fluctuations. Although the daily amount of usage might vary, such variation was very minimal. However, it was surprising to note that no immediate use of the delivered precast concrete products was conducted based on the stable erection schedule.

The most important factors that could cause an increase in the level of carbon emissions during transportation included:

- 2.4.2 Insufficient care (3.87)
- 2.1.2 The driver is not aware of a few typical damages during transportation (3.60)
- 2.4.3 Lack of routine inspection (3.57)

It seems that the contractors agreed on the important role played by the drivers during transportation. All contractors stated that by providing sufficient care, the damages from transportation could be reduced. Routine inspection before the release of the precast concrete products was very important to reduce carbon emissions from transportation. According to one contractor, during a three-month period, two rejections of the precast concrete products had happened, causing re-delivery to be arranged.

On the other hand, the large quantity supply base was not rated as an important factor by the contractors. Even if the quantity required for the next few days was delivered to the construction site, the precast concrete products could be stacked appropriately to

avoid damages. In addition, as the installation schedule was very stable, the contractors would not face any demand fluctuation. It is a common practice to order the precast concrete products to be used in the next one or two days. Consequently, large quantity supply would not happen in current construction projects which used the precast concrete products.

Table 2: Ranking and grouping and non-value adding activities in delivery management

Ranking	Factor No.	Description	Severity		
			AR	Sig. (2-tailed)	SD
1	2.4.2	Insufficient care	10.07	N/A	2.88
1	2.2.3	Transportation is not taken into consideration	9.20	0.183	2.61
2	2.1.3	Inappropriate packings and supports	8.70	0.0495 N/A	2.49
2	2.4.3	Lack of routine inspection	8.50	0.798	3.51
2	2.1.2	The driver is not aware of the few typical damages that may occur during transportation	8.30	0.498	2.63
2	2.1.1	No skilled attention to the details of supports and frames	8.20	0.471	2.75
2	2.3.3	No advance order and confirmation order	7.57	0.199	3.76
2	2.2.2	No single sourcing supply with long-term contract	7.40	0.142	3.79
3	2.3.2	Not fully prepared for the arrival of the precast concrete products	7.20	0.008 N/A	3.04
3	2.2.4	No quality audits of the precasters prior to the award of the contract	6.97	0.800	4.20
3	2.1.4	No standing instructions	6.43	0.220	2.36
4	2.3.1	Demand fluctuations	5.53	0.041 N/A	3.19
4	2.4.1	No accurate delivery notes	5.03	0.336	2.53
5	2.3.4	Insufficient data exchange with the precasters	4.37	0.021 N/A	2.30
5	2.2.1	Large quantity supply base	3.53	0.077	1.72

Notes: AR = Average Rating; SD = Standard Deviation

The severity of the non-value adding activities is shown in Table 2. The most severe non-value adding activities included:

- 2.4.2 Insufficient care (10.07)
- 2.2.3 Transportation is not taken into consideration (9.20)
- 2.1.3 Inappropriate packings and supports (8.70)

In order to achieve low carbon transportation for the precast concrete products, it seems that contractors should take transportation into consideration by ordering

locally manufactured products. The price structure should not be the only consideration especially under the "all-in-one" price structure. For one contractor, there were three L6 (highest financial grade) precasters located 3km away from the project site and yet the contractor chose one precaster that was located 15km away. The selection would cause more carbon emissions to be emitted during transportation. In addition, by providing appropriate and sufficient packings and supports as well as sufficient care, damages during transportation could be eliminated.

DISCUSSIONS

Some of the practices originated from the lean concept, e.g. the JIT delivery, were challenged by some academics. For example, Rothenberg *et al.* (2001) stated that the survey results did not significantly support the hypothesis that lean is greener, and it was only interview data that supported the relationship between lean management and environmental management practices.

As to JIT delivery, many academics argued that the small lot nature of just-in-time would actually increase the carbon emissions level in the transportation cycle. Venkat and Wakeland (2006) stated that just-in-time supply chain did not necessarily reduce carbon emissions. When cold storage is not required for a particular product line, emissions depend largely on the transportation mode, and larger deliveries at less frequent intervals all along the supply chain generally lead to the lowest emissions. Some project managers interviewed have raised the same concern.

However, it should be noted that the JIT delivery system has several pillars, including at least:

- Just-in-time (JIT): JIT means that the right parts needed in production reach the assembly line at the time they are needed and only in the amount needed in a flow process (Ohno 1988). The just-in-time nature was believed to have benefits in reducing carbon emissions, as observed by Wu and Low (2011). The immediate use of building materials after arrival can significantly reduce transferring and singling out activities, thus reducing carbon emissions (Wu and Low 2011).
- Small lot sizes: Small lot sizes were considered as an important feature of JIT sourcing and were believed flexible enough to overcome the obstacles of higher delivery costs and loos of discount rates (Banerjee and Kim 1995). The small lot nature of JIT delivery can possibly increase the carbon emissions. However, the amount of carbon emissions should be assessed case by case before conclusions can be made. The small lot nature of JIT delivery can reduce the inventory level. The benefits achieved by lower inventory level, e.g. lower carbon emissions in this case, should also be assessed.
- Long-term relationship: A long-term relationship between contractors, subcontractors and suppliers is essential to a JIT delivery system. It can help improve the information exchange between contractors, subcontractors and suppliers, thus supporting the JIT nature as discussed earlier.

It is therefore necessary for contractors to balance the three pillars of JIT delivery. Starting with just-in-time and long-term relationship can help the contractors achieve some benefits in reducing carbon emissions.

CONCLUSIONS

In accordance with previous literature, this paper has identified many areas in the installation cycle of precast concrete products that can be improved. These non-value adding activities were described, evaluated and ranked by a weighted factor model. Two value stages, which are site layout and delivery, were investigated. It is found that site layout design, the use of green materials, accurate specifications of precast concrete products and estimation of quantities are the factors that can bring down the carbon emissions level. Similarly, in delivery management, it is believed that by providing sufficient care and support system to the precast concrete products, as well as arranging the delivery in a just-in-time manner, the carbon emissions can be reduced. Knowing the sources of unnecessary carbon emissions, appropriate actions can therefore be taken for further improvement.

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INTERFACE MANAGEMENT FROM AN OFFSITE CONSTRUCTION PERSPECTIVE

Michael McCarney[1] and Alistair Gibb [2]

[1] *School of Engineering and Built Environment, Glasgow Caledonian University, G4 0BA, UK.*

[2] *School of Building and Civil Engineering, Loughborough University, Leicestershire, LE11 3TU, UK.*

This paper is the subject of an ongoing PhD study with the primary research question: what is the relationship between offsite and interface management? While interface management takes many forms, the focus of this study has been organisational interface management to determine the various process and people factors, which have an effect on efficiency. The literature on offsite construction has been analysed to determine the relationship of the process and people factors identified. The changing nature of the construction process to a more specialist sub-contractor format has created new problems in the management of interfaces, none more so than the interfaces that have emerged from the offsite production and onsite incorporation of bathroom construction. The focus of the research is to determine a pragmatic framework of the main process and people factors which have an impact on the interface management of offsite and onsite forms of bathrooms/wet rooms. This paper includes a summary of a literature review on offsite and interface management. A pilot study using semi-structured interviews was carried out with six academics and industry practitioners to gauge the validity of the questions and the relevance of the 16 factors. The data gained from the pilot study was analysed using a five point Likert scale. This paper focuses on the process factor of design management and the people factor of communication. The results from the small sample clearly indicate the importance of early engagement of the contractor in the design process and that open communication between all stakeholders is essential to resolving organisational interfaces issues. The results of this study have also confirmed that the management of interfaces are of equal, if not more importance when incorporating offsite forms of bathroom construction into the construction process. In conclusion further research is required to determine the main factors, which will impact on successful organisational interface management.

Keywords: interface management, offsite construction, people factors, process factors.

INTRODUCTION

The traditional construction processes that existed in the UK until around the 1970's, saw a large proportion of the work on site carried out by workers directly employed by the main contractor and required little input from subcontractors. The dominant organisational structure that has functioned within the vast majority of construction projects since those days, now relates to a division of the works, with many

[1] M.McCarney@gcu.ac.uk

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subcontractors on site engaged in their own area of the project. The many divisions created by this approach have lead to various forms of interface which must be managed. One approach adopted on some projects and which reduces the number of trades working on site is the use of 'offsite construction'.

This is the first paper that relates to a PhD study aiming to understand the effects of process and people factors on interface management in relation to offsite production and onsite incorporation of bathroom pods. An appreciation of traditional construction is provided, highlighting the domination of specialist subcontractors. The theme of offsite construction is introduced, confirming that although offsite forms of construction are considered by many to be new to the industry, processes such as prefabrication and industrialisation have been integrated into traditional construction for many years. From a review of the existing literature on offsite construction and, in particular, offsite forms of bathroom construction, a number of process and people factors are identified.

The fragmentation of the industry has accentuated the need for research into interface management. Literature confirms that little research has been carried out into interface management; the main contributors to interface management theory consist of Wren (1967), Morris (1983), Stuckenbruck (1983), Healy (1997) and Gibb (1999). With the construction industry now a specialist subcontractor based industry, adopting offsite forms of bathroom construction, new interface problems have emerged from the offsite manufacture and onsite incorporation, which need to be identified and managed. Gibb (1999) has proposed three forms of interface which have direct relationship to construction: physical, contractual and organisational. This research will focus on organisational interfaces.

The review of literature on offsite construction and interface management identified nine process factors and seven people factors. This paper will focus on the process factor of design management and the people factor of communication within the analysis of the pilot study.

TRADITIONAL CONSTRUCTION

'Tradition' is defined as a specific custom of long standing (Collins, 2004). 'Traditional Construction' is a term regularly used in construction management literature to define the onsite construction processes. Moreover, the traditional view of building construction consists invariably of " a process of preparing a site, bringing in materials and components, forming materials into elements such as frames, walls and roofs, assembling readymade components, installing services and then finishing ready for occupation" (Morton, 2008, p.152). While simplistic in description, it outlines the construction process which has operated for centuries. Prior to the 1970's, large construction organisations carried out all the associated work 'in house', directly employing trades such as joiners, electricians, plumbers, painters etc. The Architect, while directly responsible for design on the project, also held the role of contract administrator, controlling lines of communication within the team. In the 1970's extensive use of subcontractors emerged. Dainty *et al.* (2001) argue that main contractors adopted this form of contracting due to the 'volatility of the market', thus leading to the fragmentation which is dominant in today's UK construction industry.

CURRENT DRIVERS AND CONSTRAINTS

Whilst it is acknowledged that prefabrication already existed in the traditional construction sector, the Egan report 'Rethinking Construction' (1998) attempted to

develop offsite forms of construction, by following the principles already in use within the manufacturing industry. Egan (1998) considered that greater use of prefabrication and standardisation would greatly enhance the productivity of the construction industry. It is widely accepted that cost, time and quality are the traditional drivers which operated within the industry (Blismas *et al.* 2005). However, Blismas *et al.* (2005) argue that when consideration is given to offsite construction, additional drivers need to be included such as design management, whole life costing, health & safety and sustainable construction, thus adding to the capability and skill set required for the management of the process. Gibb and Isack (2001) carried out interview surveys with 59 leading client representatives across a wide spectrum of markets. The outcome of the survey identified that, from a client's perspective, lowest whole life cost was considered the main driver applicable from the pre determined list of drivers contained in the study. Whilst it is generally perceived that cost is the main driver, it is encouraging that clients' are considering 'whole life costing', which may lead to value for money being considered by enlightened clients as the main driver, thus allowing cost comparison to include not only direct costs but also indirect costs.

METHODS OF BATHROOM CONSTRUCTION

The bathroom/wet room area of a construction project is commonly identified as the most intense area of a project in terms of the number and variety of activities and trades required to successfully construct it (Taylor *et al.* 2009). The continuum of construction methods available for the construction of commercial and public bathrooms, range from total onsite construction to total offsite manufacture, with various forms of hybrid in between. Taylor *et al.* (2009) use a case study approach to compare two methods of constructing a bathroom. One method is the use of bathroom pods and the other is a pre-finished 'kit' of parts.

The pre-engineered kits came in the form of 'flat pack' panels with sanitary ware attached to them, designed for ease of assembly The pre-engineered kit form has a heavier reliance on the skills of the onsite fitter but still less than the traditional onsite bathroom construction.

Benefits include:

- Reduction in personnel on site
- Reduction in construction programme
- Reduction in waste
- Reduction in snagging

Taylor *et al.* (2009) found that traditional bathroom construction demands a high level of supervision, which in turn leads to a considerable level of trade interaction compared to other areas of traditional construction. Snagging works are a challenge due to the interface coordination of other trades. Although pod and kit construction reduce the level of interfaces between trades, it is impossible to avoid a level of interface between offsite and on site. What is important is to recognise the variations in the types of interface which may, in certain situations demand a higher level of management expertise to achieve the benefits of offsite construction. In a similar study, Pan *et al.* (2008) reviewed the maintenance costs applicable to bathroom construction via case studies of student accommodation. A comparison is made of the maintenance cost of offsite and traditional *in situ* bathrooms, by reviewing four forms of bathroom construction; precast concrete modules, GRP modules, and two different types of traditional built in-situ bathrooms. A quantitative study of the maintenance

records resulted in the traditional built in-situ bathrooms being classed as the most expensive to maintain, followed by the precast concrete modules, resulting in the GRP module being classed as the cheapest to maintain. Considering the level of data analysed and the recognition given to the constants and variables between the various types of bathrooms, it is feasible to conclude that the findings of this study can be used as a general indicator of the level of maintenance cost attributable to the types analysed in the study. However, caution should be given to generalising the findings (Pan *et al.* 2008).

INTERFACE MANAGEMENT

The concept of interface management would appear to have had little exposure in general management literature and construction research in particular, evident by the limited publications and time gaps between same. Wren (1967) developed the concept of interface management to review the relationships between two or more organisations, thus indicating the issues which arise from people and processes. The organisational interface is the contact point between organisations which, in one sense, are independent of each other, but which interact and become interdependent to achieve a common goal. The management of the construction interface would appear to be a major contributor to the success of a project, thus reinforcing Morris's (1983) call for more in depth research into interface management theory. Morris (1983), in a review of the life cycle of a project, considers that the design phase plays a significant factor in contributing to the many interface issues that arise in both a technical and organisational sense. Traditionally, the RIBA plan of work is used as the vehicle that details the various steps from inception to start up. However, no check points exist in the plan to take account of interfaces at the various stages, which possibly contributes to the lack of reference to interface management. This is surprising considering the effects of design on interfaces and the success of a project (Morris 1983). Stuckenbruck (1989) further argues that project integration and project interface are similar in detail and where the project allows, personnel involved at the design stage should continue their involvement during the construction phase.

Healy (1997) further highlighted that, considering the importance of interface management to the success of a project, it has received little attention in project management research. This may be due to the difficulty in succinctly quantifying/measuring the tangibility of interface management. However, in a practical sense, it takes up a considerable amount of management time and energy. Healy (1997 p 268) defines interface management in the context of project management as “a boundary where an interdependence exists across that boundary and where responsibility for the interdependency changes across that boundary”.

The importance of interface management in the construction industry has been succinctly captured by Pavitt and Gibb (2003, p.8): “Interfaces, joints and connections between different elements or sections cause more problems than most of the rest of the building”. Furthermore, the shift from the traditional form of contract to more varied management forms has seen a significant shift in the employment of labour from direct to indirect; therefore highlighting the need to better manage the interfaces between the parties (Pavitt and Gibb, 2003).

The introduction of various forms of offsite construction into the construction process does not appear to alleviate the problems associated with interface management. Gibb (1999) defines interface management by identifying three distinct forms of interface,

which are considered of particular relevance to construction in general and offsite in particular:

- Physical Interfaces – as the term suggests refers to the actual physical connection between elements or components, which form actual linkage, physical interface can be related to hard interfaces.
- Contractual Interfaces – relates to how the work packages have been formed from a contractual basis, i.e. can influence the number of process and people interfaces.
- Organisational Interfaces – refers mainly to the soft interfaces, which affect the successful management of a project. Organisational interfaces can relate to individual and /or group relationships.

The main focus of this paper in relation to interface management will be on organisational interfaces, with an emphasis on the people and process issues. Whilst offsite construction as an element of the process will possibly reduce the organisational interfaces, consideration should be given to the following:

- The project management issues may vary from the traditional.
- Interface issues will need to be incorporated into the process at an earlier stage than traditionally.

THE INFLUENCE OF DESIGN ON INTERFACE MANAGEMENT

Traditionally the design phase and the construction phase were seen as separate operations, each able to function independently. However, recent research has identified the importance of the design-construction interface and its effect on the project. A study carried out by Alarcon and Mardones (1998) of four projects associated with the same construction company, using a qualitative research approach to gather data by observations and interviews, identified that 40-50% of design time is taken up by rework and design changes and that a considerable amount of time was wasted during the flow of design information. Alarcon and Mardones (1998) also highlighted the lack of communication and coordination between designers, which directly affects the design interface. It is suggested that his may be attributed to a lack of knowledge in areas related to buildability/constructability by designers and a lack of input by the various specialists involved in the project, thus emphasising the need for a design manager to coordinate the design process. Alarcon and Mardones (1998) argue for the inclusion of the principal contractor in the design process. However, this is very much dependent upon the method of procurement used.

THE INFLUENCE OF COMMUNICATION ON INTERFACE MANAGEMENT

Chua *et al.* (2003) propose a ‘Process-Parameter-Interface Model’ to aid the management of the design process. The model has been developed to encourage transparency in communication and collaboration. The component parts of the model include the interface, which encourages specialist designers to share essential design information with other specialists. This will aid the overall design process, thus creating a more transparent environment. The other component parts of the model include the engine, which promotes collaboration between the various parties and the design dictionary, which acts as a vehicle for accumulation of information from other designers. All designers can access this to gain a better appreciation of other design functions. Whilst in practise the model may not be considered a new approach to the

design process, its value can be attributed to highlighting the importance of sharing information, which in turn can have a positive effect on the interface issues when reviewing the design process. Chua and Godinot (2006) argue that better communication between all actors involved in the process would result in improved interface management.

PROCESS AND PEOPLE FACTORS

The review of the existing literature, which relates to offsite construction and interface management, was used as the vehicle to identify the main process and people factors central to the overall research. The process factors include procurement, supply chain management, whole life costing, health and safety, design management, lean construction, sustainability, tolerance and quality. The people factors include communication, role of the project manager, culture, client/design team, leadership, perception and integration. While the majority of the aforementioned factors were identified in literature, the people factors of culture and client design team where included following unstructured interviews with two experienced offsite professionals.

METHODOLOGY FOR PILOT STUDY

Creswell (2009) argues that it is incumbent upon the researcher to have an understanding of their philosophical stance before choosing the appropriate research method. The philosophical stances reviewed include 'ontology', which relates to the study of things as they actually are and 'epistemology' the theory of knowledge, how we know what we know (Easterby-Smith *et al.* 2002). This study will follow the epistemology stance. Fellows and Liu (2003) argue for the importance of the identification of the intended paradigm when analysing data, two approaches include 'positivism' deals with empirical evidence i.e. facts and figures, while 'social constructivism' relates to the contribution of people and the interpretation of the spoken word. This study will follow the social constructivism paradigm.

The research process starts with a review of the existing literature, to gain an understanding of the relevant theory and research questions, which contribute to identifying the process and people factors which are relevant to the research. Two unstructured interviews with industry professionals were carried out to gauge the relevance of the process and people factors identified. Interview questions where formulated to form the basis of six pilot studies which will aid the refinement of the actual questions used in the case study research (Yin 2009). While nine process and seven people factors have been identified as applicable to the overall research, the focus of the analysis of the pilot study will be on design management and communication. The data was analysed using a five point Likert scale to gain interviewees opinions, which allowed comparative views to be established between the participants (Fellows and Liu 2003).

ANALYSIS OF PILOT STUDY

The pilot study was used to check the validity and interpretation of the questions asked. The sample participants consist of three academics (P1-P3) and three practitioners (P4-P6) with varied levels of experience.

Table 1: designation/experience of Interviewees

Interviewee	Discipline	Academic Experience (years)	Traditional Bathroom Experience (years)	Offsite Bathroom Experience (years)	Total Experience (years)
P1	Research Fellow	10	6	Nil	16
P2	Lecturer	10	Nil	Nil	10
P3	Lecturer	20	27	2	49
P4	Senior Project Manager	Nil	35	4	39
P5	Senior Project Manager	Nil	24	1	25
P6	Project Manager	Nil	22	2	24

The main questions used in the semi-structured interviews utilised the Likert scale (Strongly agree, Agree, Neither agree nor disagree, Disagree, Strongly disagree) to gauge the respondents' view followed by a comment section to gain further information.

The first two questions relate to 'interface management in general' to gauge the perception of the respondents. P1, P3 and P5 'Strongly agreed' that "effective interface management is more important when using offsite solutions", citing the technical interface as more important, it is crucial to involve the contractor early and the benefits of using offsite components can be lost if the interface is not managed well. P2, P4 and P6 'Agreed' with the premise of the question, stating it is important in relation to the construction process, the need to be aware of interfaces at the early stage and the need to coordinate the design early in the process. The responses demonstrate a unanimous agreement that effective interface management is important when using offsite solutions both by academics and industrialists. The second question reversed question one by claiming, 'using offsite solutions improves interfaces management'. P1, P3 and P5 disagreed, claiming it is made more difficult, that the use of offsite by its very nature creates interface problems and can cause more difficult problems than what would be the norm on traditional projects. P2, P4 and P5 agreed with the statement citing it improves management not only offsite but also onsite, the need to be aware of the interfaces at the early stage and by agreeing the design early allows information to be passed to other trades thus improving communication. It is worth highlighting that the three interviewees that 'Strongly agreed' with question one, also 'Disagreed' with question two, while the three that 'Agreed with question one also 'Agreed' with question two, which suggests an effective link and relevance of both questions although the limited sample size is acknowledged.

Nine questions in the pilot study related to the process factors identified earlier. However, the analysis focuses on one process factor in this section namely 'Design Management'. The interviewees were asked three separate questions in this section. All six interviewees 'Strongly agreed' with the part A statement that 'effective management of the design process significantly improves interface management'. Comments ranged from an organised approach very important to the process, crucial

to the success, imperative that the design manager incorporates contractors' designs, such that ultimately the design team take full responsibility and the key to the success of the project relies on someone taking ownership of the design. P1, P3, P4, P5 and P6 all 'Strongly agreed' with the statement that 'design management can significantly affect interface management in bathrooms', qualifying their response by restating the same responses as part A and adding the need to involve the supply chain in the coordination of design. P2 'Agreed' with the statement but qualified that he was unsure as to relevance of the question. Part C stated that 'design management has more influence on offsite than onsite bathroom construction' P1, P2, P4 and P6 'Agreed' with the statement citing that, in principle there should be no difference. However, offsite construction requires early design freeze to be effective. P3 and P5 both expressed 'No view', stating that design management is equally important to both onsite and offsite. Overall the responses demonstrated a strong link between design management and interface management in relation to offsite bathroom construction. What is also evident is the importance of interviewees commenting on statements, as the responses in relation 'Agree' and 'Have no view' denoted comments that were very similar.

Following on from the questions which focused on the process factors were a further seven questions relating to people factors, including 'Communication'. Part A of the communication question asked "Does effective communication improve interface management?" All interviewees 'Strongly Agreed' adding comments such as: communication is key to effective interface management, communication is the most important factor, it is very important that parties speak to each other and communication is key to the whole construction process. Part B suggested that "Effective communication has more influence on offsite than onsite bathroom construction". P1 'Strongly Agreed' explaining that communication has more relevance with offsite as there is more potential for things to go badly wrong. P2 agreed with the statement, citing that a higher level of communication is necessary within a manufacturing process. P3 and P4 'Disagreed', professing that effective communication is required regardless of the process and effective communication is more important onsite than offsite as the parties involved in the manufacturing are more focused. P5 and P6 'Neither agreed nor disagreed' citing that effective communication is equally important to both offsite and onsite. Of interest to the responses for part B are that the two academics with no industrial experience considered that effective communication is more relevant to offsite bathroom construction, whereas the academic with substantial industrial experience and the three project managers 'Neither agreed or disagreed'/'Disagreed' commenting that the importance is the same regardless of whether offsite or onsite construction, which highlights the divergence views of academics and industrialists in relation to communication within the platforms of offsite and onsite bathroom construction.

DISCUSSION ON THE PILOT STUDY

The mixture of academics and industrialists was used to check the relevance and wording of the questions before proceeding with the main case studies. The authors considered that the academics contribution would be most relevant to the structure of the questions while the industrialists main contribution would be with the data gained. However, in reality, all participants made effective contributions to both the structure and the data.

The data collected confirmed that when using offsite forms of bathroom construction, effective interface management is vitally important, even more than when using onsite forms of construction. Also it is considered necessary to be aware of the interface early on in a project, which in turn will improve the management of the technical and people processes. The questions applicable to the process factor of design management, unanimously supported the view that management of the design is crucial to the success of a project, none more so than when using offsite forms of bathroom construction. The analysis of the questions relating to communication also confirmed that communication is central to effective interface management. However, subsequent questions revealed that communication has the same relevance regardless of whether the main process is offsite or onsite. While it is acknowledged that the pilot study has a small sample size, it is encouraging that the interviewees all considered that the identified process and people factors had relevant to the study of interface in relation to offsite forms of bathroom construction.

CONCLUSIONS

The 21st century construction industry is now firmly ensconced in the use of specialist subcontractors to construct the full range of buildings in the UK. This has highlighted the need for the industry to recognise the essential nature of interface management. Interface management is a subject that has not been researched in great detail by academia nor industry. This may resonate from the vast array of interfaces which exist in traditional onsite forms of construction.

This study has focused on offsite forms of bathroom construction and integrated the theme of interface management, as an area of research, which should be more manageable to research in depth than the vast area of interfaces which prevail in traditional construction. Offsite forms of bathroom construction by the very nature of the construction methods should have fewer interfaces to manage and therefore be less of a management issue in terms of project success. However, the results of the pilot study highlight that the management of interfaces is more important when introducing offsite forms of bathroom construction into the project, emphasising the need for early engagement of the construction parties during the design stage.

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ORGANISATIONAL STRATEGY AND BUSINESS PERFORMANCE

PRO-INNOVATION BIAS IN CONSTRUCTION-ENABLERS AND RISKS

M. Loosemore and S. Holliday

Faculty of the Built Environment, University of New South Wales, Sydney, Australia

The term innovation has become ubiquitous in modern business and political circles in recent years. Innovation is increasingly seen as essential for commercial success and as a means to increase living standards, competitiveness and productivity in a world of depleting resources. By thinking more creatively about the risks and opportunities they face, it is argued widely that individuals, organisations and nations can get ahead of their competitors. But is innovation always positive and what are the enablers of innovation which determine its success? We explored these questions through interviews and focus groups with thirty thought leaders in the UK construction sector. From our analysis we conclude that there are four main enablers of innovation in the construction sector, namely: collaboration, regulation, skills, education and research and, leadership. Recommendations are made to capitalize on them.

Keywords: innovation, bias, risk, barriers, enablers.

INTRODUCTION

Innovation is the process of bringing new creative ideas to reality and implementing them through new work practices, processes, business models and strategic partnerships to produce new products and services which are of value to society (de Man 2008). Recent research has challenged the traditional linear models of innovation which according to Barrett *et al.* (2008) have dominated construction management literature. It is now widely accepted that the innovation process is far from linear but is messy, uncontrollable, unpredictable and full of feedback loops and setbacks. As Fuglsang (2008) points out, it is often difficult to define the beginning and end of the innovation process. Innovation is highly interactive and cyclical, involving many people and organisations with multiple interests "co-creating" new knowledge under the influence of market and many other social, political and organizational forces. The aim of this paper is to discuss the challenges in managing this process in construction and to distil a number of key enablers which might help to address them.

PRO-INNOVATION BIAS IN CONSTRUCTION

Gambatese and Hallowell (2011) argue that there is a common perception that the construction and engineering industry is a low innovation sector. However, there is considerable evidence to demonstrate that innovation does occur, even if it does primarily emerge from the adoption of ideas from other industries (Gann 2003) and does not register in traditional scientific measures of innovation (NESTA 2007).

Loosemore M and Holliday S (2012) Pro-innovation bias in construction- enablers and risks *In*: Smith, S.D (Ed) *Procs 28th Annual ARCOM Conference*, 3-5 September 2012, Edinburgh, UK, Association of Researchers in Construction Management, 787-796.

Indeed, Winch (2008: 23) has questioned the continued "holding-up" of manufacturing as innovation best practice. He points out that the automobile sector also "has its incompetent back-street garages and dodgy car salesmen.." and that it is important to recognize that the construction sector at its best, displays highly sophisticated skills in addressing difficult production problems in a way that draws considerable respect from other sectors. The drivers of innovation are of course constantly changing and in construction, cost and time efficiency are often quoted as overriding priorities. However, Manley and Rose's (2009) content analysis of construction innovation publications found that concepts of sustainability, energy, environment, people and lifestyles were far more prevalent, suggesting that drivers of innovation are more complex than we may think. As Swedberg (2006) points out, while traditionally innovation has been driven by economic imperatives, today innovation is seen as a process of bringing about social advantage as well as economic benefits and that these can be both direct and indirect. It is now accepted that innovations have important, significant and often unintended positive "spill-over" benefits for societies which were not targeted in the original innovation strategies. Although many firms try to minimize these indirect effects through mechanisms like patents, Baumol (2010) argues that the distributive implications of unplanned innovation spill-overs account for the bulk of the enormous growth in the western world's welfare over recent centuries and the reduction of poverty and inequality in developing countries. Certainly, as Loosemore and Phua (2011) argue, this is what many construction firms would claim but in many cases the reality is very different.

Whatever the motives lying behind innovation, the literature within and outside construction reflects widespread agreement that innovation has become critical to social and economic progress, sustainable development and the battle against unemployment and productivity growth. However, while innovation can no doubt play an important role in meeting these challenges, we must be careful not to automatically assume that all innovation is positive. With all the recent hype surrounding this topic, it is all too easy to uncritically embrace the concept without considering the social, economic and ecological costs it may have to communities, nations and business. As Rogers' (1995: 104) research revealed, most innovation literature is uncritical and heavily laden with positive value - "Innovativeness, like efficiency, is a characteristic we want all organisms to possess". Rogers argued that innovation downsides are written about far less frequently than the benefits, largely because much of the research in this area is funded by change-agencies that have vested interests in seeing certain innovations adopted. These biases are then injected in the work of the researchers and consultants whose work they sponsor. Green (2011) and Ness (2010) and Ness and Green (2012) show that pro-innovation bias afflicts the reform agendas of construction industries around the world. These it is argued, not only mask the realities of practice within the industry driven by its dominant "enterprise culture" but also obscure the significant risks to business prosperity and employee well-being which they present. As Rogers (1995) argues, while pro-innovation bias is beneficial from the perspective of policy, financial and business considerations, the implication that an innovation should be uncritically adopted by "all" members of a social system is dangerous and ignores potential externalities for some segments of society. It is clear that if we are to fully understand the innovation process it is essential that we see innovation from a range of perspectives and not from just the perspective of the vested interested that are driving it.

Barriers to innovation in construction

Over the last decade or so, numerous research projects have sought to identify barriers to innovation in the construction industry. For example, Barrett and Lee (2004) cited: clients and industry bodies protecting their own interests; low awareness of improvement initiatives; poor education and training; lack of R&D; poor strategy and implementation procedures; lack of clear benefits; resistance to change; insurance issues; lack of government leadership; inappropriate legislation; complacency and; the temporary nature of projects. Every country has its unique barriers and in Australia, one of the greatest is its complex, cluttered and fragmented regulatory environment (BEIIC 2011). In Australia there are over 70 overlapping bodies which regulate the industry and central to this network are governments which as BEIIC (2011) pointed out, play a critical role in the innovation process in their capacity as regulators, sponsors, clients and policy makers. However, in qualifying this, Gann (2003) argues that as governments increasingly outsource innovation to the private sector, the leadership skills to drive innovation are too often missing. In Australia, other important but highly contentious institutions include the construction unions. While some argue that they protect traditional trade demarcations and prevent change (RCBCI 2002) others argue that Union activities have had a positive impact on industry reform, especially in areas like safety and equal opportunities (Ferguson 1999). Finally, there is the education sector and professional institutions and trade associations which protect and reinforce the industry's traditional discipline-based knowledge domains. As Pan *et al.* (2005) point out, innovation is likely to challenge and even destroy traditional knowledge domains and is therefore likely to be resisted. In particular, Locke and Spencer (2011), argue that fundamental changes in universities over the last two decades have made them less relevant to business's and society's needs and that stronger university, business and community partnerships are needed to fulfil their potential in a national innovation system.

Cultural impediments to innovation also exist in construction industries around the world. In general, innovation is perceived as an academic activity, which in most instances, produces theoretical results of little commercial value (Lenard 1996). Dodgson and Gann (2010) argue, that clients can play an important role in reversing this perception. However, as Ivory (2005) found, many clients are unwilling and unable to effectively encourage innovation, because of: competition with other priorities; short-term capital costs involved in innovating; internal politics and difficulties in achieving consensus between project stakeholders; increased risk exposure and workloads in managing innovation; indemonstrable benefits and; inadequate competence to confidently manage the process and judge net benefits. Qualifying this further, Sexton *et al.* (2008) point out, there are many client types and while some prominent clients take their leadership responsibilities seriously, the majority of construction clients play a passive role in the innovation process. For example, Manley's (2006) large-scale survey of the Australian construction industry, showed that repeat public sector clients have a relatively high level of innovation competence, compared to contractors, consultants and suppliers. However, more recent research byLoosemore and Phua (2011) provides evidence to show that despite many private firms wanting to innovate, many clients, even apparently sophisticated clients, represent a significant barrier to innovation. This is largely because theydo not understand the relationship between their buildings and their core business and see buildings as a tradable short-term asset rather than a long-term investment. Furthermore, Brandon and Shu-Ling (2008) argue that relying on clients as drivers of

innovation is a “cop out” by the industry. They contend that relying on clients to drive innovation discourages firms from investing in their own new ideas and recognizing their collective responsibility for the advancement of the industry. Similarly, Bresnen (2008) argues that there is a problem in assuming that clients have a coherent innovation agenda which means that client-led innovation can cause more problems than it solves.

Another way in which clients inhibit innovation is through their employment practices and research indicates that non-traditional relational procurement methods such as alliances and partnerships would seem to benefit innovation (Walker and Maqsood 2008). However, alliance contracts are often undermined by the culture of the industry in which they have to exist and ultimately, alliance contracts like any other project are staffed by people who have been educated and instilled in the confrontational and fragmented traditions on the construction industry. Furthermore, the PPP literature shows, many new forms of partnership are partnerships in name only (Akintoye and Beck 2009). Such projects are often misused as a mechanism for the public sector to transfer risks to the private sector without regard for capacity to manage it and that this encourages special purpose vehicles to adopt tried-and-tested solutions rather than to experiment with innovative ones.

Finally, construction occurs through complex and often unwieldy constellations and networks of firms. The way that the risks and benefits of innovation are distributed through these networks is often problematic in not fairly reflecting the proportion each firm’s contribution to the process (Winch 2008). Lamborde and Sanvido (1994) argue that this is one of the construction industry’s major barriers to innovation – the separation of potential innovators from the potential benefits of their innovations. For example, a domestic sub-contractor’s lack of involvement in design means that any technological innovations must be offered through a principal contractor who is likely to filter the potential benefits to the innovating sub-contractor. Another problem with construction supply chains is the lack of integration of manufacturers (Slaughter 1983). For example, while a builder’s benefits are project-specific, manufacturer's benefits are product-specific. This introduces the dilemma that while builders are best placed to identify innovations, material/product manufacturers have little incentive to respond in a time-frame which enables builders to benefit from them. However, as Dodgson and Gann (2010) argue, traditional boundaries between manufacturing and services are fast becoming obsolete as new boundary-spanning technologies (such as BIM) emerge enabling firms to develop new integrated systems solutions which provide customers with a single point purchase and ongoing support for buildings and structures.

METHOD

While the barriers to innovation in the construction sector have been widely researched and documented, less has been written about the enablers of innovation that might counteract their negative effects. To this end, we undertook semi structured interviews and focus groups with thirty of the UK’s recognised political, institutional, organisational and academic leaders. Our respondents were chosen because of their prominent role in influencing UK innovation government policy and reform within the UK. Our rationale in selecting these people was to harness their collective tacit and explicit insights, knowledge and experience in influencing policy reform this area. The interviews and focus groups lasted between one hour and three hours and were guided by one simple question - "What would enable more innovation to happen in

the construction sector?" . In managing our discussions we deliberately took an unstructured "constructivist" approach which enabled our respondents to follow their own path through the subject but under our guidance as we sought to follow any leads we considered important. Our pursuit of leads was guided by our own conceptual mind-map of enablers which we did not show our respondents but which had derived from the innovation literature. As the interviews progressed we gradually adjusted and refined this conceptual map to reflect the combined schemas of our respondents and this in turn guided subsequent interviews. Recognising that this method mean later respondents were guiding in their thinking more than earlier respondents, we distributed our map for feedback and comment after our final analysis was completed.

DISCUSSION OF RESULTS

A simplified version of our conceptual map is shown in Figure 1 and shows four main innovation enablers, namely: collaboration; regulation; skills, education and research; leadership. It is important to point out that opinions of our respondents were wide, varied and sometimes opposing. However, these themes (illustrated in Figure 1) emerged as dominant in our transcripts and are a discussed in more detail in the sections below.

Collaboration

The basis of the collaboration argument is that few firms in the construction industry have the full range of competencies necessary to innovate. So they must collaborate to do so. Collaboration not only creates the necessarily broad knowledge and skills-base to generate and convert new ideas into reality but also spreads the significant risk associated with innovation. To drive innovation, collaborative arrangements must extend beyond the traditional boundaries of the construction industry. This is because few firms within it have the necessary cultures, systems, attitudes, skills, capabilities and resources to innovate. Furthermore, traditional knowledge domains have been inappropriately narrow given the close relationship between the industry's activities and wider society (in social, economic and ecological terms). These new and poorly understood interdependencies will present managers with new problems which are messy and cannot be clearly defined and resolved. Solutions to these challenges will also causes us to question the efficacy of vertically hierarchical and integrated business models (which have a strong tendency to create internal boundaries between disciplines, functions, units, departments and regions), in favour of horizontally dispersed network models with permeable boundaries. This idea of strategic communities of practice of course introduces new governance challenges of managing such dispersed structures. First they will require a more reflective and non-linear way of thinking in a more collaborative environment which involves construction business, communities and governments working in new organizational configurations which are likely to challenge traditional competitive relationships and perceptions.

Increasingly, to deal with these new challenges, individuals, firms and governments are going to have to innovate and it is in new relationships and at the intersection of different knowledge domains, that the solutions to today’s challenges lie. Innovation happens when people are exposed to multiple ways of thinking by looking into other cultures and disciples including the physical and social sciences, arts and humanties. The most enlightened organisations realize this and build this into their business structures and strategies. To them, notions of interdisciplinarity and collaboration are replacing traditional competition as a way to share complementary ideas, resources and capabilities to mutual advantage. This can be facilitated by the development of

knowledge sharing networks underpinned by rigorous evidence-based analysis which is inclusive of all firms within the industry - not just the larger firms. New communication technologies can help facilitate this process as can new design technologies like BIM which potentially enable firms to work in a more integrated and collaborative fashion. However, the key is how these technologies are deployed and used, not the technologies themselves. Procurement reform is also critical to this process. Partnerships, alliances and relational contracting are seen as particularly important mechanisms to enable more integrated working.

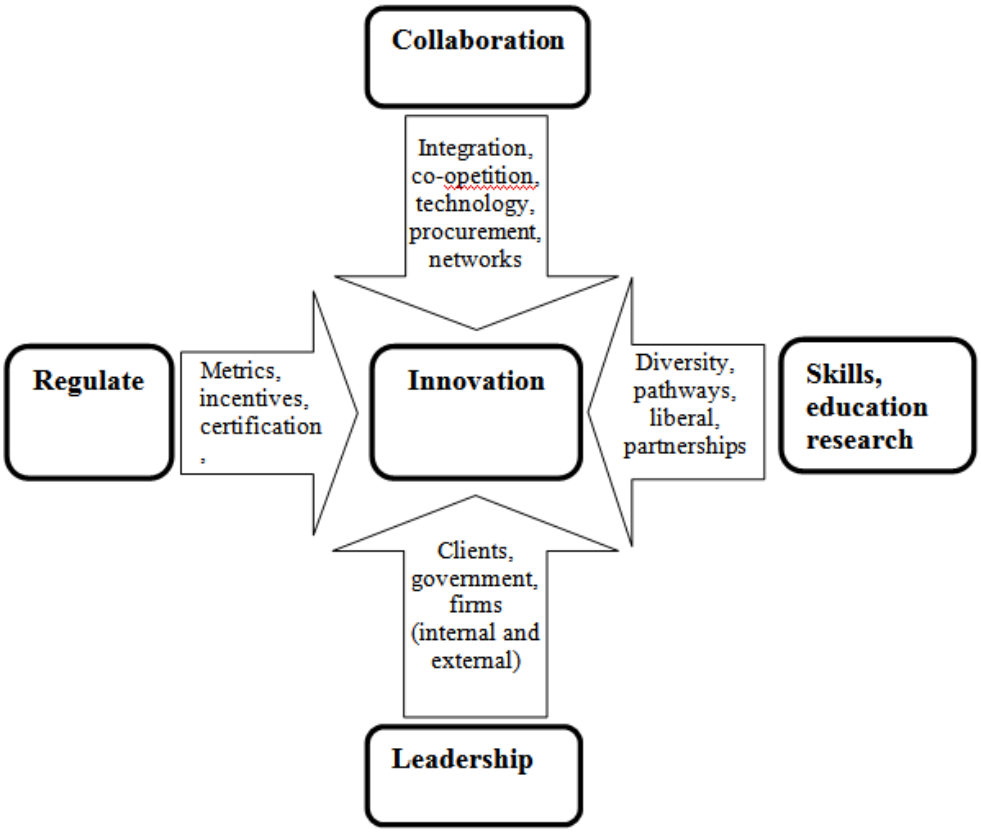

Figure 1 Key enablers of innovation in construction

However, currently there is little history of innovation in the construction industry which means that venture capitalists are reluctant to invest the resources necessary to bring new ideas to reality. Instead, innovation in construction sector will likely depend largely on collaboration with highly capitalized, risk taking, research intensive companies with demonstrated success at innovation. In other words, innovation is more likely to occur "around" the industry rather than within it and in this environment, the unique partnerships a firm creates to capture and ring-fence the intellectual property that arise from such partnerships will be critical to its competitive advantage. At another level, collaboration in an increasingly globalised world, where the size of many projects exceeds the capacities of individual firms to deliver them, may also require firms to "hunt as a pack" for work in overseas markets and to embrace the idea of co-opetition where competitors share common resources and capabilities in a way which provides mutual advantage. In essence, what is being advocated is a "deeply" integrated business model which breaks down the traditional institutional, professional and disciplinary silos which have been recognized to artificially create inefficiency in the construction industry. In simple terms, a "deeply"

integrated business model is one where suppliers, manufacturers, designers, contractors, sub contractors, operators and clients work collectively to share the risks and rewards associated with innovation in an open, transparent and collaborate environment of collective responsibility where personal interests are put aside in the interests of the whole and where resources are shared and used where they best fit. Deeply integrated supply chains create a single point of responsibility for innovation, improve communication and allow the early involvement of firms in the development process preventing solutions being locked-in before all available knowledge has been brought to bear on them.

Leadership

Our respondents identified four sources of leadership which were seen as important to innovation in construction. First, firms in the construction industry have a responsibility to lead by driving innovation through their supply and demand chains. They must do this by increasing investments in R&D, educating clients about the benefits of innovations, being more willing to support new ideas, helping smaller business partners to do so and continuously striving to improve performance on their projects. Second, and in contrast to this supply-led view of innovation, clients must also take a lead and demand more innovation. Major clients in particular must show leadership and create a competitive environment for innovation to flourish. However, there is a point at which too much competition stifles innovation by eroding margins and reducing industry performance to the lowest common denominator. Instead of focusing on price alone (which often disadvantages innovative firms), they must recognize the value delivered over the life cycle of their investment, enabling supply chains to have a stake and a say in the way it is designed, constructed and performs. The third source of leadership is external to the industry. According to our respondents, innovation is more likely to be driven by the adoption of innovations from outside the industry than from within it. Finally, at an industry level there is also a need for a champion to catalyze innovation and change, in the way that Latham did in the 1980s and Egan did in the 1990s in the UK. These people caught the imagination of the industry and engendered a universal appetite for reform never seen in the UK construction industry before. However, it is critical that any reforms are evidence-based and that new ideas must not be transplanted from other industry contexts without recognizing the unique cultural and organizational attributes of the industry which differentiate it from other industries.

Skills, education and research

The basis of the skills, education and research agenda is to deepen and broaden the industry's gene pool. The point here is that diversity in knowledge, culture and gender is the key to innovation. But the industry also needs to deepen the gene pool by attracting the very best people. Attracting the best people is not an easy task given the competition from other industries for human resources and will essentially come down to improving the industry's image through strong leadership and highlighting the important and positive contribution the industry makes to the economy, culture, environment and society. Furthermore, it will require the industry to address the under-representation of minority groups at senior levels. For example, women are grossly under represented at senior levels in the industry and there are few education and career pathways formalized for people to work their way up from operational to management roles. To alleviate this problem, education needs to be more flexible to enable people to learn at work, we need to recognize and accredit prior and

experiential learning on-the-job and there need to be clearer pathways and transitions between all levels of education in the industry. We should also ensure that education is relevant to what the industry needs and contributes to the performance of firms in the industry, while at the same time providing the broad-based liberal education needed to think differently. Finally, there needs to be stronger ties between universities, governments and commerce to ensure the industry can independently monitor the benefits of innovation and learn lessons to improve future processes. Stronger ties will also ensure that the results of research better contribute to industry performance and satisfy industry needs while at the same time recognizing the critical importance of basic research for longer term prosperity and innovation.

Regulation

While the inability of regulation to bring about cultural change was widely recognised by our respondents, the basis of the regulation argument is that the construction industry will not innovate voluntarily. Rather, construction has repeatedly shown that it is a compliance-based sector which must be forced to change through regulation and legislation which mandates standards and create incentives to innovate. Certification schemes can also be used to force firms to comply with certain minimum standards and to “cut-off” what is a very long underperforming tail. But regulations should not be penal. They should also drive structural reform within the industry and provide incentives for those firms which wish to innovate. The industry also needs standard methods and metrics for measuring and demonstrating the benefits of innovation and incrementally improving targets need to be set to drive performance up across the industry. However, the need for regulation must be balanced with the dangers of over-regulation which is widely known to stifle innovation by increasing the risk of noncompliance, restricting the boundaries of "legal" innovative activities and by making innovation more dependent on time consuming approvals external regulatory agencies.

CONCLUSIONS

The aim of this paper was to discuss the enablers to innovation in the construction sector. Our interviews demonstrate that there is much that can be done to improve levels of innovation in the industry. However, it is important to bear in mind that these findings are based on opinion only and that they follow nearly two decades of contentious industry reform which has produced mixed results. It is also important to recognise the many risks associated with the strategies summarised in Figure 1 and discussed above. It must be said that these are not well understood although some were noted by our respondents in our interviews. For example, due to the breakup of traditionally vertically integrated firms and increasing regulatory and technological complexity, we now face a world with multiple and potentially cascading interdependencies and uncertainties which did not exist in the past. As the global financial crisis has vividly illustrated, an isolated problem in one part of the world is now capable of spreading and magnifying uncontrolled to previously remote and unrelated businesses and societies in other parts of the world. As a result of these changes, and indeed, some of the strategies suggested here, we have also seen the emergence of what is being called the "hollowed out" firm and the ‘invisible worker’. It is also important to point out the divergence between the vision presented here and the reality of the construction industry where traditional knowledge domains and working practices remain firmly in place. The reality of the construction industry is a highly fragmented and casualised one, where firms are forced to focus on price, profit

and contracts rather than innovation and collaboration. While the discourse of innovation in some segments of the industry is intended to modernise its working practices, the unknown and unintended externalities associated with their implementation need to be better understood before they are implemented in practice.

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VALUE MANAGEMENT IN INFRASTRUCTURE PROJECTS IN WESTERN AUSTRALIA: TECHNIQUES AND STAGING

Andrew Whyte and Carlo Cammarano [1]

Department of Civil Engineering, Curtin University, GPO Box U1987, Perth, Western Australia

Infrastructure projects to service the mining industry in Western Australia (WA) are on the increase, somewhat in contrast to a stalling of projects nationally and globally. It remains important therefore for WA companies to be competitive in the realisation of a client's brief. Value management (VM) has long been regarded as an effective means to eliminate unnecessary capital and life-cycle costs, however, whilst many are familiar with the underlying theory, its use locally is perceived to be less widespread. The research presented here investigates the extent to which value management is implemented by Western Australian engineering and construction companies in both the design and construction fields; exploring, the various value management techniques used in practice and, VM staging. This study documents benefits achieved by means of value management and, the attitudes of industry professionals towards the feasibility or need in establishing a compulsory value management procedure for all (civil engineering) developments. To investigate current value management implementation in WA a pilot-study research methodology embraced a qualitative semi-structured interview approach of ten respondents from organisations involved in design and construction of civil engineering work. Straw poll project results suggest WA industry to be well aware of both, the concept of value management and, the benefits that may arise from its use to address the life-cycle of a project; case-study specification analysis is then presented to explore VM benefits/disbenefits explicitly. The research presented here concludes that industry does have formal value management procedures within a preliminary design phase. Findings show however that industry is resistant to a statutory requirement for value management and, argue that in WA competition is enough to drive the uptake and utilisation of VM.

Keywords: value management/engineering, design-specification, Western-Australia.

INTRODUCTION

As engineering and building challenges increase in complexity due to environmental and political factors inherent in the modern age, as well as ever accelerating changes in technology, construction companies are seeking ways to remain competitive in today's market (Qiping 2004). As the engineering industry expands and the projects undertaken may be increasingly multifaceted, it is important for companies to provide

[1] andrew.whyte@curtin.edu.au

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value for clients. Value management is an effective design management method able to reduce unnecessary capital and life cycle costs (Kelly 2004).

This project paper investigates the extent to which value management is implemented in Western Australian engineering companies in both design and construction fields. It also determines the various value management techniques that are used within value management as well as the time at which value management is usually implemented. Case-study discussion documents the benefits achieved by means of value management and the attitudes of industry professionals towards the feasibility or need of establishing a compulsory value management procedure for all civil engineering projects.

LITERATURE REVIEW

The roots of value management might be traced back to the US General Electric Company which, at the time of the Second World War, sought solutions to address the significant shortages of available resources, skilled labour and raw materials. Electrical engineer, Lawrence Miles, saw the need to drastically update the procedure of manufacturing products to counteract the effect of short supplies of highly demanded commodities and is credited with developing a formal procedure of resource optimisation, which he termed value analysis (Smith 1998); this analysis documented the benefits of substituting materials, which actually improved the quality of the final product while at the same time reducing costs. Although value management was born out of the manufacturing industry, it has developed rapidly and spread across several industries on a global scale (Ashworth 1997).

This concept was extensively used in the design stages of US construction projects by the late 1960s. During this time, the UK construction industry showed interest in the concept (Palmer 2002). The UK construction industry adapted Mile’s value analysis and developed it under the name 'value management'.

The term 'value management' is considered somewhat synonymous with 'value analysis' and 'value engineering'. Despite an (ongoing) Australian Engineering bias towards an American branding of Value Engineering (VE), Value Management (VM) was formally recognised in the Commonwealth of Australia, and the state of Western Australia, in 1977 with the establishment of the Institute of Value Management Australia (Spaulding 2005).

Value Management (VM) and the analysis techniques involved is applicable as an design management methodology, and is argued as being as relevant to civil engineering infrastructure projects, as it is to architecturally orientated building projects. VM is a systematic means to improve the value of products and services and might be argued as essential in any objective comparison of the available alternative fit-for-use materials and specification options in (civil) engineering design. VM can be defined as 'a service that maximises the functional value of a project by managing its development from concept to use through the audit of all decisions against a value system determined by the client' (Kelly 2004).

A common value management exercise generally involves seven phases; orientation, information, creativity, evaluation, development, presentation and feedback (Kelly 2004). A comparison of international journals investigating the issues concerned with the successful implementation of value management has several recurring factors. There are costs associated with implementing value management; some suggest that value management does not provide a decent return on investment to warrant spending

resources on it. However many types of projects (predominately complex, unique or repetitive) do benefit greatly from value management are (Smith 1998), where VM costs about 1% of the total project cost and can result in positive returns (Norton 1995). In conjunction with the cost of implementation, some suggest that 'lack of time to implement value management' remains a serious impediment particularly for segmented delivery methods such as design-bid-build contracts, where it is common to fast track the construction stage and leave minimal time for development of alternative solutions (Cheah 2005).

Often engineering companies have reservations about using value management. This fact stems from the evidence that there is a lack of knowledge about value management, as a result there are no opportunities given to employ creative thinking techniques to develop alternative solutions (Bowen 2010). Application is also directly influenced by senior management and company policy as it is argued by some that there is lack of support from individuals with authority to call for the formal application of value management within the preliminary design stages (Qiping 2004). To an extent this might be argued to stem from a traditional (somewhat blinkered) fixation, by both Western Australian mining clients and their representatives, upon the capital cost and need for quick installation of civil engineering components, to the exclusion of infrastructure cost-in-use variables, as a means to simply get them in, to allow mine-resource extraction and transportation to commence as soon as possible.

Wixson and Heydt (1991) comment on the importance of 'people', stating that it is the people involved in the team that have a direct bearing on the success of a value management study; therefore, top level managerial support is critical (Cheah 2005). Whilst acknowledging this to be the case, it might be suggested that the mining industry currently exploiting the huge resources available in the northern region of Western Australia (an area the size of Western Europe with a population of just 2.5 million) have traditionally regarded infrastructure support as a somewhat peripheral concern. This historical attitude is changing however, with senior (client) personal and design consultants recognising that the majority of the support structures and facilities put in place two or three decades ago, to facilitate mining operations, have now reached and overrun their expected life-cycle requiring essential expansion refurbishment and retrofitting.

When considering the need to design and construct support and infrastructure facilities for the future, West Australian design-teams are now being charged to compare objectively, alternative design specification solutions; value management exercises are relevant and somewhat fundamental, with life-cycle cost analysis (LCCA) a key measurement technique to assist with value management exercises to best determine the effectiveness of design proposal options (Selg 2006). By reducing risks and life cycle costs, the end result will be a deliverable that provides the most benefit for the client (Harvey 2008).

Value management techniques:

To assist (civil engineering) design teams address alternative infrastructure solutions a number of (documented) value management techniques can be argued as relevant. One such technique is that of 'Brainstorming' (Stewart 2010), which seeks open, non-critical discussion of alternative design solutions.

Review of alternative materials 'strengths, weaknesses, opportunities and threats' (SWOT) might be argued to help specify the objective of the project and identify all

factors, internal and external, that will either be favourable or unfavourable (Armstrong 1992).

Infrastructure (civil engineering) design options may also be assessed by a 'Function Analysis System Technique' (FAST) of the particular elements which comprise a project. It determines what functions are to be delivered, what something must do and not what it is. By focusing on the function, designers may focus on alternatives to achieve the function. 'Risk-Analysis', alongside FAST, allows a structured approach to identify potential risks associated with the project which are then attributed costs in regards to money, time and negative impacts (IVM 2011).

VM may also be deemed to encompass 'Cost-Benefit analysis' (B/C) as a systematic approach in comparing the quantifiable benefits and costs for a particular project or indeed the overall value of the contributory components or sub-components. The fundamental purpose is to determine whether the investment of time and money is worthwhile. Whilst, in the hugely profitable mining industry, infrastructure investment usually is worthwhile, this method is relevant when considering alternative solutions for the same projects. Usually the option with the highest ratio, namely higher benefit relative to cost, is considered as being the most appropriate option (Flyvbjerg 2008).

VM analysis might also be complemented by a 'Stakeholder Analysis' technique where all major stakeholders with influence or authority over a project are identified to assist in focusing the scope and attention of the value management exercise to consider major priorities. These priorities usually seek to satisfy the stakeholders (IVM 2011). Whilst perhaps it might be somewhat glibly stated that a Stakeholder Analysis is largely a client's briefing procedure, this more structured, defined approach might well identify, and allow consultation with, any individuals who may otherwise have slipped through the client briefing 'net'.

RESEARCH METHOD

The objectives of this study included the investigation into the extent of value management implementation in the Western Australian engineering industry, alongside an investigation into issues deemed critical with regards to the success of value management. The study also sought to assess: the level of familiarity with value management locally; common value management study techniques; timing of VM implementation; issues that hinder VM success and the benefits that arise from implementing a value management approach.

To measure and achieve study objectives, a semi-structured interview questionnaire methodology was developed, to identify issues key to value management, from a sample catchment of companies directly involved in design and construction of civil engineering work. Respondents were actively selected from the region's largest local companies (including BHP-Billiton, SKM, GHD, AECOM, Brookfield-Multiplex and BG&E) whose extensive project portfolios contribute greatly to state turnover in the mineral and oil and gas rich region of Western Australia.

The semi-structured interview was designed to include multiple-choice questions with an opportunity to share comments. Responses were given quantifiable scores to aid in analyses, supported by opinion gleaned from participating professionals. This research pilot study targeted 10 experienced professional civil engineers working in and around Perth Western Australia.

A case-study to assess and compare alternative design material specifications seeks to allow quantitative research findings regarding potential actual cost savings, to

complement qualitative research data generation regarding VM technique applications and appropriate stage implementation.

PRIMARY RESEARCH RESULTS AND DISCUSSION

Characteristics of Interviewees

The number of respondents was limited to 10 civil engineering companies: 6 of these companies specialised in design, 2 were involved in design-build and the remaining 2 companies were involved in construction. As Western Australia continues its development in civil and mining works, most of the respondents, 90%, noted that they are involved in industrial related work such as mining. Additionally 50% stated they are also involved with building and engineering work such as large commercial buildings and infrastructure; representative of the different types of work in Western Australia.

Familiarity with Value Management

A major aim of the interview questionnaire was to determine familiarity with the concept of value management. Out of the 10 respondents interviewed, all of them indicated that they are familiar with the concept of value management as a design management tool and noted that it is very effective at reducing unnecessary costs.

The interview responses also noted that 90% of the interviewees have an in-house structured, management policy that includes appropriate value management procedures, which is largely concerned with review of principal fit-for-use component specification alternatives. The companies who stated that they do have a value management policy were also primarily design based companies. This supports secondary research investigations, that it is primarily the designers' responsibility that has the biggest impact on both the capital cost of a project as well as the life cycle cost (Selg 2006).

The respondent companies also spanned both the private and public sectors across several fields of work including engineering, building and industrial infrastructure applications; private companies encouraged the use of value management as a means to increase the value of a project for the client while also promoting themselves as a competitive player in the engineering industry.

Utilisation of Value Management Techniques

Having introduced some of the range of theoretical VM techniques in the literature-review section above, Table 1 highlights the most common techniques considered applicable to a value management study in Western Australian civil engineering projects. The most used techniques are "Cost-Benefit Analysis" and "Risk Management", scoring 80% each; followed by "Brainstorming" and "Stakeholder Analysis". These techniques can easily be applied to the early design stages, specifically in the value management studies, to enhance the overall value of an engineering project. It was also commented by a number of respondents that early contractor involvement is an important technique. Early (sub) contractor involvement is beneficial because construction knowledge can be successfully integrated into the design procedure to create an effective solution in terms of constructability. Many of the respondents noted that a combination of these techniques are advantageous in the development phases of the value management study, quoting that all stakeholder concerns are explicitly considered along with the potential risks of each alternative.

These issues are further considered by means of a cost-benefit analysis that attempts to compare qualitative and quantitative factors that affect the cost and benefit.

Table 1: value management techniques utilisation

VM Technique	% application in projects
Risk Analysis	80%
B/C analysis	80%
Stakeholder analysis	70%
Brainstorming	70%
Issues Generation & Analysis	50%
Value Analysis	20%
SWOT analysis	20%
FAST analysis	30%
SCAMPER	0%

Timing of Value Management Implementation

All of the design and construction companies indicated they used value management in the conceptual design phase. 50% of the sample space also noted value management can be used during feasibility and detailed design. The preliminary design stage is the most effective time to implement value management as it has more potential to provide significant cost reductions as more appropriate solutions are developed based on a consideration of all major stakeholder issues and concerns. It was noted by the interviewees that the greatest possible savings can be achieved during the planning and definition phases, which will ensure that appropriate investment decisions are made. 40% of the respondents highlighted they incorporate value management in the post construction and maintenance phase, commenting that it is still possible for cost reductions and effective construction methods based on value engineering proposals from constructors.

Table 2: timing of value management implementation

VM Stage	% application in projects
Conceptual design	100%
Feasibility	50%
Detailed design	50%
Post-construction/maintenance	40%
Construction	10%

Factors Affecting Value Management

Time Limitations is considered by the sample as one of the biggest factors that hinders the implementation of value management (table 3 below). It was commented by several interviewees that company policy or design procedures do not allow for sufficient time, particularly in the traditional 'Design Bid Build' contracts where there is added pressure to fast track the construction phase. Indeed given the need for civil engineering consultants and contractors to realise their respective infrastructure projects early, to enable early mine-operation resource production, this is unlikely to change. Consultants therefore seem to have rationalised expectations to accommodate

the (short) period given (predominantly at the 'conceptual design' stage as described above) to allow respective fit-for-use comparisons. Although 'Time Limitations' is a significant factor in hindering value management, value management procedures are still widely used, which attests to the fact that it is a highly regarded management tool that is effective in increasing project value and reducing costs. Other factors related to the implementation of VM were found to be “Lack of Understanding” “Ambiguity” and “Lack of Commitment”. These issues are related as they represent a combination of a lack of understanding that usually correlates to ambiguous concerns being presented, as well as a lacking of commitment to expend one’s own efforts on the exercise.

Table 3: Mean (importance) score of issues affecting value management

VM Issues	Mean (importance) score
Time limitations	2.6
Lack of understanding	2.5
Ambiguous specification	2.3
Faulty ambiguous drawings	2.1
Lack of commitment	2.1
Lack of support	1.9
Unforeseen constraints	1.9
Budget limitations	1.7
Confrontational relationships	1.6
Nonstandard drawings	1.5

Benefits of Value Management

Implementing the value management tool into existing design and construction business procedures requires the investment of both time and money. Table 4 highlights the potential benefits that arise from implement value management. “Improved Project Value for the Client” “Improved Effectiveness” are two of the highest ranking benefits, followed by “Cost Savings”, “Improved Cooperation” between parties and “Documentation of Issues and Opportunities”. Improved project value and effectiveness can be expected, but it further supports that these benefits are commonly achieved when implementing value management. It was commented by some of the interviewees that the benefits will be greater, once all participants have been briefed about the value management procedure so that they are conscious of the importance of their individual participation. Feedback of information is also important as it will enable the designer to build up a knowledge base of solutions that may be applicable for future value management studies for similar projects. The benefits are evident to clients and engineering companies alike and by implementing value management they can increase their competitiveness in the industry.

Table 4: Mean (importance) score of benefits of value management

VM Benefits	Mean (importance) score
Improved project value for client	2.9
Improved effectiveness	2.7
Cost savings improved profit	2.6
Improved relationship/coordination	2.5
Documentation of issues/opportunities	2.5
Improved reputation	2.1
Reduced claims or disputes	1.8

Rating of Current Value Management Procedures

The interviewees were asked to rate the current value management procedures in the companies they represent. 25% rated their process as "Very Good". Another 25% rated it "Below Satisfactory"; whilst 13% suggested processes to be non-existent. Generally then, findings suggests that participating companies are conscious of applying value management but are still developing the effectiveness of their process. The majority of the respondents, 37%, noted that their procedure is "Satisfactory". Although it was stated their procedure is effective and has provided significant benefits, it is felt that there is room for improvement by means of additional training.

Compulsory Value Management

It was noted that a significant number of client organisations, in the public and private sectors, encourage value management. However, making value management a statutory requirement was not supported by the respondents to this study. All 10 of the respondents replied that value management should not be a formal requirement for civil engineering projects in Western Australia. It was stated on several occasions that value management should not be a requirement but instead each individual company should determine for themselves whether they would invest in VM implementation. Making value management a statutory requirement for Australian projects may in fact hinder performance was a response, as they will be asked to do something that they have already considered, compounded by the fact that they will have to align their fully developed existing procedure with additional specified regulations, and as a result companies might be apt to focus on "checking the boxes" to prove they have complied, distracting teams from focusing on the main goal of improving value.

Case Study Analysis

A basic value management case-study exercise showed how the collaborative efforts of a multi-disciplinary team might be approached; with participation of both client and designers alike, to explicitly assess the best viable option from a range of alternative solutions. Respondents identified a scenario which required the construction of three retaining walls at three locations around the city. The retaining walls were constructed using the T-Block wall system. These walls are manufactured from precast concrete sections with baled rubber tyres placed in between. Before the decision was made to use the T-Block walls, the manufacturer was contacted to provide the comparative cost of construction for similar walls, to provide data towards a value management assessment. The alternative materials were considered were T-Block wall options of concrete or limestone; capital cost reduction potential is highlighted in table 5. This was presented as the initial step in an overall value management exercise that sought

to factor-in: life-cycle cost analysis; supply chain variables; tradesman expertise; client/(user) aesthetic considerations; as well as, work breakdown structure activity scheduling for the wider aspects of the project. Respondents suggested that the value management study conducted resulted in a significant cost saving accumulation due to a compounding of factors related to the repetitive nature of the project to construct multiple retaining walls.

Table 5: case-study specification comparison: percentage comparison

	Total cost	Cost of T-Block	Cost Saving	Capital cost saving
Concrete	$358,000	$229,011	$129,600	36%
Limestone	$220,400	$154,687	$65,713	30%

DISCUSSION

The general consensus of the interviewee findings validates the available literature that value management provides significant cost reductions and results in a project with increased value for the client. Previous studies argue that the cost of implementing value management is 1% of the total cost of construction, but may provide construction cost reductions of between 10-30%. In other words, VM gives a large return on minimal investment (Norton and McElligott 1995); specifically 1$ spent at concept stage can yield a saving of $100 at implementation phases (Selg 2006; Leeuw 2001). Whilst the cost to provide and maintain (civil engineering) facilities is but a drop in the (profitability) ocean for the WA resources industry, suggestions (Arditi 2002) that companies cannot afford to not use VM, rings as true for mining infrastructure as it does for more traditional building design projects.

CONCLUSION

This pilot study concludes that the Western Australian engineering industry is aware of value management procedure and familiar with its associated benefits. It indicates that value management has potential to provide increased value and effectiveness at all stages of the project life cycle. The most common techniques incorporated into a value management study are brainstorming, cost-benefit analysis, risk analysis and stakeholder analysis. This mirrors a fundamental tenet of value management, towards consideration of the most cost effective alternative solution with minimised risks while at the same time taking into consideration the opinions and concerns of all stakeholders from the beginning stages of a value management exercise. Time limitations and a lack of understanding and participation of individuals in the team will influence negatively the level of success of a VM exercise. The quality of the final decision is influenced by the level of information provided initially, compounded by the pressures to fast-track design projects to on-site construction. It might be suggested that the types of projects where value management has most potential for a high return on investment include projects that are complex and unique, or alternatively repetitive in nature. The benefit of value management across all types of civil projects depends in large part upon the commitment and initiative of each individual member making up a design (and value management) team. Value management as a statutory requirement is not supported by this WA straw poll.

RECOMMENDATIONS

Based upon the findings and conclusions of this study it might be recommended that future work seek a wider review of standardisation for value management approaches

in WA, particularly given the majority of the original infrastructure facilities have now reached and overrun their expected life-cycles, and that industry practitioners must now begin designing and installing, both fit-for-use and whole-cost appropriate, expansions, refurbishments and retrofitted facilities. Indeed, it is recommended that further case-study analyses of value management applications seek to document and address explicitly opportunities for adding value to resource-industry infrastructure.

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A CRITICAL REVIEW OF PMS IN CONSTRUCTION: TOWARDS A RESEARCH AGENDA

Fei Deng[1], Hedley J. Smyth and Aaron M. Anvuur

Bartlett School of Construction & Project Management, University College London, 1-19 Torrington Place Site, London WC1E 7HB, UK

Performance measurement system (PMS) is a fast evolving and diverse research field attracting many researchers and practitioners from the fields of strategy, accounting, operations, human resource, and marketing. The characteristics of the construction industry that influence the research and directions adopted in practice significantly contribute to certain weaknesses in application, such as limited focus on business performance measurement, insufficient organisational learning, and difficulty in linking the project PMS with the firm. The *aim* of this paper is to briefly review the literature of PMS (specifically at the corporate level) for addressing the knowledge gap and presenting a research agenda in the context of construction. The main findings from this review are: (1) the evolution of PMS in construction management literature is much slow; (2) further research should focus on the design and implementation related issues of PMS in construction; and (3) benchmarking is an integral part of PMS but it is insufficient for 'continuous improvement'. Finally, a research agenda is presented.

Keywords: performance measurement system, PMS, benchmarking, strategy, firm performance

INTRODUCTION

Performance measurement (PM) has gained significant interest among researchers and practitioners (Neely and Bourne 2000). Traditional financial measures have not met the multiple requirements of an increasingly competitive and turbulent marketplace (Kaplan and Norton 1992). Researchers express a general dissatisfaction with traditional backward looking PMSs (Bourne *et al.* 2000). The main weakness of traditional PM is the absence of non-financial measures, e.g., productivity, quality, and leadership (Neely 2005). This causes other problems, including failure to link PM and strategic initiatives of organisations, focusing on external reporting rather than internal decision making, and anticipating future performance. Therefore, traditional PMSs are insufficient and inappropriate (Neely *et al.* 1995). PM has given considerable attention to the introduction of the Balanced Scorecard (BSC) approach (Kaplan and Norton 1992), although other frameworks were designed earlier to decrease the gap between financial and nonfinancial measures, for example, the

[1] f.deng.11@ucl.ac.uk

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Performance Pyramid (Cross and Lynch 1988/89). Furthermore, researchers focused upon how PMS is successfully designed to satisfy specific requirements, implement firm strategy, and then gain competitive advantage through such a process (Bourne *et al.* 2000; Neely and Bourne 2000; Neely *et al.* 1995).

The PM revolution has spread to the construction industry (Bassioni *et al.* 2004), where most large construction engineering organisations have adopted PMS, and a growing number of organisations are adopting BSC and excellence models (Robinson *et al.* 2005a). Some industry reports have identified many areas for performance improvement and highlighted the role of PM in improving the current situation of the industry (Egan 1998; Latham 1994) –a critical reason for that PM having increasing popularity in construction . However, PM in construction is mainly project-focused, whilst the PM of construction organisations has received small interests (Love and Holt 2000). The *aim* of this paper is to review the literature of PMS (specifically at the company level) for addressing the knowledge gap and subsequently presenting the research agenda in the context of construction.

AN OVERVIEW OF PM IN CONSTRUCTION

PM in construction is mostly project-based, specifically the productivity issue in project management (c.f. Bassioni *et al.* 2004) and project success criteria and factors (e.g., Chan *et al.* 2004; Chua *et al.* 1999). Many developed countries have launched their own project-based PM programmes, such as the US (Lee *et al.* 2005), the UK (CBPP-KPIs, 2002), and Canada (Rankin *et al.* 2008) [an excellent review of national PM programmes can be found in Costa *et al.* (2006)]. As a project-based industry, radical changes to the way of delivering projects will contribute to the performance improvement of the industry (Egan 1998), while the project focus dislocates PM from the corporate centre (especially management support and budgets), from programme management and hence hampers the feedback loop from being effective. However, PM is a diverse research field in construction, and the literature can be generalized into three main purposes:

1. Industry purpose: assess the performance of the industry, both nationally and internationally (e.g., Costa *et al.* 2006; Fisher *et al.* 1995; Lee *et al.* 2005; Rankin *et al.* 2008).
2. Business purpose: measure the performance of the construction organisation, including both one-time evaluation and continuous measurement (e.g., Bassioni *et al.* 2005; Beatham *et al.* 2005; El-Mashaleh *et al.* 2007; Horta *et al.* 2010; Kagioglou *et al.* 2001; Love and Holt 2000; Luu *et al.* 2008; Rankin *et al.* 2008; Yu *et al.* 2007). As noted, this purpose has been weak due to the lack of non-project budgets to facilitate, adequate feedback loops and the spreading and embedding of lessons learnt to generate improvement in project businesses and construction.
3. Project purpose: evaluate the performance (and success) of construction projects (e.g., Chan *et al.* 2004; Liu and Walker 1998). This may work over the project lifecycle, but most project organisations measure insufficiently to induce improvement opportunities within a project hence potential benefit is to tease out generic lesson for spreading and embedding of lessons on other projects.

Given many existing research approaches, following sections mainly focus on the review of PMS at the company level, including defining PMS, applying conceptual frameworks, and benchmarking.

DEFINING PMS

PMSs provide information that helps a firm to align its management processes, such as target setting, decision-making and performance evaluation, with the achievement of chosen strategic objectives (Ittner *et al.* 2003). PMS is a widely used but rarely defined term (Franco-Santos *et al.* 2007; Neely 2005; Neely *et al.* 1995). For example, Franco-Santos *et al.* (2007) found that PMS was explicitly defined in only 17 out of the almost 300 articles they reviewed. The fact that the lines of literature on PMS span many management disciplines, such as strategy, operations, accounting, human resources, and information systems contributes to the lack of a cohesive body of knowledge. According to Franco-Santos *et al.* (2007), the three defining aspects of a PMS are its features, roles, and supporting processes. Firm level definitions of PMS in construction management research are extremely limited However, some general definitions can be found in the literature (see Table 1). For example, Bassioni *et al.* (2005) define PMS as the measurement system implemented by construction organisations for the purpose of internal management of the firm, not the evaluation by clients and stakeholders, while Love and Holt (2000) highlight that an effective business PMS should enable a construction company to evaluate and establish its position with respect to the business environment, indicating the principal role of PMS within a construction organisation. According to Table 1, most of the characteristics of PMS are highlighted fully or partially by construction management research, but some important and implicit characteristics of PMS are largely overlooked, such as communication, influencing behaviour, and system review.

As reviewed above, no research in construction makes explicit the definition of PMS at corporate level, while most of them present a vague definition or refer to those definitions in management literature, which coincidently keeps pace with Fanco-Santos *et al.*'s (2007) finding that most researchers did not define PMS when they used it. This prevents or severs the link between corporate strategy and measured performance which the review stated was important earlier (e.g. Banker *et al.* 2004).Vague definitions of PMS in construction also show an incomplete realization of PMSs' features, roles, and processes, but those aspects of PMS definition have induced lots of fruitful researches in management literature, for example, empirical investigations of the role of PMS in building organisational capabilities and facilitating decision-making. Additionally, despite an incomplete exploration of PMS in construction, the literature shows a common concern on the strategic alignment, and this consistent concern may be influenced by the application of BSC, as those who do not adopt a BSC approach tend to overlook the importance of strategic alignment. Strategic alignment is a fundamental aspect of PM frameworks and PMS design, but it is difficult to transfer strategies from the corporate centre to projects in construction context, and more difficult to gain feedback from the construction projects whether organisational strategies have been implemented effectively. Obviously, this discrepancy hampers the application of PM frameworks in terms of "translating strategy into action".

Table 1: Mentioned characteristics of the definition of firm-level PMS in the construction management research (●: Fully Mentioned; ○: Partially Mentioned)

Aspects	(Kagiogl ou *et al.* 2001)	(Beatha m *et al.* 2005)	(Bassion i *et al.* 2005)	(Yu *et al.* 2007)	(El-Mashaleh *et al.* 2007)	(Luu *et al.* 2008)	(Horta *et al.* 2010)
Features of PMS							
Performance Measures	●	●	●	●	●	●	●
Supporting infrastructure		○	○				●
Roles of PMS							
Measure performance	●	●	●	●	●	●	●
Strategy management	○	○	○	○		●	
Communication		●					
Influence behaviour							
Learning&improvement	○	●	●	○	○	○	○
Processes of PMS							
Design of measures	●	●	●	●	●	●	●
Collection of data	●	●	●	●	●	●	●
Inform. management	○	○	●	●			○
Evaluation and reward	○	○	○	○	○	○	
System review		○		○			
Defined Explicitly?	No	No	No	No	No	No	No

APPLICATIONS OF CONCEPTUAL FRAMEWORKS

The application of conceptual frameworks in construction is limited to BSC, European Foundation for Quality Management (EFQM), and Malcolm Baldrige National Quality Award (MBNQA) (see Table 2). A previous survey shows that the application of PM frameworks is even more narrow in practice, indicating that KPIs approach, BSC, and EFQM are dominating the business PM in the UK construction industry (Robinson *et al.* 2005a). It is clear that the degree of popularity of those frameworks in general largely affects their applications in construction, but it does not mean that these frameworks are more appropriate for construction context than those that are not applied in practice and/or adopted in research, for example, a recent framework – Performance Prism (Neely *et al.* 2002), which has not been applied in construction industry but does have great potentials.

Some researchers in construction tried to understand the performance of construction firms by designing conceptual frameworks, such as Kagioulou *et al.* (2001), Love and Holt (2000), and Bassioni *et al.* (2005). Kaigioulou *et al.* (2001) design a conceptual framework by adding two dimensions—project and supplier perspective—into the BSC to make it more appropriate for the situation of construction industry, where project performance and suppliers performance are crucial to the overall performance of construction firms. As the project management team is usually temporary, the perspective of innovation and learning is problematic in construction industry. The conceptual framework concentrates on practical application in practice (e.g. the PM

matrix, and the alignment among strategies, goals and measures), and case studies also show some usefulness and validity, whilst no evidence shows causal links among performance dimensions and empirical validation is needed as stated by the authors. A more complex and comprehensive framework is designed by Bassioni *et al.* (2005), who build it upon the principles of BSC and EFQM, and empirical weights of these dimensions are presented (Bassioni *et al.* 2008). Although interviews show that the framework is practical to some extent, successful application is doubted because of its complexity.

Some other researchers assume that these frameworks can be applied directly in construction industry and used as a management technique both in research and in practice, such as Yu *et al.* (2007), Luu *et al.* (2008), Arditi and Lee (2003), and Beatham *et al.* (2005). Yu *et al.* (2007) designed 12 benchmarking measures under four perspectives of the BSC, indirectly showing that strategy alignment is not the predominant issue for the application of the BSC. This contradicts with the premise of the BSC. A more specific approach is adopted by Luu *et al.* (2008), who apply the BSC to design PMs within a case study construction firm, and firm strategies are deployed to design PMs. Besides the application of those popular frameworks, some operation models are adopted to benchmark the overall performance of construction firms, e.g. DEA (El-Mashaleh *et al.* 2007; Horta *et al.* 2010). Simple measures are adopted to make the benchmarking process more applicable. Although progress has been made in the application of PM frameworks, there are significant challenges at the planning, deployment and assessment and review stages (Robinson *et al.* 2005b). As applications of KPIs, BSC, and EFQM have been adopted in the industry for a long period, barriers and problems during the application process should be further researched (Bassioni *et al.* 2004).

PMS design issues are concerning the design of an appropriate system within a construction firm and successful implementation of the system. Given that the KPIs programme in the UK provides little chance for construction firms to change, Beatham *et al.* (2005) present an integrated business improvement system, containing four stages—understanding, performance measures system design, implementation of PMs, and use of PMs. Robinson *et al.* (2005b) discuss three main issues of PMS in construction: planning, operationalisation, and assessment and review. In their other research, six key considerations have been highlighted in implementing PMS: leadership and commitment, choosing appropriate PM models, choosing right measures, understanding the purpose of PM, knowledge management, and managing the change (Robinson *et al.* 2005a). Their findings show that most of case study organisations are at infancy stages in implementing PMS (Robinson *et al.* 2005b).

Table 2: Applications of conceptual frameworks in construction

Authors	Dimensions	Objective	Method	Sample	Source
Kagioulou *et al.* (2001)	BSC; project management; suppliers	Design a conceptual framework for construction firms	Case studies	2 cases	BSC
Bassioni *et al.* (2005)	13 dimensions combining both BSC and EFQM	Design a holistic and conceptual framework for construction firms	Interviews, case studies	11 interviews, 5 cases	BSC, EFQM
Yu *et al.* (2007)	4 BSC dimensions	Develop an implementation model for construction firms	Interviews, questionnaire survey	12 experts 34 firms	BSC
El-Mashaleh *et al.* (2007)	Schedule; cost; safety; customer; profit	Propose a benchmarking model	DEA	74 firms	None
Luu *et al.* (2008)	4 BSC dimensions	Identify and validate KPIs to measure strategic performance	Interviews and case study	1 case	BSC
Horta *et al.* (2010)	Organisational and operation	Develop a methodology for assessing company overall performance	Questionnaire survey, DEA	22 firms	None
Arditi and Lee (2003)	MBNQA	Develop a tool to measure the firm service quality	Questionnaire survey	19 owners, 21 contr.	MBNQ A
Beatham *et al.* (2005)	EFQM and KPIs	Review key facets of PMS to design a new one	Case study	N/A	EFQM

BENCHMARKING PRACTICES

The development of competitive benchmarking makes PM revolution more real (Eccles, 1991). Many benchmarking systems exist in the construction industry, such as Fisher *et al.* (1995), CII-BM&M in the US, CBPP-KPIs in the UK, and Canada-Benchmarking Programme (Rankin *et al.* 2008). Given no available benchmarked standards for the construction industry, Fisher *et al.* (1995) designed ten measures to collect benchmarked data in the US, which is the first benchmarking system (model) in the construction industry (El-Mashaleh *et al.* 2007). This research aims to be the third-party benchmarking system for providing objective and industry-cross standards. Other well-known benchmarking systems include Construction Industry Institute Benchmarking and Metrics (CII-BM&M) and UK construction best practice program (CBPP-KPIs). All these benchmarking programmes are initiated to become a third-party facilitator. Clearly, there are some benefits, such as marketing advantages, improved performance opportunities, agreement on common definitions for metrics, and setting an industry-cross standard (Costa *et al.* 2006). However, some problems are also significant: *i)* Project specific benchmarking initiatives provide little indication of the overall performance of organisations from business perspective (Beatham *et al.* 2004; El-Mashaleh *et al.* 2007; Kagioglou *et al.* 2001); *ii)* Availability and validity of data (Beatham *et al.* 2005; Costa *et al.* 2006; Kagioglou *et al.* 2001); *iii)* Failure of demonstrating the relationship between measures from a holistic view (El-Mashaleh *et al.* 2007; Kagioglou *et al.* 2001); *iv)* Little measures related to suppliers' performance, employee satisfaction, site management, and quality management (Costa *et al.* 2006; Kagioglou *et al.* 2001); *v)* Little alignment of the benchmarking measures to company strategy (Bassioni *et al.* 2004; Beatham *et al.*

2004; Costa *et al.* 2006; Kagioglou *et al.* 2001); vi) Large proportion of lagging indicators and limited leading indicators that provide chances for changing performance (Beatham *et al.* 2004).

Besides these benchmarking initiatives at the national level, researchers in construction also adopt benchmarking approach to measure the performance of construction projects and firms (e.g., El-Mashaleh *et al.* 2007; Garnett and Pickrell 2000; Horta *et al.* 2010; Yu *et al.* 2007). Garnett and Pickrell (2000) present a seven-step benchmarking model to measure performance of two case study organisations, and conclude that this benchmarking model could be a powerful tool in investigating and managing change on construction projects. Luu *et al.* (2008) adopt a benchmarking approach to compare the case study construction company's overall performance with its main competitors in the construction market, and then comparative weak areas are identified. Yu *et al.*'s (2007) research aims to provide robust benchmarks for construction organisations and a practical methodology to design benchmarking system for the PM of construction organisations. El-Mashaleh *et al.* (2007) and Horta *et al.* (2010) adopt a similar benchmarking methodology by highlighting that various metrics should be integrated to measure the organisation efficiency and effectiveness.

CONCLUSIONS

PM and PMS have become a significant way of conceptualising and developing practice for business performance improvement. In construction PM has been adopted conceptually and in practice to evaluate the performance of construction projects and organisations. The literature review has shown several conclusions:

1. There are some conceptual frameworks inspired mostly by BSC and EFQM, to some extent showing effective application in construction industry. Although explicit definitions of PMS in construction are scant, strategic alignment is widely mentioned in both conceptual frameworks and practical design of PMS, indicating a mixed and vague usage of PMS. Additionally, as PMS design issues are overlooked in the construction industry, many construction companies are at the infancy stage in designing and implementing PMS (Robinson *et al.* 2005b).
2. The evolution of PM in construction is much slower than that in the management literature, which further hampers the potential of the PMS revolution across the industry. Researchers in construction started to design conceptual PM frameworks of organisations in early 2000s, and more recently, people have began to adopt various practical PM methodologies to measure the performance of construction firms. Methods of application have gained very limited attention in the construction industry, whilst no existing research adopts empirical and theoretical analysis of PM frameworks and methodologies.
3. Benchmarking approach plays an indispensible role in evaluating the performance of construction projects and companies by aggregation, but this is insufficient for "continuous improvement" for at least three reasons: *i)* benchmarking performance of projects in the industry captures very limited aspects of project performance, and most of PMs are lagging indicators, which means it cannot give project management team instant directions and suggestions to improve the performance; *ii)* any construction project is completely different with others and the management team is built temporarily, which demonstrates that previous benchmarking information can hardly present useful and accurate guidelines for them; and *iii)* benchmarking to improve industry practice as a whole assumes on

the one hand it is backward rather than different in comparison to other industries and on the other hand that project KPIs will aggregate up to sectoral improvement without demonstrating the causal link to induce such improvement.

The literature claims that there is a need to carry out further research on PM in both construction projects and firms. The analytical evaluation in this review has identified further issues that need to be addressed. Questions that have to be addressed include:

1. Given the project-based characteristic of construction industry, how do differences of management style between construction site and home office influence PM? How to integrate construction project management into the entire PMS of firms? How to stimulate performance information feedback (learning loop) from the temporary project management team to the programme and firm levels, and then spread and embed the lessons learnt to induce performance improvements?
2. Given various stakeholders involved in the construction process, how do those stakeholders influence the PM on construction site, which further influence the entity PMS within the firm? How to identify potential influencing forces and manage this effect? How to measure inter-organisational performance, such as the supply chain? Measuring and managing the performance of inter-organisations in construction will be significantly valuable.
3. The literature shows that large construction firms are at the infancy stage in implementing PMS. What are the contingencies that influence the design, implementation, and use of PMS, their associations with PM practices, and their effects on project and firm performance in the construction industry? How to present a structured process of developing and maintaining a dynamic PMS that enhance the flexibility of PMS so that they can cope with organisational and environmental changes?
4. The literature shows no empirical and theoretical analysis of PM effects in the construction industry. Does the implementation of BSC, EFQM excellence model, and/or KPIs approach really affect the performance of construction organisations? What are the mechanisms, how do they work and what improvements can be made?

Many of the above issues can be addressed through traditional research methods. However, some require high levels of industry engagement. Therefore an additional recommendation is that research methodologies and methods that facilitate high levels of engagement, such as action research, are employed.

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CORPORATE ENTREPRENEURSHIP FOR CONTRACTING COMPANIES: THE CURRENT ISSUES

Harijanto Setiawan[1], Bilge Erdogan[2] and Stephen O. Ogunlana[3]

School of the Built Environment, Heriot Watt University, Edinburgh, EH14 4AS

Entrepreneurship has recently received major attention from many business practitioners and scholars and evolved rapidly in many industries. Due to the project based nature, high competition and business risk characteristics of the construction industry, entrepreneurship is considered very important for sustaining and improving the performance of contractors. An extensive literature review on entrepreneurship, with a particular focus on the implementation of corporate entrepreneurship by contractors, has been carried out. It was found that corporate entrepreneurship is defined by many characteristics. This study adopted the characteristics which are grouped into five categories: innovativeness, risk-taking, competitive aggressiveness, pro-activeness, and autonomy (Lumpkin and Dess, 1996). There is very little research focusing on entrepreneurship in the construction industry, exploring those characteristics together. So far, researches in construction management have only been carried out in innovativeness, risk taking and competitive aggressiveness individually. This study, as part of doctoral study, is aimed at clarifying the entrepreneurship concept and presents a theoretical framework to investigate entrepreneurship in construction in a systematic way in order to illuminate further studies that will investigate the relationships between each characteristic and to explore the outcomes of different combinations of these characteristics in terms of corporate strategies.

Keywords: corporate strategy, contractors, entrepreneurship.

INTRODUCTION

The construction industry has been considered as an industry that drives a country social and economic establishment (Halpin and Woodhead 1998, Winch 2010, Wong *et al.* 2010). The industry is responsible for providing and maintaining physical assets which are beneficial to the nation to achieve social and economic goals (Gann and Salter 2000, Winch 2010).

High competition and high risk have been considered as the construction industry's challenge (Schaufelberger 2009). However, Chinowsky (2001) points out that

[1] hs4@hw.ac.uk

[2] B.Erdogan@hw.ac.uk

[3] S.O.Ogunlana@hw.ac.uk

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construction companies tend to apply prudent and conventional management in their businesses in many ways. To achieve long term success, construction companies need to implement the right corporate strategy. This study hypothesizes that entrepreneurship is an important strategy that can be applied in construction businesses.

Over the last few decades, the term entrepreneurship has become very popular, phenomenal and is widely discussed among people around the world (Hebert and Link 1989, Lumpkin and Dess 1996, Yalcin and Kapu 2008). Entrepreneurship has been considered as an important driving factor of business success (Covin and Slevin 1991, Lumpkin and Dess 1996, Wiklund and Shepherd 2003). Many practitioners and scholars have considered entrepreneurship as an important issue and given serious and deep attention to it (Luchsinger and Ray Bagby 1987, Hebert and Link 1989, Sharma and Chrisman 1999, Lazear 2005, Yalcin and Kapu 2008). Consequently, research efforts on entrepreneurship have developed rapidly and significantly, and spread widely into a variety of disciplines, such as history, management, psychology, sociology, economics (Hebert and Link 1989, Schendel 1990, Gartner *et al.* 1992, Moon 1999, Sexton and Landstrom 2000, Hoskisson *et al.* 2011, Brandstätter 2011). The boundaries of entrepreneurship have expanded from 'individuals creating a new venture' to 'a business concept to run an existing company and individuals within that company' (Luchsinger and Ray Bagby 1987, Jennings and Lumpkin 1989, Covin and Slevin 1991, Lumpkin and Dess 1996, Lumpkin and Dess 2001, Antoncic and Hisrich 2003).

This study is aimed at clarifying the concept of entrepreneurship and exploring the implementation of entrepreneurship in construction in a systematic way. In reviewing the literature, it was found that entrepreneurship can be divided into individual and corporate entrepreneurship. This study focuses on corporate entrepreneurship for contractors because corporate entrepreneurship covers the activities within the company, while contractors must deal with high business competition and particular challenges such as maintaining a good relationship with the clients who are actively involved in the construction process (Nam and Tatum 1997), and bringing together numerous independent and diverse companies under one goal (Barrett *et al.* 2008, Gould and Joyce 2009).

ENTREPRENEURSHIP

Despite the numerous studies on entrepreneurship, a coherent and holistic theoretical underpinning of entrepreneurship is still lacking. It is still the concern of many scholars around the world to find one consistent and acceptable definition of entrepreneurship (Jennings and Lumpkin 1989, Gartner 1988, Lumpkin and Dess 1996, Sharma and Chrisman 1999, Moon 1999). Many definitions on entrepreneurship are available from previous research efforts. When these definitions are investigated, it emerged that entrepreneurship has been considered as an action (Hebert and Link 1989, Jones and Butler 1992, Lumpkin and Dess 1996, Sharma and Chrisman 1999) or a process (Bolton and Thompson 2004, Lazear 2005, Yalcin and Kapu 2008); and is related to either individuals in a firm (Hebert and Link 1989, Sharma and Chrisman 1999, Bolton and Thompson 2004, Brandstätter 2011) or the firm (Jones and Butler 1992, Lumpkin and Dess 1996, Lazear 2005, Yalcin and Kapu 2008).

Entrepreneurship is linked to creating new business (Yalcin and Kapu 2008) or maintaining existing business (Jones and Butler 1992, Lazear 2005) or both (Hebert and Link 1989, Sharma and Chrisman 1999, Lumpkin and Dess 1996, Bolton and

Thompson 2004). Different aspects are highlighted in the definitions such as opportunity (Jones and Butler 1992), risk (Hebert and Link 1989), creativity (Hebert and Lin 1989, Jones and Butler 1992, Bolton and Thompson 2004, Brandstätter 2011), and innovation or newness (Lumpkin and Dess 1996, Sharma and Chrisman 1999, Lazear 2005, Brandstätter 2011).

Corporate Entrepreneurship and Individual Entrepreneurship

Existing work on entrepreneurship suggest that entrepreneurship can be applied at two levels: the individual level and the organizational level. Entrepreneurship at the organizational level has been considered as corporate entrepreneurship (Burgelman 1983, Jennings and Lumpkin 1989, Guth and Ginsberg 1990, Schendel 1990, Sharma and Chrisman 1999) or intrapreneurship (Kuratko *et al.* 2005, Antoncic and Hisrich 2003). The authors prefer corporate entrepreneurship term since it is more commonly used in the extant literature.

This study has reviewed several definitions of corporate entrepreneurship and found three main aspects in almost all definitions. The three aspects are renewal or extension of on-going business, creating new business and taking place within existing organizations (Burgelman 1983, Jennings and Lumpkin 1989, Guth and Ginsberg 1990, Schendel 1990, Sharma and Chrisman 1999, Antoncic and Hisrich 2003). Entrepreneurship at the individual level refers to entrepreneurs and intrapreneurs. Both are related to individuals involved in business process but in different situations and conditions.

Three different subjects have been identified in previous definitions of entrepreneurs which are: business initiators or creators (Luchsinger and Ray Bagby 1987, Gartner 1988, Sharma and Chrisman 1999, Lazear 2005), or owners (Brockhaus 1980, Gartner 1988), or managers (Brockhaus 1980, Sharma and Chrisman 1999, Luchsinger and Ray Bagby 1987). These subjects were related to the several activities in running a business, such as combining resources (Hebert and Link 1989, Lazear 2005), creating innovation (Hebert and Link 1989, Sharma and Chrisman 1999, Bolton and Thompson 2005), and making judgmental decisions (Hebert and Link 1989). Additionally, the subjects are also associated to risk and uncertain condition (Hebert and Link 1989, Luchsinger and Ray Bagby 2001), and the principal purposes of profit and company growth (Gartner 1988).

Intrapreneurs are considered as employees of a firm who do not have full responsibility for the business success but are considered important for the business success because ideas of company's top management to renew the organization are often subsequently implemented by the managers at ranks below top management (Burgelman 1983, Martiarena 2011). Compared to entrepreneurs, intrapreneurs tend to take less risk because they work for owners within corporate boundaries (Pinchot 1986, Ross 1987, Thornberry 2006, Martiarena 2011).

Based on the previous reviews, Table 1 summarizes the definitions of terminologies that are used in this study.

The Characteristics of Corporate Entrepreneurship

Since this study focuses on corporate entrepreneurship, this part will review the characteristics of corporate entrepreneurship proposed in previous research. There is a large volume of published studies describing characteristics of corporate entrepreneurship. This study identified several characteristics such as innovation/venturing within existing organizations and strategic renewal of existing

organizations (Guth and Ginsberg 1990), risk-taking, innovative, and proactive (Covin and Slevin 1991), innovativeness, risk taking, pro-activeness, competitive aggressiveness and autonomy (Lumpkin and Dess 1996), new ventures, new business, product/service innovativeness, process innovativeness, self-renewal, risk taking, pro-activeness and competitive aggressiveness (Antoncic and Hisrich 2003). This study adopts the five characteristics suggested by Lumpkin and Dess (1996) because of their comprehensiveness and conceptual clarity. They cover all characteristics which were suggested by other scholars and were followed by some further discussions such as the distinction between competitive aggressiveness and proactiveness (Lumpkin and Dess 2001), and the relationship between each characteristic to business performance (Hughes and Morgan 2007). These characteristics are defined in Table 2.

Table 1: The Definitions of Terminologies for this Study

Terminologies	Definition
Entrepreneurship	activities or processes at personal or organizational level in the context of creating a new business or managing existing business, considering opportunity, risk, creativity and innovation as important aspects
Corporate Entrepreneurship	entrepreneurial activities or processes within an existing organization to renew on-going business and to create new business
Entrepreneurs	owner, not always the initiator, of the company who is running a business, by creating an opportunity, inventing and commercializing creative innovation on new goods and/or services and new methods of production under risk and uncertain conditions
Intrapreneurs	individual within or work for the organization (employees) that have and use entrepreneurial skills for organization development

Table 2: Characteristics of Corporate Entrepreneurship (Lumpkin and Dess 1996 & 2001)

Characteristics	Definition
Autonomy	independent action by an individual or team aimed at bringing forth a business concept or vision and carrying it through to completion.
Innovativeness	a willingness to support creativity and experimentation in introducing new products/services, and novelty, technological leadership and R&D developing new processes.
Risk taking	a tendency to take bold actions such as venturing into unknown new markets, committing a large portion of resources to ventures with uncertain outcomes, and/or borrowing heavily.
Proactiveness	an opportunity-seeking, forward-looking perspective involving introducing new products or services ahead of the competition and acting in anticipation of future demand to create change and shape the environment.
Competitive Aggressiveness	reflects the intensity of a firm's efforts to outperform industry rivals, characterized by a combative posture and a forceful response to competitor's actions.

CORPORATE ENTREPRENEURSHIP IN CONSTRUCTION

Numerous studies have tended to consider contractors as project based firms (PBFs) which are characterized by temporary project within permanent firm in order to deliver an unique end product to meet client's need (Gann and Salter 2000, Barrett and Sexton 2006, Blindenbach-Driessen and van den Ende 2006, Bosch-Sijtsema and Postma 2009). In carrying out their activities, contractors need to manage both business and project which have different characteristics. Business processes involve repetitive activities while projects are usually temporary and unique (Gann and Salter

2000). Volpe and Volpe (1991) identified two main challenges to be successful in contracting business: to win competitions to get projects and to deliver projects successfully.

This study develops the theoretical framework shown in Figure 1 in order to present the findings of an extensive literature review on corporate entrepreneurship for contractors considering these challenges. The framework illustrates the theoretical relationship between five characteristics of corporate entrepreneurship with the contractors. Factors that influence each characteristic of corporate entrepreneurship and the role of entrepreneurs and intrapreneurs in contractors' activities are also drawn in the framework. Each part of the framework is discussed below.

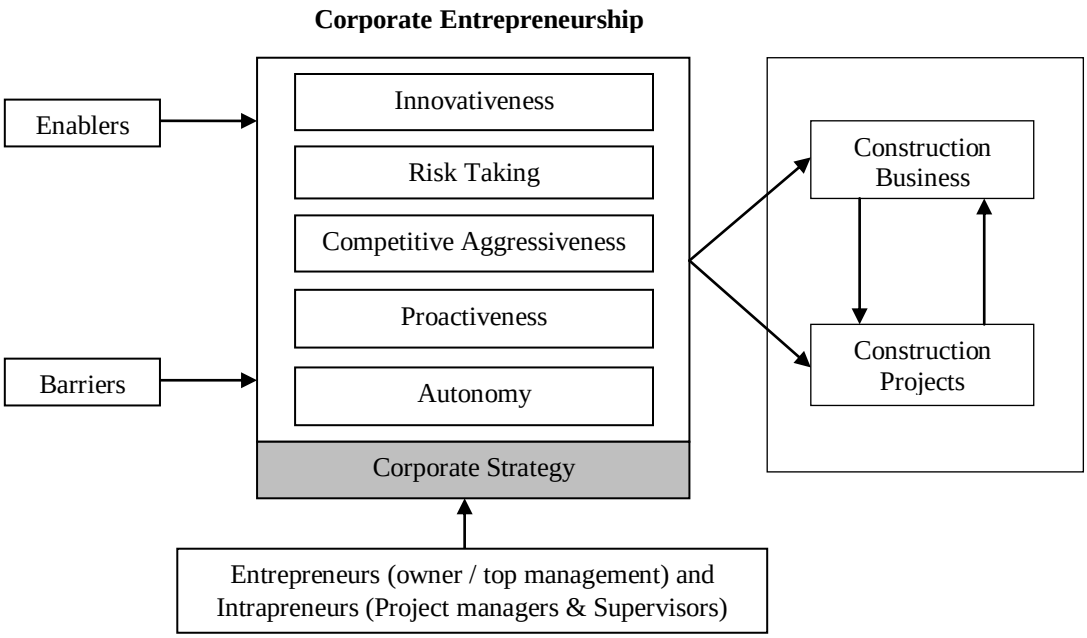

Figure 1: Theoretical Framework of Corporate Entrepreneurship for Contracting Companies

Contractors

Contractors need to integrate construction businesses and construction projects in order to maintain the continuity of tacit knowledge from one project to another project (Blayse and Manley 2004). It was considered that the success of a project cannot be achieved by management of the project alone but by the integration of management of project and management of business. It was also found that technical supports from central resources within contractors are mobilized to projects (Gann and Salter 2000).

Corporate Entrepreneurship and Contractors

Pellicer *et al.* (2010) argued that innovative performance is essential for companies to reach and maintain a successful competitive position in order to develop scientific and technological capacities in a wide range of technical fields. Barrett *et al.* (2008) suggested that sustainable competitive advantages can be enhanced through successful creation, management and exploitation of appropriate innovation. Innovation outcomes will improve market growth (Slaughter 1998), increase the opportunity to win projects (Blayse and Manley 2004), solve clients' problems (Blindenbach-Driessen and van den Ende 2006), improve quality (Gambatese and Hallowell 2011b), and improving reputation (Lim *et al.* 2010). Innovativeness can also increase

profitability, improve cost efficiency and increase productivity (Lim *et al.* 2010, Gambatese and Hallowell 2011b, Slaughter 1998, Blayse and Manley 2004).

Contractors' risk attitude has been considered as an important aspect of contractors' competitive success for survival and growth. Risk attitude is a basis of risk taking behaviour (Kim and Reinschmidt 2011a). Their further study recommended that contractors' risk attitude has a relationship with diversification as the contractors' corporate strategy for survival and growth (Kim and Reinschmidt 2011b). Contractors' risk attitude is also associated to bid decision in an international construction project (Han *et al.* 2005).

Entering international market has been considered as a contractors' strategy to deal with construction market change (Han *et al.* 2010), to avoid domestic market recession (Jung *et al.* 2010) and to counter the domestic business cycle (Abdul-Aziz and Wong 2010). Contractor's strategy to enter the international market can be considered as a contractor's competitive aggressiveness.

Factors influencing corporate entrepreneurship characteristics

A variety of factors that influence innovativeness, risk taking and competitive aggressiveness in construction have been identified in the literature review. Blayse and Manley (2004) identified the factors influencing innovativeness in construction as clients and manufacturing firms, the structure of production, industry relationship, procurement system, regulation and standards, organizational resources (e.g. leadership, communication, etc.). Their finding was supported by other authors (Barrett and Sexton 2006, Blindenbach-Driessen and van den Ende 2006, Bosch-Sijtsema and Postma 2009). Meanwhile risk taking is influenced by consequences of decision making, personal condition of decision maker (such as: psychological traits and experiences), condition of project (such as: completeness of project information, uncertainty in cost estimates, contract size), condition of company (such as: urgent need for work, the availability of required cash) (Wong and Hui 2006, Wang and Yuan 2011, Acar and Göç 2011). Finally experience in bidding, support of government for international market expansion, worldwide demands, and high competition in domestic market are considered as factors that influence competitive aggressiveness (Fu *et al.* 2002, Zhao and Shen 2008).

No studies focusing on the factors that influence proactiveness and autonomy have been found during the literature review. This is identified as one of the gaps in the current corporate entrepreneurship research and will be investigated further in the following stages of the doctoral study.

Entrepreneurs and Intrapreneurs in Contractors

Entrepreneurs and intrapreneurs are considered as an important factor that support innovativeness and risk taking in construction. Gambatese and Hallowell (2011a) mentioned that the specific characteristics of Project Managers and Supervisors are the most impactful factors of innovativeness in construction, support of upper management is also considered as enabling factor of innovation in construction (Gambatese and Hallowell 2011b). Meanwhile decision makers' attitudes towards risks play an important role in risk-based decision making (Wang and Yuan 2011).

FUTURE RESEARCH

This study posits that there is very little discussion about entrepreneurship in construction literature. The study on entrepreneurship at the individual level to date

has tended to focus on the characteristics of entrepreneurs and intrapreneurs. However, no study was found to consider the involvement of entrepreneurs and intrapreneurs in contractor firms even though they have been considered important for contractors' success.

Previous research efforts in construction management focusing on entrepreneurship at the corporate level have investigated only three characteristics of corporate entrepreneurship: innovativeness, risk taking and competitive aggressiveness. Several research efforts are found on innovativeness, whereas there is very little research on risk taking and competitive aggressiveness could be found. Previous research focused mostly on risk management instead of risk taking behaviour and competitive advantage instead of competitive aggressiveness. No research has been found that explored proactiveness and autonomy.

In addition, there is no research that addresses the five characteristics together. Integrating several characteristics at once will provide more accurate idea of corporate entrepreneurship than focusing on one single characteristic. This doctoral study will focus on bridging these gaps in corporate entrepreneurship research and will investigate the relationship between entrepreneurship and success of business and project with an ultimate aim of developing a model that will guide contracting companies in successful implementation of corporate entrepreneurship.

In order to identify the relationship between characteristics of corporate entrepreneurship and how they influence the success of contractors business, interviews will be conducted with the key parties in selected contractor firms. Two groups of resources will be interviewed in order to get the idea from firm level and project level. The first group are contracting firms' top management and the second are project managers. The results of the interview will be analysed using grounded theory in order to identify findings that are perceived to be most significant by the interview respondents. Subsequently, quantitative measures, specifically Structural Equation Method would be useful for supplementing and extending the qualitative analyse. The findings from these analyses would be used to develop the corporate entrepreneurship model.

CONCLUSIONS

This study has reviewed the concept of entrepreneurship and the specific nature and challenges for contractors. Appropriate definitions of several terminologies that are related to entrepreneurship have been derived for this study. The application of corporate entrepreneurship has also been investigated. Finally the theoretical framework of corporate entrepreneurship for contractor firms has been developed to underpin the further study on how the performance of entrepreneurship in construction is affected through integration of several characteristics at once. A wider study aimed at developing a framework for entrepreneurship development in contracting firms is ongoing.

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MANAGING THE PERFORMING PARADOX IN ARCHITECTURAL COMPETITIONS

Beatrice Manzoni[1], Peter Morris[2] and Hedley Smyth[2]

[1] *Construction and Project Management, Bartlett School of Graduate Studies, UCL, 1-19 Torrington Place, London, WC1E 7HB, UK - Organisation and Human Resources Management Department, SDA Bocconi School of Management Via Bocconi 8, 20136 Milan, Italy*

[2] *Construction and Project Management, Bartlett School of Graduate Studies, UCL, 1-19 Torrington Place, London, WC1E 7HB, UK*

In architecture competitions are fascinating. Over the years, they have increasingly become a popular mechanism for architects in acquiring work and clients in looking for designers. Still they are a debated topic presenting several controversial issues. In fact, competitions, as architecture in general, are a fertile ground for contradictions and management oxymora struggling among opposing forces, such as artistic recognition and market constraints, individual passion and collective collaboration, creative spark and discipline. These are actually examples of paradoxes that architects confront regularly. In organizational terms, a paradox is a set of contradictory yet interrelated elements, logical in isolation but irrational when juxtaposed. Paradoxical tensions exist simultaneously and persist over time with no resolution, therefore attending competing tensions is critical for architectural practices. Through an inductive qualitative case based research, this paper explores why a performing paradox exists within architectural competitions, what tensions are experienced and how they are managed.

Keywords: architecture, architectural competitions, paradoxes, performance, practice management.

INTRODUCTION

In architecture competitions are fascinating. Over the years, they have increasingly become a popular mechanism for architects in acquiring work and clients in looking for designers (e.g. Nasar, 1999). Still they are a debated topic presenting several controversial issues. In fact, competitions, as architecture in general, are a fertile ground for contradictions and management oxymora struggling among opposing forces, such as artistic recognition and market constraints, individual passion and collective collaboration, creative spark and discipline. These are actually examples of paradoxes that architects confront regularly, even if they have frequently been labelled in different ways e.g. contradictory forces (Blau, 1984), dialectics (Cuff, 1992), management oxymorons (Brown *et al.* 2010), but also dilemmas (Rönn, 2008;

[1] beatrice.manzoni@ucl.ac.uk; beatrice.manzoni@unibocconi.it

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Kreiner, 2010) and potential conflictive interests (Volker, 2010) when looking specifically at competitions. This asks for additional research regarding the paradox meaning.

In organizational terms, a paradox is a set of contradictory yet interrelated elements, logical in isolation but irrational when juxtaposed. Paradoxical tensions exist simultaneously and persist over time with no resolution, therefore attending competing tensions is critical for architectural practices, as it is in many other creative industries e.g. design and consultancy (Andriopolous & Lewis, 2009, 2010), media (DeFillippi, 2009) and film industry (DeFillippi & Arthur, 1998). Moreover, creativity based contexts are an interesting research setting, as they reveal paradoxes and tensions of project organization (Sydow *et al.* 2004). Multiple tensions are in fact also experienced in projects (Brady & Maylor, 2010) especially while seeking to foster innovation and efficiency (Lewis *et al.* 2002).

Based on these premises, what paradoxical tensions are embedded within architectural competitions and firms competing? How are they experienced and managed by architects? Kreiner (2007) said that competitions are like 'horse riding': you cannot predict if a horse will win or not, but you can train the horse to win and at least you have to know how to train it. This paper focuses in particular on one type of paradox of architectural competitions - the performing one - together with its underlying tensions and possible management approaches to handling them.

The paper is structured as follows. First organisational paradox studies are reviewed to provide a theoretical lens to approach architectural competitions from a management point of view. Secondly the methodology is explained: an inductive qualitative multiple case based approach is used to explore how architects define competing strategies. Finally, case findings are presented, explaining what the performing paradox in competitions is and how architects confront competing demands.

A PARADOX LENS TO APPROACH ARCHITECTURAL COMPETITIONS

A "paradox denotes contradictory yet interrelated elements – elements that seem logical in isolation but absurd and irrational when appearing simultaneously [...] Researchers use paradox to describe conflicting demands, opposing perspectives or seemingly illogical findings" (Lewis, 2000: 760) at multiple levels (organisational, project, group, individual). Despite being the two sides of the same coin, opposing elements are rarely perceived by actors experiencing them as interrelated, as their conflicting nature is the one predominant and a resolution often typically implies a choice between one side or another.

According to existing research, the range of possible paradoxes happening in organisational life is so wide and varied, that starting with Lewis (2000) a framework was looked for to identify repeated patterns across studies. Paradoxes are "puzzle needing a solution" (Poole & Van de Ven, 1989: 563) and categorising them is a way to make order into multiple manifestations. The most recent contribution is the one proposed by Smith & Lewis (2011), mapping paradoxes of learning (e.g. old vs. new, radical vs. incremental change, episodic vs. continuous change), belonging (e.g. self expression vs. collective affiliation), organising (e.g. collaboration vs. competition, empowerment vs. direction, control vs. flexibility, routine vs. change) and performing (e.g. long vs. short term, financial vs. social goals). These paradoxes also refer to core

activities of an organisation (knowledge, identity and interpersonal relationships, processes, goals).

Once identified, "living with paradox is not comfortable or easy" (Handy, 1994: 13) and a fundamental current debate regards the management of paradoxical tensions. The fact that paradoxes should be better faced instead of avoided is unquestioned, as well as that paradoxes' potential should be exploited. Paradox can, in fact, be something extremely positive: tensions foster creativity and complex insights and trigger change, acting as brainteasers and challenging common logic and thinking (Handy, 1994), even if they also risk being the source of organizational paralysis (as it was in the case of Lego Company discussed by Luscher & Lewis, 2008). Paradoxes help to catch and explain the complexity, ambiguity and diversity of organizational life (Cameron & Quinn, 1988), sustain long-term performance (Cameron, 1986), through enabling learning and creativity, fostering flexibility and resilience and unleashing human potential (Smith & Lewis, 2011), foster organizational performance (Cameron & Lavine, 2006) and high performing groups (Murnighan & Conlon, 1991).

Recognising possible management approaches to them is therefore critical to exploit this positive potential. Effective management leverages paradox "in a creative way that captures both extremes" (Eisenhardt, 2000: 703). Existing research (e.g. Poole & Van de Ven, 1989; Andriopoulos & Lewis, 2009) suggested two tactics in particular: integration, stressing interdependence between the opposites, and splitting, focusing on each pole separately (spatially or temporally).

RESEARCH APPROACH

An inductive qualitative research approach was adopted, based on the roadmap proposed by Eisenhardt (1989), consisting of conducting case studies, while simultaneously reflecting on constructs and theories found in the literature. Well conducted case studies are surprisingly objective because of their close adherence to reality (Yin, 2009) and their capability in producing accurate, interesting and testable theories (Eisenhardt & Graebner, 2007). Moreover creative and professional services are a complex social setting where causal dynamics and actors' motivations are not immediately apparent and this makes the use of qualitative procedures appropriate and rewarding (Elsbach & Kramer, 2003). Case studies also enable more nuanced insights when dealing with paradox (Andriopoulos & Lewis, 2009, 2010).

Regarding data collection, the research involved in-depth case studies of two architectural practices (Table 1) based in London and approached relying on the Building Design (BD) top 100 list.

Table 1: Case study architectural practices

Firms	Description
Firm A	Established in 1972 in London, where 40 people are based. Working in Europe, South America and Asia. Well recognised in the UK and abroad. Hundreds of projects completed in architecture, interior design, master planning, historic building conservation, retail design, urban design. 17 significant awards won. Around 4-6 competitions done per year, mainly invited, but also open ones, playing a pivotal role day-by-day in acquiring new business.
Firm B	Established in London in 1989, with offices also in Bristol and Amsterdam. Working also in the US, in Africa and in the Emirates. Over 100 employees. Known for houses, schools, sports and exhibition buildings, healthcare facilities and art galleries. Several prizes won. 5 competitions per year on average, mainly invited but also open ones. A competition for a bus station at the end of the nineties played a pivotal role in the story of the practice.

The cases were selected based on their experience in competitions and firm characteristics. As suggested by Andriopoulos & Lewis (2009: 698) firms were sought based on "similarities that would aid comparisons and replication, yet with sufficient heterogeneity to help assess potential generalizability and [...] differing sizes and ages". Their willingness to participate also played a role, as architectural firms tend not to be very open about their strategies (Emmit, 1999; Volker, 2010). 'Archistars' have been explicitly avoided, resembling a biased way of approaching competitions, due to their glamorous reputation.

As suggested by Miles & Huberman (1984) for methods triangulation, several data sources were used: semi-structured interviews, archival data, observation and informal discussions. A total of 30 semi-structured, face-to-face interviews have been conducted with people involved in competitions (e.g. partners, architects, PR and marketing officers...). The interviews, ranging from 40 to 120 minutes in duration, were audio-taped and transcribed verbatim to ensure reliability. An interview protocol, made up of open ended questions, addressed the following aspects: the practice in general and the entire competition process (strategy, staffing, design process and execution). The interview protocol evolved systematically: the initial research aims was general and broad, as suggested by Glaser & Strauss (1967), but as data collection and data analysis proceeded, interviews became more focused. Interviews continued until theoretical saturation was reached (Strauss & Corbin, 1990). Archival materials, observations, field notes and informal discussions were also useful to expand the understanding of each case context, reinforcing or questioning interviews' findings.

Regarding data analysis, the qualitative data of this study was processed through a method of cross-case comparative analysis (Eisenhardt, 1989), following Glaser & Strauss (1967) and Miles & Huberman (1994), broadly consisting in within-case analysis and cross-case comparisons. Systematic and iterative comparisons of data, emerging categories and extant literature concurred to the development of cohesive constructs.

THE PERFORMING PARADOX: WINNING THE JOB BUT PROTECTING THE CREATIVE ETHOS. WHAT ARE THE TENSIONS EXPERIENCED AND WHY?

Together with direct commissions competitions should be the way through which architectural practices acquire work. Yet it is much more complex, as competitions serve simultaneously both financial goals and creative ones: "being creative and exploring and exploiting one’s creative skills are a major challenge for architect"

(Styhre & Gluck, 2009: 231). This is aligned with the debate between economic and symbolic performance, commercial success and artistic expression (Lampel *et al.* 2000) profit and breakthroughs emphasis (Andriopoulos & Lewis, 2009).

Financial goals means acquiring new work and clients. Competitions are a way to get work: "through competitions you get other jobs" (Architect Assistant, Firm A) to the point that competitions are entered "where there is an actual job at the end" (Head of Communications, Firm B). Doing competitions is also about establishing long-term relationships with clients. This was the case of a competition done in the early history of Firm B: “the client was important, and we hoped we could create a relationship and get some repeat job: we did something else with them again afterwards” (Architect, Firm B). Competitions serve also the purpose of diversifying and expanding the business, in point of services offered, sectors, clients' typology and geographic market: competitions "help you expanding your business and experience outside your traditional sectors and expertises" (Associate, Firm A) and prevent you from becoming specialised. "I think early on we wanted to get a range of projects and not get specialized. That’s the point of winning a school competition, and then a health one. We knew this is the only way to make your practice expanding" (Architect, Firm B). It also happens that a competition "is in a country where we have never worked but we would like to. The Amsterdam project, our first one in Europe, was from a competition. We also opened an office there due to that" (Architect, Firm B).

Winning a competition is critical. "Everybody wants to win!" (Associate, Firm A), also because even when a competition reimbursement exist, it hardly covers the investments actually made for competing and winning the commission is the only way to fully get money back. However even within the same interviews, there are contradictory statements (this 'doublethink' is not infrequent in paradox studies and has also been studied by El Sawad *et al.* 2004). The fact that winning is not so important is a recurring statement in all the interviews. "It doesn’t matter a lot if you win or not. We sometimes didn’t win but we kept on doing competitions anyway" (Architect, Firm B). Therefore, many times competitions are done for reasons which are opposite to financial performance. It can be a matter if experimentation in design terms: "the reason why you do competitions from an architect point of view is not to win the competition, is to explore in design terms. That’s the motivation [...] You can interpret the brief in different ways, you can explore new ideas, either you win or not" (Architect, Firm B). "We use competitions as an opportunity to progress, to find new things about design, to work with different people, work in different technologies. It can be all range of research" (Partner, Firm B).

Competitions fulfil also emotional individual needs and enhance employees' morale and satisfaction, people "feel better, feel the value, enjoy themselves, and you can’t price that. There a lot of benefits" (Project Director, Firm A). Competitions keep architects fresh and energized (Andriopolous & Gotsi, 2005). "Say for instance that a partner is interested in a project and wants to try a design out. It happened to me that we worked on this competition we knew we were never going to win it. But the principal just did want to work on it and he was really excited. He basically spent a lot of time to challenge himself. It was an investment for the future" (Architect Assistant, Firm B). Really creative work is an exception in the day-to-day work which is characterised by collaborations with clients and end users, negotiations over time and budget and a lot of routine work (Sthyre & Gluck, 2009). This is recurring observations in case studies. An Associate from Firm A says that "you work on a project for some months and then if the chance happens to work on a competitions and

you do it, it forces you to do also more research than you normally do. With competitions you get into deep knowledge and you can propose everything that is new. And this is interesting". "What a competition does is giving the opportunity to get out of it for a short while doing a bit of design, presentation work, contribute to that process which is away from the usual work" (Director, Firm A). Doing a competition is, therefore, "always intellectually refreshing and challenging" (Architect, Firm B).

It is also a matter of building reputation and getting publicity: "even if we don't win it, you are still in the news [...] if it is a key competition it will be on architectural press" (Communications Coordinator, Firm B). "Architects use competitions as a way to get noticed as a practice (Architect, Firm A). "It is potentially good PR and marketing for the company" (Director, Firm A). Moreover, "even if we don't win we get some interesting work we can show and which might be slightly different from what we usually do (Project Director, Firm A). "If we didn't enter a competition, it would be a lost opportunity for getting a brand into a marketplace. It is important to enter a competition to make people recognize our name (Director, Firm A).

In some case through competitions practices join the local or even national and international architectural debate. Talking about a recent competition an Architect from Firm B says that "it was definitely the most interesting competition last year" and "also the other practices involved were large in terms of profile, scale of projects, buildings realized (Architect Assistant, Firm B). Moreover, "all big practices are made of people who want to be big at one point. The partners are interested in doing works they think are interesting. Of course profits matter, but what they are interested in is good design" (Architect Assistant, Firm B). For company A "the good aspects are that you get the opportunity to concentrate on the design. [...] Design is important and it attracts people's attention" (Project Director, Firm A).

Finally, it is also a learning opportunity both at an organisational and individual level. "In competitions you are looking for new ideas" (Architect, Firm A) and "we certainly learn new things we bring into the commission work" (Director, Firm A).

MANAGEMENT APPROACHES. HOW TO HANDLE WITH TENSIONS?

Acquiring jobs and therefore new clients is a different thing from exploring extreme creativity, being published and fulfilling emotional needs. "The nature of architectural work requires special management practices to handle the creative temperament within an organizational frame" (Brown *et al.* 2010: 540). Implications exist mainly at three levels within the office dealing with architectural competitions: strategy formulation, staffing, design execution. These three levels emerge from the data, being however close to the model proposed by Bayer & Gann (2006) regarding bidding strategies in project based professional service organisations (bidding policy, staffing, project acquisition, project execution and portfolio).

Strategy formulation: targeting restricted competitions to win the job, while going for open ones to protect the creative ethos

In both case studies, reconciling both goals into the same competition is difficult and firms tend to adopt a splitting tactic, assigning different competitions different goals. Invited and limited competitions are joined for financial purposes, while ideas and open ones for creative and reputational objectives. "There are two kinds of competitions. On the one side you have a site which gives the opportunity to do

something similar you did in the past and you basically copy what you have done before: you talk about all the different things, you describe everything really well and discuss all the elements in details. On the other side you try to make something completely new" (Architect Assistant, Firm B). This is confirmed by a Project Director in Firm A who says that "if it is a totally open competition you can get genuine innovation from new people. An invited competition usually implies that you go to people who can do the work, as they did the same kind of works before". This also explains why well-established practices, with almost no difficulty in accessing job opportunities coherent with their business, sometimes enter also more open competitions or call for ideas. Also Wheelwright & Clark (1992), in the product development domain, suggested project portfolios including projects that pay the bills and projects providing experimentation and keeping up the spirit; while Andriopoulos (2003) proposed to involve employees in diverse range of projects to support their passion and creativity, while at the same time achieving financial goals.

Staffing: exploiting established competencies and teams to win the job, while exploring new ones to protect the creative ethos

Across the cases, in staffing people on competitions there are two main issues. First, the tendency is to staff people based on time availability. A Project Director from Firm A says that "you pick people from where you can" (Architect, Firm A), while in company B the situation is similar: "it is just a matter of who is available" (Project Architect, Firm B). Availability is of course a reasonable criterion, but not the only one. Emmit (2010) suggested also to take into account the attitude towards the project to ensure project goals' compatibility; communication skills; compatibility to decrease the conflict risk; staff's costs, experience (even if a mix of experienced and less experienced is beneficial); emotional stability; motivation, personality; qualifications; skills and values. Both cases state that to win a competition, "the best way would be to assign people purely responsible for competitions" (Architect, Firm A). This is the reason why, for example, firm A tend to have "a selected group of people doing more or less all the competitions" (Associate, Firm A). Building knowledge takes time, while re-use knowledge already present in the team because of past competitions is easier and more efficient. Old combinations of members are also familiar and routinised and can speed up task execution, while new combinations offer novel prospects for creativity, together with higher internal and market risks (Chen, 2005). When competitions are done for building reputation or fulfilling emotional needs, both firms take passion and values into account, accepting people proposing themselves, notwithstanding specific competencies. "You might have people coming and asking to take part or you as a director decide the team" (Architect, Firm B). "It is up to individuals: you might have some people who like to find their own field of work, while some others want to always try something new. (Project Architect, Firm B). Firm A is also open to people who "just finished university as they are very fresh with ideas (Associate, Firm A).

Design execution: implementing the brief and fulfil client's demands to win the job, while challenging it to protect the creative ethos

To win a competition clients' demands need to be fulfilled. However the design team always tries to propose something different. In fact "much of the work of architects is expressed in discourse around the brief, drawing on the particulars of the professional identity to negotiate the always indexical conceptualization of the building as a complex project, to present to the world something that embodies their professional ambitions - sometimes despite the client's brief" (Brown *et al.* 2010: 542). An

Architect Assistant in Firm B says that it is also "sort of interesting that architects, even having read the brief and understood what the client is asking, run off and do something else". It is well known in the history, for example, what Louis Sullivan said to a lady who had come in for a colonial house, 'you will take what we give you'. A Project Director in Firm A says they are 'listening architects', however in a competition the dialogue between the architect and the client is missing "and that is the real dilemma [...] It is not like a monologue but it is not a conversation as well" (Project Director, Firm A). In addition to that, "some clients don't know what they want until they see it " (Project Director, Firm A) and this implies the architect has to guess what the client wants and to find a balance between following the brief and challenging it. It is always "about starting from our understanding of the brief, of the client, of the site, of the uses, of the complexity of the program. And then about our response to all of these elements: how we established the building taking into account the constraints, the requirements, the brief, the client" (Project Architect, Firm B). However the way the brief and the design solution is approached is partially different depending on the realistic goal the practice has in mind. If the ambition is winning the commission, "meeting the brief should be the biggest concern [...] this was our initial starting point, but actually it should have been probably creating something eye catching, dramatic and unusual. The brief was very pragmatic. Ultimately they chose the building which was less compliant with the brief and more experimental and more landmark building in the end" (Architect, Firm B, talking about a university building project). In their study upon a Scandinavian architectural practice Styhre & Gluck (2009) also pointed out that especially younger architects complain about the fact that in competitions the focus is too much on actually winning the competition rather than stretching the boundaries for what could be done. Rather than following the programme for example architects should try to reformulate and reinterpret it before engaging into architectural solutions, being "open to be challenged by a brief or a site" (Architect Assistant, Firm B). An integration tactic could also lead to read the brief carefully and transform it into clear guidelines to set the boundaries of the proposal, but being more creative into the concept development phase, challenging some, but not all, the brief's statements.

CONCLUSIONS AND DIRECTIONS FOR FUTURE RESEARCH

This paper discussed the performing paradox experienced by architects in competitions, when they are divided between winning the job and fostering and preserving the creative ethos. The ability to understand paradox is not only a research skill but also a critical managerial one (Handy, 1994). Exploring paradox facilitate the understanding of inconsistencies and contradictions of the competitions' dynamic context, as also Eisenhardt (2000) noted. Moreover understanding opposing tensions is the first step to manage them.

The performing paradox addressed in this paper presents managerial implications with regards to strategy formulation, resource allocation and staffing, design concept and execution. These implications translate into management approaches to paradox: mostly splitting tactics are adopted by the two British firms, even if a 'balancing act' searching for more integration could be suggested and explored in future research. In sum:

- Selectively address different types of competitions (open, restricted…), depending on the strategic objective (winning the commission, satisfying

employees, pure creative exploration and internal R&D). Avoid addressing a competition with a multi-fold goal.

- Resist the temptation of staffing people solely depending on time availability and exploit existing competences and teams when winning the job is a priority, while exploring new ones when it is more about 'fulfilling emotional needs'.
- Agree to the compromise of what the client asks for when getting the job is a the key point, while risk in affirming the practice's identity, even notwithstanding the brief, when the goal is creativity and people's motivation.

Future research could first explore other categories of paradox (learning, belonging, organising), underlying related tensions and management approaches; secondly extend the comparisons to other case studies; finally explore if and how nested tensions and their management vary in firms with different degrees of project management practices or different success rate in competitions, understanding the impact of project management on competitions' management.

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TOWARDS THE IDENTIFICATION OF FACTORS AFFECTING THE DEVELOPMENT OF SMALL SIZED CONSTRUCTION CONTACTING ORGANISATIONS

Robert Ozols and Chris Fortune

School of the Built Environment, University of Salford. Salford, Manchester UK. M5 4WT,

The UK construction industry is characterised by its fragmentation into large numbers of small sized construction contracting organisations. Previous data has indicated a record of failure of such construction based enterprises especially in times of economic recession. A study has been conducted with small sized construction contracting organisations in order to explore the pertinent factors found to affect their survival and/or growth. The participants in the study were selected from the University of Salford's Leading Enterprise and Development (LEAD) programme, which seeks to promote successful companies in business. The study was conducted from an interpretative perspective using a qualitative approach. Six in-depth semi-structured interviews have been conducted with key players in commercial/residential construction contracting organisations including the owners of two failed businesses. The methodology adopted allowed the generation of "insider accounts" that provided rich deep contextual data. From the interviewed participants, a number of factors have emerged that have been classified under the headings of service orientation; supply-chain; quality benchmarking; trading period; critical self assessment; specialist service; employment status; local links to community and inadequate control measures. Further data analysis and comparison with factors identified from literature allowed an initial conceptual framework of factors thought to aid the development of small sized construction contracting organisations SCCOs. The framework provides the basis of further data collection so as to ensure greater robustness of the emergent framework.

Keywords**:** small sized firms; development, growth.

INTRODUCTION

Research into small sized construction contracting organisations SCCOs is limited. The shape and size of the construction sector is in continual flux and reflects the demands placed upon it. The specialisation of sub contractors and the growth of self employment have become widespread since the 1970s. This has transformed the construction industry into an industry characterized by fragmentation and large numbers of small sized companies.

This research is concerned with micro and small sized companies which has been identified in this paper as small sized construction contracting organisations (SCCOs) employing between 1 and 50 staff. Table 1 indicates the main features of such micro and small sized organisations as set out by the European Union (2005).

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Table 1. Micro, small and medium sized firms European Union (2005)

Enterprise category	Headcount	Turnover	or Balance sheet total
medium-sized	< 250	≤ € 50 million	≤ € 43 million
small	< 50	≤ € 10 million	≤ € 10 million
micro	< 10	≤ € 2 million	≤ € 2 million

The Office of National Statistics (2012) determined the failure rates for small businesses operating in the United Kingdom Construction Industry for 2009 were 19.1% out of 19,008 firms and in 2010 there were 18.4% failures. This shows that the trading period of construction contracting organisations, especially for newly formed micro and small sized organisations cannot be taken for granted. It is interesting to reflect that similar percentage figures have been found in the United States where the Surety Information Office (S10) determined that failure rates for small businesses operating over a two year period to be 21.7%. Initially literature has been reviewed in this paper to identify factors thought to influence the development of

LITERATURE REVIEW

Achanga *et al.* (2006) research although limited both in terms of geographical location and size Achanga acknowledged that many SMEs were vulnerable in that they operated in sectors where there were few barriers to new entrants and where they had little power to dictate to suppliers their needs. Porter (1980) set out the “five forces” framework representing the impact of participating parties that contributed to the construction industry and the continual demands placed by each sector on one and another. Karagiannopoulos *et al.* (2005) operating from Lancaster University’s department of management science described the impact of Porter's “five forces” in terms of the intensity of rivalry among competitors and claimed that was the most significant of Porter's “five forces”.

The second factor identified by Porter (1980) that threatened potential new entrants’ impacts on the micro and small sized construction contracting organizations was the influence new entrants have on the average levels of industry profitability. The most common forms of barriers to entry of SCCOs, is usually the scale and amount of the investment required by a SCCO to enter the industry as an efficient competitor. The threat that substitute products pose to industry's profitability is another factor that impacts on the development of a SCCO. This threat depends on the relative price-to-performance ratios of the different types of products or services to which customers can turn to satisfy the same basic need. Buyer or client power is one of the two horizontal forces that influence the appropriation of the value created by an industry and as such is a factor that has an impact on the survival and development of a SCCO. The most important determinants of buyer power are the number and the concentration of potential clients in a particular geographic location. Other factors related to ‘buyer’ or ‘client’ power are the extent to which the buyers are informed of alternative suppliers and the concentration or availability and differentiation of the competitors to the newly formed micro and small sized construction contracting organizations. The last factor illustrated in Porters five forces model (see Fig.1) is supplier power. This is the mirror image of buyer power. As a result, the analysis of supplier power typically focuses first on the relative size and concentration of suppliers relative to industry participants and second on the degree of differentiation in the inputs supplied. The ability to charge customers different prices in line with differences in the value created for each of those buyers usually indicates that the

market is characterized by high supplier power and at the same time by low buyer power (Porter, 1989, 1996).

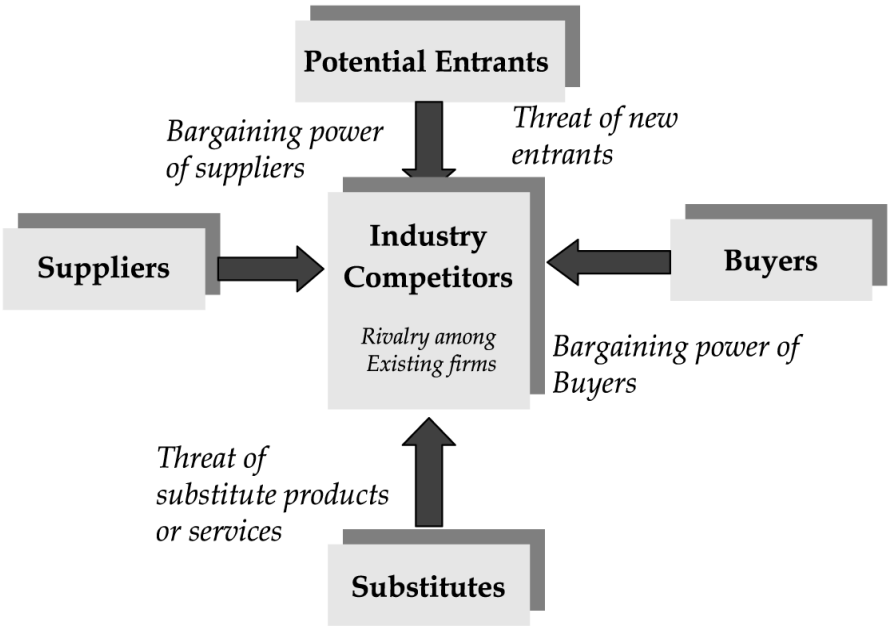

Figure 1. Porter's five forces (Source Porter 1980).

In addition to Porter's five forces model Hewitt (1997), asserted further factors such as (i) customer focus, (ii) process management, (iii) continuous improvement, (iv) innovation, (v) supplier partnership, (vi) people development and involvement, (vii) leadership and (viii) consistency of purpose as issues that are required to be addressed by small business organizations in their development. However Hewitt's work was with and selected companies that came from a general business background and not specifically construction based enterprises. Achanga *et al.* (2006) investigated critical success factors for lean implementation within SMES whereby the critical success factors which were thought to affect the development of a SCCO and are detailed as, (ix) leadership and management, (x) finance, (xi) skills and expertise and (xii) culture of the recipient organization. Achanga (2006) identified leadership and management commitment to be the most critical of the identified success factors.

In an exploring the literature related to factors that were thought to determine success in SCCOs it is important to reflect on business failure. Arditi *et al.* (2000) drew on a number of academic sources to define business failure and cited the seminal work of Frederikslust (1978) who suggested that business failure is the inability of a firm to pay its obligations when they are due. Although this statement was made prior to the current recession it's content is relevant to any business cycle supporting a further factor being (xiii) the need to maintain a positive cash flow as being a factor relevant to the survival and development of a SCCO. The thirteen factors (i) – (xiii) identified above from Hewitt (1997), Arditi *et al.* (2000) and Achanga *et al.* (2006) can be classified within the six headings from Hewitt's (1997) business excellence model which was developed to promote improvement and best practice in industry and was categorised under six headings: (a) People Management (b) Policy and Strategy (c) Resources (d) People Satisfaction (e) Customer Satisfaction and (f) Impact on Society to develop an initial conceptual frame work of factors based on literature that were thought to impact on the success of micro and small construction contracting business enterprises. These factors and classifications are in table 2 below.

Table 2. Classification of Success Factors

Factors from literature	Classifications from literature
(i) Customer focus	(e) Customer Satisfaction
(ii) Process management	(b) Policy and Strategy
(iii) Continuous improvement	(b) Policy and Strategy
(iv) Innovation	(c) Resources
(v) Supplier partnership	(d) People Satisfaction
(vi) People development and involvement	(a) People Management
(vii) Leadership	(b) Policy and Strategy
(viii) Consistency of purpose	(f) Impact on Society
(ix) Leadership and management	(b) Policy and Strategy
(x) Finance	(c) Resources
(xi) Skills and expertise	(c) Resources
(xii) Culture of the recipient organization	(f) Impact on Society
(xiii) Positive cash flow	(c) Resources

Apart from Frederikslust above, Arditi *et al.* (2000) cited Altman (1993) definition of business failure as "a company is considered to have failed if the realised rate of return on invested capital, with allowances for risk considerations is significantly and continually lower than prevailing rates on similar investments." Watson and Everett (1993) attributed business failure to four different situations: discontinuance for any reason; ceasing to trade and creditor loss; sale to prevent further losses and failure to make a go of it. Although Frederikslust, Altman and Watson and Everett developed their hypotheses from different times and backgrounds many business failures can also be related to definitions. There are critical success factors associated with other management disciplines that can be adopted for SCCOs. Chan *et al.* (2004) who focused their research on project related projects and based their conclusions on seven major journals in the construction field which was instrumental in developing a conceptual framework for factors affecting project success and this was structured under five categories. The factors within the categories have been found to be both inter-related and intra-related.

It was resolved to explore the relevance of the factors identified above from Hewitt (1997), Arditi *et al.* (2000), Chan *et al.* (2004) and Achanga *et al.* (2006) suspected as impacting on the survival and development of SCCOs.

RESEARCH METHODOLGY

Given the nature of the research problem identified above it was resolved to adopt a qualitative research approach whereby a true grounded theory approach was adopted that sought to gain data from practitioners in the field before literature related to the subject area was accessed and analysed (Straus and Corbin 1990). The interviews were sought to obtain information from the collection and analysis of insider accounts from leading actors within small sized construction contracting organizations SCCOs. The qualitative researcher has adopted an interpretive approach to the analysis of information obtained from organisations labeled as companies A-F who are categorized as small sized construction contracting organizations.

Ekanem (2007) developed the "insider accounts" approach from qualitative based research techniques into a research method in its own right to overcome the shortcomings of research with small firms. The philosophical approach was to treat people as subjects and as such therefore enable the interviewee to produce accounts of their world. This research is much more practical in small firm research, which by definition employs less than 50 people; research that uses alternative qualitative approaches such as ethnography and action research would become conspicuous and perceived to be in the way where the presence of researchers within such SCCOs would be likely to become less welcome. Through less familiarity with the organisation and its staff this interviewing technique provides detachment between the researcher and the organization and enables a good understanding of the small firms and their owner-managers to be developed. It was determined to use "insider accounts" as the technique to be used for the research.

The choice of using semi-structured open ended questions was used to encourage meaningful responses (Patton 1990). The interviews were conducted over one session so as to put the interviewees at ease and they were assured of their anonymity. This approach allowed the sessions to progress in a less constricted context. By posing the questions in a semi-structured fashion, the conversation was allowed to develop into areas where new information may have been found. This choice of interview technique facilitated a more relaxed discussion, which allowed a relationship of trust to develop.

RESEARCH FINDINGS

Raw data amassed from semi-structured interviews was held with companies A-F being a purposeful sample of six micro/small sized construction contracting organisations, all of whom met the criteria established in table 1. The interviews were conducted in four stages initially being company A operating as a general contractor. Company B a specialist contractor was subsequently seen then companies C and D offering specialist services were interviewed on the same day. To make the investigation more robust two failed companies were approached to ascertain what differences (if any) were identified and to establish what factors contributed to their failure? The results of the study have been indentified in table 3 and they were interviewed at their place of work between 23rd June 2011 and 07th February 2012. The information gleaned from the interviews was broken down to identify significant aspects of the data and then categorized. This was undertaken by initially transcribing and reading the transcripts to identify categories of response, testing the categories by classifying responses, explaining the raw data and finally, clarifying how the data was analysed.

From the result of table 3 the following factors were identified. Factors 1 (service orientation) and 2 (supply-chain) were consistent with all interviewed companies. Factor 3 (quality benchmarking) and 4 (trading period) were shared with all the successful companies. Factors 6 (specialist service) and 7 (local links to community and business) were indentified with companies B, C, and D only but factor 8 (inadequate control measures) was specific to the two failed companies only. The research therefore indicates that inadequate control measures were the identifying factor that differentiated between successful and failed company status

Table 3. Factors pertaining to successful and failed companies

	Success factors identified above for successful company A:	**Success factors identified above for successful company B**	**Success factors identified above for successful companies:** **C and D**	**Factors identified above for failed companies:** **E and F**
Factors Pertaining to interviewed companies	1	1	1	1
	2	2	2	2
	3	3	3	x
	4	4	4	x
	5	5	x	x
	x	6	6	x
	x	7	x	x
	x	x	x	8

x = not applicable

Key to factors highlighted in table 3

1. Service orientation
   a. Commercial and/or residential customer base
   b. Problem solving
   c. No hard sell
2. Supply-chain.
3. Quality benchmarking.
   a. Affiliation to institutional organisations.
4. Trading period – basis for selection of cases
5. Critical self assessment.
6. Specialist service.
7. Local links to community and business.
8. Inadequate control measures – Failure: (i) cash flow (ii) communication (iii) interest rates (iv) use of inadequate and irrelevant contracts

The results from the literature review and data analysis have identified the following criteria as being relevant to small sized construction organizations seeking to grow and survive in business. Six companies have been interviewed; four found to be ongoing successful companies and two who experienced failure. A number of open ended questions were asked and comments from the company owners may be found in the following sub-headings 1-8 which are the key factors for table 3 that have been established from the interviewed organisations.

SERVICE ORIENTATION - All the interviewed companies pursued a commercial and/or residential customer base with the exception of Company D who commented: “We do most of our work for either new housing developers or commercial developers of industrial sites”. Company E was the only firm who didn’t offer problem solving as a benefit to his failed business. Companies A, B, and C have a “no hard sell policy” The company B owner remarked: “we have never had to break into a sweat to bring business in”.

SUPPLY CHAIN (EMPLOYED STATUS) - Companies A, B, C and F had a mixture of self employed and employed labour whereas company E only used sub-contract labour and company D only employed their own staff and stated "No they are all employed by the firm and have done for a great many years. Probably 15 years ago we started employing everybody".

QUALITY BENCHMARKING - All companies had or aspired to belong to a professionally aligned industry institute with the exception of the two failed companies E and F.

TRADING PERIOD -All companies had been trading for more than twenty years with the exception of the two failed companies E and F.

CRITICAL SELF ASSESSMENT - Company A has promoted standards of excellence including customer focus, continuous improvement, leadership and consistency of purpose as a development process within the business. Self assessment of a business will make it more focused and competitive, this is borne out by comments from company B who had worked out that "87% of our work was thought a recommendation or a referral or existing customers coming back for more".

SPECIALIST SERVICE - Companies D, E, and F representing 50% of the interviewed companies offered a specialised service.

LOCAL LINKS TO THE COMMUNITY - Company B offered local links to community and business and confirmed "we've always had a strong sense of community for what we do and the fund raising that we do is never for a national charity.

INADEQUATE CONTROL MEASURES - By comparison data from the failed businesses (companies E-F) revealed that they have not managed to keep control. The business owners had either been unable or unwilling to communicate the business interests within their own business community and it is evident that associates have had their own agendas which has resulted in business failure due to a lack of control by the business owner. The owner of company E commented "it's always one of the partners who thinks it's the other partner's fault because they're not pulling their weight and vice versa". He cited another reason for business failure by attesting to a lack of cooperation between the partners and commented "It's not a job I had control over because of the electrical side of it and my partner running that and I very rarely visited. Yeah it would have interested me if it had been mine". Further reasons for business failure were cash flow, late payment and inadequate written contract agreements "Well we'd always struggled to get payment off him, he was always late, but the last one, because it involved a holiday period, Christmas. And there was timings to be set we actually worked all over Christmas for him only to find out that when we billed him for it all it then added up to £19,000 and he disappeared". When asked what was the contract agreement? He retorted: "Gentleman's agreement because he was involved with the Round Table and so was my partner". The owner of company F responded to the question "when asked what you thought made your business fail" was: "Well, obviously a lack of work. The bank rate shooting up and borrowing money at the wrong time. We couldn't work out of it. The assets wouldn't sell so it was the end, and of course we had a huge number of companies that went down on us".

After establishing the success factors from companies A-F identified in table 3 and the literature these have been collated and compared for their compatibility with each other and the findings have been listed in table 4.

Table 4. Relationship between Success Factors from literature and practitioner interviews

Factors from literature	**Factors identified by interview**
(i) Customer focus	(1) Service orientation
(ii) Process management	(2) Supply chain
(iii) Continuous improvement	(2) Supply chain
(iv) Innovation	(1) Service orientation
(v) Supplier partnership	(2) Supply chain
(vi) People development and involvement	(2) Supply chain
(vii) Leadership	(5) Critical assessment
(viii) Consistency of purpose	(6) Specialist service
(ix) Leadership and management	(3) Quality benchmarking
(x) Finance	(8) Inadequate/Control measures
(xi) Skills and expertise	(6) Specialist service
(xii) Culture of the recipient organization	(7) Local links
(xiii) Positive cash flow	(8) Inadequate/Control measures

Figure 2 has been developed from tables 2-4 illustrating classification headings from Hewitt's (1997) Business Excellence Model. The factors identified in table 4 have been brought forward to show the inter-relationship between factors from literature, depicted to the left and the practitioner findings on the right.

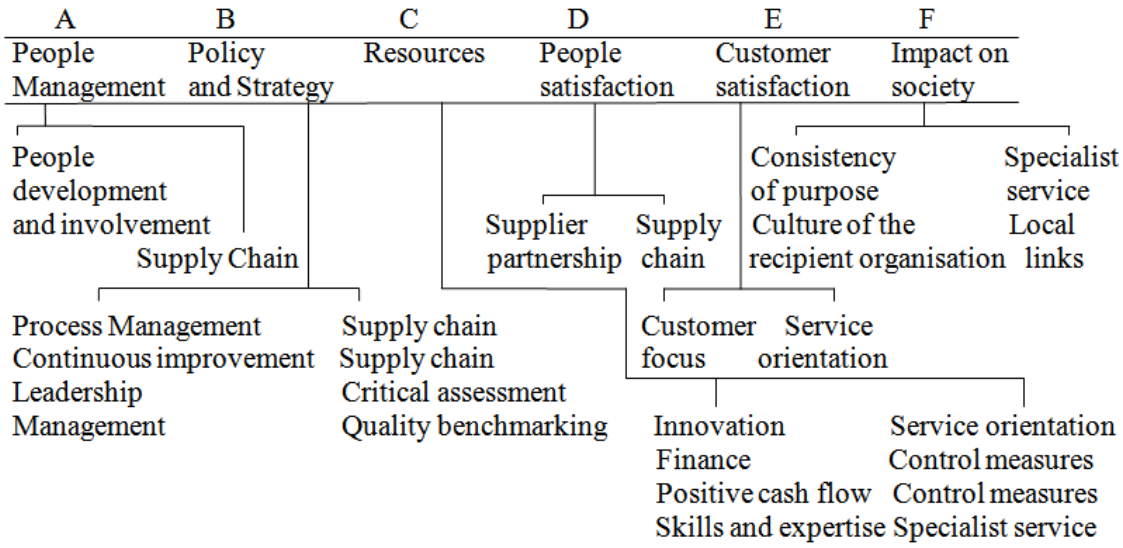

Figure 2. Classifications for Literature and Practitioner based Success Factors

CONCLUSION

By addressing and determining what is meant by a micro, small and medium sized organisation and developing success factors thought to affect an organisation's business viability the foundations have been laid to guide the research to pursue a line of investigation that enabled it to develop a study into ongoing and failed companies.

The literature review identifies the relevance and inter-relationship of SCCOs within Porter's five forces model, the exploration of the factors identified from (a) Hewitt (1997), (b) Arditi *et al.* (2000), (c)Chan *et al.*(2004) and (d)Achanga *et al.* (2006) suspected as impacting on the survival and development of SCCOs. The critical success factors found in the literature review are applicable to (a) total quality management (b) business failure and (c) project management within SMEs and the semi-structured interviews have resolved to disclose the results identified in table 3 which are pertinent to the interviewed companies. The factors from practitioner interviews and literature were then collated to show their inter-relationship with each other under the umbrella classification headings from Hewitt's (1997) Business Excellence Model.

By reviewing the results of the study there is clear evidence to support factors that are shared by the organisations suggesting consistency of unit factors that can be evaluated to determine the ability of a company to fail, continue trading and/or to succeed in business development. This study provides a basis to develop further research with interviewees based in selected case study SCCOs. Such work will enable factors found to form a conceptual framework of success factors critical for SCCOs survival and growth.

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THE ACTORS AND THEIR ROLES IN THE MEANING MAKING PROCESS OF AN ENERGY TARGET

Kjerstin Ludvig[1] and Ann-Charlotte Stenberg[2]

1 Kjerstin Ludvig, Civil and Environmental Engineering, Chalmers University of Technology, Gothenburg, Sweden

2 Ann-Charlotte Stenberg, Civil and Environmental Engineering, Chalmers University of Technology, Gothenburg, Sweden

How are new long-term energy targets for buildings managed in public construction client organisations? This paper presents an empirical account of the actors, their roles and contributions to the meaning making process regarding an energy target for public buildings and the development of an energy strategy. With this account, we wish to initiate a discussion on what actors and practices that are needed in construction sector when contextualising and implementing long-term energy targets in practice. The paper is based on a longitudinal study in a public construction client organisation in Sweden, where for example in-depth interviews and observations of meetings has been used for data gathering.

Keywords: actors, energy target, meaning making process, strategy development process, public construction client.

INTRODUCTION

Currently, a new EU directive on energy use in buildings (e.g. European Commission, 2010) needs to be managed in e.g. construction client organizations and new strategies formed in order to adapt current practices to the new demands. In order to understand how such political directives influence organisational practices, we pay attention here to the actors involved in the meaning making and strategy development process regarding energy targets.

The actors involved in the meaning making and strategy development processes can represent a formal role, a certain competence and/or personal characteristics. Earlier practice oriented strategy research have focused on top and middle managers (Vaara and Whittington, 2012). More, external actors, such as consultants, media gurus and policy-makers, have also been identified as having an influence on organisational strategy (e.g. Jarzabkowski and Spee, 2009). We refer to the actors involved in strategy development as: "strategy practitioners [..] who shape, drive and execute

[1] kjerstin.ludvig@chalmers.se

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strategies drawing on practices such as methods, processes and models for strategic analysis formulation and implementation" (Nordqvist and Melin, 2008: 328).

Drawing on calls regarding who the actors are and what they actually do when a new strategy is developed (e.g. Vaara and Whittington, 2012, Regnér, 2003), we focus here on the roles taken/played by the actors in a strategy task force (STF) during a meaning making process. The STF was a temporary group of internal (e.g. energy expert) and external (e.g. consultant) actors, who contributed to an investigation of organisational implications of a new energy target for buildings. More, their task was to develop a strategy for meeting the energy target. The team resembled a 'strategy task force', STF, as described by Rosén (2011). The aim of this paper is to contribute with an account of the actors in the STF, who they were, why they were involved and how they contributed to the meaning making in the strategy development process. By studying the actors and their roles, our purpose is to initiate a discussion on what actors and practices that are need in construction sector when contextualising and implementing long-term energy targets in practice.

Research regarding strategic actors

An actor may become a 'strategic actor' due to her/his formal position. Examples of positions can for example be a manager but also more temporarily roles. For example, Denis *et al.* (2009) identified the 'sensemaker-in-chief' as someone tasked to "shaping strategic change, at least conceptually" by influencing how meaning is made about organisational change. Further, Balogun *et al.* (2005) presented the 'boundary-shaker', an individual tasked to "implement change across existing internal organisational boundaries, in ways that simultaneously alter those boundaries" (p. 261-262).

More, an actor may also influence on strategic issues due to her/his personal characteristics and competences (Ludvig *et al.* 2012, Rouleau and Balogun, 2011). Mantere (2005) identified 'strategic planning champions' as persons who "try to influence strategic issues larger than their own immediate operational responsibilities" (Mantere, 2005: 157). Nordqvist and Melin (2008) noticed that a 'strategic champion' needs skills above being a strategic thinker. The champion also needs to be a social craftsperson, sensitive to and able to balance tensions between various actors, and an artful interpreter of practice, i.e. someone who can draw on and adjust to the local practices and norms (Nordqvist and Melin, 2008). However, what the actors in these roles actually do and how this 'doing' influence the strategy in practice needs a closer examination (Balogun *et al.* 2005). In particular, actors who attempt to influence others in public organisations face particular challenges, due to the multiple and sometimes conflicting agendas and diffuse power bases among different actors (Hartley *et al.* 1997).

Empirical research regarding development processes of new strategies, as well as the actual roles and practices used by involved actors, in particular those actors who engage in strategic activities aimed at changing the organisational boundaries (cf. Balogun *et al.* 2005) is still scarce. There are examples of studies focusing on how organisational strategies are developed in practice (see for example Rosén, 2011, Regnér, 2003) and how strategic activities over time relate to change in construction organizations (see for example Löwstedt *et al.* 2011). Yet we know relatively little about what actually happen, how and who is involved when a new strategy emerges (Vaara and Whittington, 2012, Regnér, 2003), especially in public construction organisations.

METHOD

The paper is based on a research study, which takes a micro perspective on the meaning making process regarding energy use in buildings in a Swedish public construction client organisation. The process where the officials made sense of and developed a new energy strategy to meet the target was followed for nine months, between December 2010 and August 2011. The explorative, longitudinal study posed an opportunity to, in real time, study how meaning was made over time and how it was contextualized. "Close engagement and cooperation with the practicing managers" is necessary for this type of process study where details about activities are sought for (Rosén, 2011). The empirical data set consists of narrative accounts (25 in-depth interviews), observations (13 project meetings) and documentation from the studied process. Taken together, our data set generates in-depth knowledge about how the studied actors talked and acted during the strategy development process, i.e. what they did in order to make sense of, form and formulate the new strategy.

The development of a rich chronological description, or narrative, constituted an initial step in the analysis of the data set (Langley, 1999). In the next step of the analysis, we set out to identify the actors that were, directly or indirectly, involved in or had influence on the meaning making of the energy target and/or the strategy development process. More, we searched for patterns regarding how these actors acted, interacted and how they influenced/were influenced by the process. For this paper, field observations from the project meetings were analysed in-depth, in terms what roles the key actors took/were given and how they contributed to the sensemaking/strategy development process. The analysis of the project meetings (transcripts and recordings) was an iterative process between data and theory, as we wanted to let the data 'speak'. In this paper, we focus on four key actors in the STF during the strategy development process and gives examples of the actions/interaction.

THE STRATEGY DEVELOPMENT PROCESS

The studied organisation, a Swedish public construction client organisation (here called Alpha), is part of a public county organisation (here called the Gamma group), which is governed by democratically elected politicians. The county organisation provides public services within sectors such as health, culture, environment and transportation etc. Alpha was formed in 1999 and owns, rents and manages public facilities. More than 80% of Alpha's energy use is related to operation and maintenance of nine large emergency hospitals.

In 2010, the owners of the Gamma group, i.e. the politicians, decided to become fore-runners regarding energy efficiency by officially setting the target that "Gamma will reduce energy use in buildings by half until 2030". The decision was inspired by activities at European and national level. That is, the European Commission had launched a revised directive on energy use in buildings; all member states should reduce energy use by 20% from year 1995 to 2020, and from 2020 all new buildings should use almost no energy (European Commission, 2010). Sweden adopted an additional national target aiming at reducing the energy use by half before year 2050 and the public sector was envisaged to lead the way by setting even more ambitious targets.

In the beginning of 2010, the owners of the Gamma group informally contacted Alpha's senior energy expert to get assistance in the formulation of Gamma's new energy target. This expert had successfully executed several energy reduction projects

and initiatives, and was seen as 'Mr. Energy' by his colleagues. As a result of these informal initial discussions with the owners, Mr. Energy initiated an investigation project regarding the consequences of the new energy target within Alpha. With mandate and blessings from Alpha's general manager (top management) he also formulated the task assignment, set the budget for and conducted the project. Already from the beginning, Mr. Energy had a clear vision of what he wanted to achieve regarding energy issues in the Gamma group. He also knew from start what he wanted the investigation project to result in; namely a renewed focus on energy efficiency in buildings. To his assistance, he formed a team, hereafter called the 'Strategy Task Force' (STF) (cf. Rosén, 2011). The STF had regular meetings, best characterized as "free discussions" (cf. Jarzabkowski and Seidl, 2008), from November 2010 to August 2011. Below we present the four actors, their different roles (taken or given), interests and contributions to the meaning making of the energy target and the strategy development.

The Key Actors

In total, seven actors who represented various but interrelated expertise areas participated in the STF work. However, all seven did not participate at the same time but joined the STF when their particular competencies were needed. Three of them (an energy coordinator at Alpha who participated during the first two months, and two junior consultants who assisted Mr. Consultant at different times) had only minor roles during the strategy development process. Here, we focus on the four STF actors (briefly described in Table 1) that had the greatest influence on process.

Table 1: The actors in the strategy task force

	Background	Period involved in the STF
Mr. Energy	Senior engineer, more than 30 years of working experience of energy efficiency issues. Alpha's internal energy expert. At Alpha since it was formed.	Involved from pre to post process, Jan 2010 and onwards.
Mr. Consultant	Senior engineer, 25 years of working experience or energy efficiency issues. Regularly engaged by the Gamma group.	Involved from process start to the end, Sept 2010 and onwards.
Mr. Economy	Real estate economist, 10 years of working experience, but only one year at Alpha.	Involved from Nov 2010 to March 2011.
Mr. Synergy	Senior engineer, 30 years of working experience of e.g. technical maintenance of buildings. At Alpha since it was formed.	Involved from Feb 2011 to August 2011.

Mr. Energy

The most central character in this story is 'Mr. Energy'. As described above, he was given the opportunity to influence the politicians when they set the energy target. This resulted in a visionary formulation of the new energy target that included the whole Gamma Group. This happened months before the energy target was officially launched in June 2010. Thus, Mr. Energy laid the foundation for an increased organisational focus on energy issues, where all stakeholders would share the responsibility to meet the new energy target.

Already in the initial discussions with the owners Mr Energy realized that extensive measures were needed in order for Gamma to meet the target. Accordingly, he initiated the investigation project and orchestrated the strategy development process,

with mandate and trust from top management. More, he identified and attracted personnel resources that he needed in the STF at certain times. More, he set the agenda for and acted as the convener at the STF meetings. Although letting the others run the discussions during the meetings, he orchestrated the investigation project to ensure that the STF kept focus on the goal, i.e. the development and implementation of the new energy strategy, and how to reach it. For example, when the meeting discussions entered into too long negotiations on technical details, Mr. Energy interrupted and asked "What do we want to show? What kind of decision do we want [from top management]?"

As the leader of the investigation project, he regularly briefed top management, mostly on informal basis such as 'water cooler' conversations between meetings but he also initiated formal meetings and presentations. He took on the role as top management's voice in the STF meetings: "I don't know exactly how [the general manager] thinks, but as I understood it he needs a clearer statement [from us] to go the Real Estate Committee".

Throughout the process, Mr. Energy planned when and what to inform others about. He used his personal networks, inside and outside Alpha, to spread the message about the energy target. He scheduled/arranged the meetings with and presentations for the stakeholders such as Alpha internal professional networks, other energy related development projects within Gamma and the Gamma owners. More, he set up an external reference group for the STF, to validate their work process and results. Thus, he put a lot of effort in how, what and when to communicate with different stakeholder groups in order to create commitment and action for the new energy strategy. In the STF team, he was with no doubt the 'strategist'.

According to Mr. Energy, meeting the new target would require reorganisation of work and decision-making processes, at Alpha as well as within the Gamma group. He thought that the current organizational structure, with autonomous sub-organizations, at times blocked Alpha's efficiency and he saw an opportunity to use the energy strategy as lever to loosen what he referred to as the 'silo mentalities'. In parallel to the work in the investigation project, Mr. Energy planned for and strategized on the next phase, i.e. the implementation of the new energy strategy in practice. For example, with strong mandate from top management he prepared for an 'energy committee' to implement the new energy strategy. In order for the committee to work and manage the energy issue across the organisational structures of today, Mr. Energy planned that it would not necessary follow the current organisational structure, but 'shake the organisational boundaries' (i.e. the composition did not attempt to have representatives from all sub-organisations, but competent driving-spirits no matter organisational belonging). However, due to for example diffuse power and diverging objectives among the sub-organisations and top management, the energy committee was not in place as soon and smoothly as Mr. Energy wished, and therefore the implementation of the strategy was delayed.

Mr. Consultant

The first to be invited to the STF by Mr. Energy was an external energy consultant, 'Mr. Consultant'. He and Mr. Energy shared positive experiences from working together in an energy related project a few years earlier. Mr. Consultant was also involved in several of Gamma's highly strategic investment projects in new-building and redevelopment of health care buildings, where he successfully strived for and reached increased energy efficiency at low cost in buildings.

Together, Mr. Energy and Mr. Consultant formed a creative and committed core duo. Supported by junior colleagues, Mr. Consultant set up and modelled scenario analyses, he wrote reports and prepared PowerPoint presentations. During the STF meetings, he took the leading role in discussions on technical issues, since he needed for example data about the current buildings, building area now and in the future, investment plans etc in order to develop the scenario model. Often, he draw illustrations and diagrams on a blackboard in order to illustrate for the others what he meant, i.e. he used the interactive drawings as a sensemaking device. Some of these illustrations were later digitalised and used in presentations and reports. Thus, Mr. Consultant was the ’doer’ in the team, who ‘materialised’ and visualised the STF work into tangible scenarios and presentations.

The scenario model analyses, developed by Mr. Consultant, indicated that the additional cost for the Gamma group to meet the energy target would be lower than the Mr. Energy and Mr. Consultant had expected. However, the funding for the additional cost had to be solved before the STF could continue with informing their Alpha colleagues about the new energy strategy; “It is very difficult to sell in this political argument [regarding the strategy]. First we need to solve the funding.” Hence, Mr. Consultant and Mr. Energy realized that they had an ‘attractive message’ (i.e. that meeting the target would not cost much), but a pedagogical challenge regarding how to present the results so that top management legitimated further action regarding the new energy strategy, i.e. facilitated arrangement of funding of the additional costs. Improving the 'pedagogic' in presentations (e.g. briefings for owners and top management) and dialogues with stakeholders was considered a continuous and important task by the STF and much discussed in meetings.

As a mean to make sense of various problems/issues that appeared during the investigation project, Mr. Consultant often referred to discussions and details from Gamma’s parallel strategic investment projects in which he was also working. Thus, he contributed with ideas and experiences from ongoing projects, but also brought back inspiration to the projects from the STF discussions. The result of this cross-fertilization was that as the investigation project progressed, the tentative energy strategy was discussed and, where possible, implemented in ongoing investment projects. These implementation activities were in turn used by Mr. Energy as ‘good examples’ in the communication about the energy target in different contexts.

Mr. Economy

Mr. Energy and Mr. Consultant soon realized that they together lacked very important knowledge; they needed someone who knew the ‘language of economy’ in order to succeed with the strategy and its implementation. Consequently, Mr. Economy was engaged in the STF by Mr. Energy. Due to his confidence-inspiring manner, his humble and generous attitude, Mr. Economy had developed a large network within the Gamma Group. Even though neither Mr. Energy nor Mr. Consultant had worked with him before, their confidence in Mr. Economy was huge.

According to Mr. Energy and Mr. Consultant, Mr. Economy opened their eyes to what they referred as the ‘profitability dilemma’, i.e. that the common focus on and request for profitability of investments did not apply to this politically set target in public organisations; ”What are we actually talking about? It’s not about profitability, it’s about investment costs. The decision [to reduce energy] is made [by the politicians], you have no choice but to implement it. But at what cost?” More, Mr. Consultant expressed his and Mr. Energy’s initial efforts as; ”Well, we were very much focusing

on profitability […], but then [Mr. Economy] told us not to worry about that". This input from Mr. Economy helped the others to refocus from 'profitability of investments' to 'costs for meeting the target' during the end of 2010. When Mr. Energy and Mr. Consultant struggled with deciding on what to present for Alpha top management and at what level of detail (February 2010), Mr. Economy proposed to present an overview of what they actually knew at the time, without digging into unsure details. Technical or financial details were not relevant to present, Mr. Economy reckoned, before the strategy was further outlined. This illustrates how Mr. Economy managed to identify and make sense of the needs of both the STF and the top management and find bridging solutions.

Thus, Mr. Economy helped the STF to focus on how to 'package and present' the energy strategy, rather than on the profitability of technical solutions. More, he used his personal network to informally inform and/or anchor different aspects with for example the general manager and/or the financial manager; "I informed and anchored this with [the general manager] today, and I have also discussed this with [the financial manager]".

However, in the end of March 2010, Mr. Economy had to leave the STF due to illness. The gap he left in the STF was significant. While the technical part of the strategizing progressed, the financial part regarding meeting the energy target slowed down considerably when Mr. Economy was on sick leave, as illustrated by Mr. Energy; "The problem now is that no one from the [Economy department] is involved and committed. If [Mr. Economy] had still been in the STF, we would have been much further ahead. […] We thought that the [general manager] would have driven this issue, but he did not".

The others in the STF referred to Mr. Economy's contribution and importance to the investigation project frequently, as expressed by Mr. Energy, when he in April realised that HOW much influence Mr. Economy had had on the progress of the STF; "It was these kinds of discussions that we had a lot with [Mr. Economy] before he got sick, and now we have lost valuable months since we did not continue the discussions." Thus, Mr. Economy played an important role in the STF that was not fill/replaced when he left.

Mr. Synergy

Mr. Synergy was invited to his first STF meeting in early winter 2011 when, according to Mr. Energy, the identified main barrier for a successful implementation was taken care of, i.e. the funding issue. Thus, the strategy development project went into a new phase where focus was on facilitating Alpha's and Gamma's organisational meaning making about the energy target. Mr. Energy started to inform colleagues and customers about the new energy target and the energy strategy, since he saw early information spreading as a key to gain acceptance and create commitment among stakeholders for the energy issue. Hence Mr. Synergy was invited to the STF at a time when he was assumed to contribute with his broad perspective and interest, open minded personality and reflective manner. His own explanation to why he was invited by Mr. Energy was "because I am interested in finding synergy effects from this investigation project".

Mr. Energy and Mr. Synergy had been colleagues for the last decade, thus developing a professional relationship. Further, Mr. Synergy also knew Mr. Consultant very well, and he describes how they had developed a close client-consultant relation: "Well, we do not socialize in private, but we often use each other as discussion partners and try

to think strategically". They acted as sounding boards and 'confidents' for each other, i.e. they were each others 'counsellors' regarding professional issues. Due to his relations with both Mr. Energy and Mr. Consultant he could easily 'slip into' the STF and become 'one in the team'.

Mr. Synergy became the 'reflective one' in the STF, questioning already made assumptions and estimations. His questions were not critical, but constructive and made out of a genuine interest in understanding the investigation process and the strategy. However, his questions forced the STF to reflect on their work and the process. More importantly, Mr. Synergy brought the customer perspective into the discussions when he questioned the scope of the investigation project in terms of what and whose costs to include in the scenario modelling and presentations. If the STF could show the customers potential synergy effects, for example that the energy efficiency measures could contribute to the efficiency in operation of care, that would provide the customers with incentives to commit to the energy target.

Thus, Mr. Synergy was brought into the strategy development process when his characteristics and competences were valuable for the STF and he managed to broaden their sometimes too narrowed focus, to a more open and customer oriented approach.

ANALYSES AND DISCUSSION

Our purpose with this paper is to initiate a discussion regarding actors and practices in construction organisations challenged by new long-term energy targets. In order to do so, we present the actors in a Strategy task force during a meaning making and strategy development process of an energy target, with focus on the actors' roles and contributions.

A general view has been that strategy is something that only managers are involved in and that the centre of strategic activities is found among corporate management and board of directors (cf. Regnér, 2003). Here, we have an example of a periphery expert (according to Regnérs definition) who initiated and manoeuvred a strategy the meaning making and the development of a new energy strategy. The paper shows how this one actor, Mr. Energy, took the role of 'strategic champion' (Nordqvist and Melin, 2008, Mantere, 2005) at Alpha and became a 'sensemaker-in-chief' (cf. Denis *et al.* 2009). He had a position as appreciated energy expert due to his professional experiences and characteristics. He was enabled in the role as strategic champion by top management, as they gave him mandate to act upon the new energy target. Mr. Energy was a driving spirit, who possessed discursive competences (Ludvig *et al.* 2012), such as being a skilled networker who knew who to influence, how and when. Yet, he needed support.

In order to succeed with the development and implementation of an energy strategy, he foresaw a need to shake organizational boundaries (cf. Balogun *et al.* 2005), i.e. a need to influence and create action among actors outside his formal area of responsibility and his core competence (the energy issues). Therefore he initiated and orchestrated an investigation, conducted by the STF, in order to develop a new strategy. Here, he had the mandate to recruit competences/ personnel resources, i.e. the co-strategist, he needed. Mr. Energy chose his co-strategists among colleagues that he knew, respected and trusted. He identified what competencies and perspectives he needed to complement his owns, in particular phases of the strategy development process. Initially, a 'doer' was introduced. Mr. Consultant was a driving spirit, as Mr.

Energy, and entrepreneur with advanced technical competence regarding energy efficiency in buildings. He was also engaged in several ongoing investment projects, thus he contributed to the STF with insights in current building practices in Alpha. Soon after a colleague who knew the 'language of economy' became engaged. Mr. Economy complemented the former two in terms of competence (he was a real estate economist and therefore knew how to communicate about strategic issues on the 'language of economy' as stated by Mr. Energy) and personal networks (he was in regular contact with for example financial managers). The fourth actor in the STF was invited at a time when Mr. Energy wished to broaden the perspective in the STF discussions, from technical and financial matters to creation of commitment and action among colleagues and customers, through communication. By then, Mr. Synergy's the broad perspective and curiosity was needed in order to widen the STF discussions. Thus, each of these actors had a particular role and brought specific competences to the STF.

A consequence of how Mr. Energy composed the STF was that an efficient team was formed and the meeting dialogue was characterized as free, creative and humoristic. However, the discussions were seldom questioned in detail as no one in the team took on the role as 'criticizer'. To some extent it seems as, the roles for each actor in the team were already defined by Mr. Energy when they actors entered the team, as he knew them in person from earlier. It can be discussed how the meaning making process would have been different if other actors would have participated. As seen in the empirical account, Mr. Energy chose his co-strategist carefully, including the exclusion of those who should not be allowed to contribute to the meaning making, or in worst case even could jeopardise his vision of increased energy focus in Alpha. But what actors were excluded and why? From this account, we still know little about that and to find an answer we need to search among actors outside the STF, which is certainly interesting but outside the scope of this paper.

Hence, few actors actually participated in the actual development of the energy strategy. Mr. Energy was more concerned with how to 'get everyone on board', rather than on broad participation in the actual meaning making process. The consent and support for the strategy was needed among actors outside the construction organisation, because the energy reduction measures concerned e.g. the customers and financial department. The dialogues Mr. Energy held with other stakeholders, like project managers and financial managers, were mainly used to communicate about the target and the strategy, as a way to create sense of the situation (c.f. Gioia and Chittipeddi, 1991, Maitlis and Lawrence, 2007) and thereby legitimize the tentative strategy.

Above this initial account, we see several aspects regarding actors and practice in need of more research attention. This paper has consciously not focused on actors and actor groups beyond the STF that were influenced by or had influence on the studied meaning making process. In particular, the relation and interaction between Mr. Energy and the top management team has not been examined here, but such analysis could contribute to the research calls regarding power, politics and agency in the context of strategy development and sensemaking (e.g. Vaara and Whittington, 2012, Maitlis and Lawrence, 2007, Weick *et al.* 2005). More, the actors' roles and contributions to the STF are likely to change over time, but the time perspective needs further examination.

To conclude, we have seen how the actors in the STF, namely a strategic champion accompanied with a doer/technical expert, one that knew the language of economy and a curious colleague with broader perspective than only energy, systematically and tactically contributed to the meaning making process of the energy target. This account is an initial step in our examination of who the actors are and what they actually do, when public construction client organisations are challenged by long-term energy targets.

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MANAGING CHANGE THROUGH PARTICIPATION: DEVELOPING SHARED CONSTRUCTION GUIDELINES IN 26 PUBLIC ORGANISATIONS

Nína Baldursdóttir and Eveline Ottosson

Division of Construction Management, Department of Civil and Environmental Engineering, Chalmers University of Technology, 412 96 Gothenburg, Sweden

Increasingly public sector clients are being asked to do more for less and are pushed to achieve higher levels of transparency and accountability. Thus, organisations' ability to address challenges like these has become increasingly important. As a result, a range of models have emerged to help organisations successfully manage this development. The research presented in this paper draws on an exploratory case study of an ongoing change process in the City of Gothenburg, where 26 municipal organisations are developing a shared process (Shared Construction Guidelines) for how to conduct building and infrastructure projects in the City. The aim is to describe this case of participatory change and to shed light on its complexities. Findings show that there is a high degree of commitment and participation in the case of Shared Construction Guidelines. However, there seems to be a gap between top management and the rest of the change organisation and resources are limited, especially in terms of time. Also, several findings indicate challenges regarding the understanding of the change. Altogether, this might explain why all members do not feel that they can fully affect the process, even though it is based on broad participation. Finally it is highlighted how the existing literature on change management falls short when describing complex participatory change processes.

Keywords: change management, organisational change, participation, shared processes.

INTRODUCTION

Increasingly public sector clients are being asked to do more for less, i.e. produce more public value with fewer resources. At the same time, these organisations are progressively being scrutinised and pushed to achieve higher levels of transparency and accountability throughout the whole process of delivering construction projects. Responding to these pressures inevitably throws up a host of challenges, especially concerning the development and merging of organisational routines across large and diverse authorities. This in turn challenges deeply-ingrained working practices among public and private actors alike. Thus, organisations' ability to address challenges like these has become increasingly important and as a result, a range of models have been developed (Seijts and Roberts 2011; Rothermel and Lamarsh 2012). These models intend to help organisations understand and adapt to change, but still many authors claim that organisations' attempts to manage change initiatives often fall short (e.g Higgs and Rowland 2005; Keller and Aiken 2009).

Baldursdóttir N and Ottosson E (2012) Managing change through participation: Developing shared construction guidelines in 26 public organisations *In*: Smith, S.D (Ed) *Procs 28th Annual ARCOM Conference*, 3-5 September 2012, Edinburgh, UK, Association of Researchers in Construction Management, 863-873.

Even though there are a lot of studies supporting the idea of successful change through employee participation (e.g. Kotter and Schlesinger 2008; Rowlinson and Cheung 2008; Seijts and Roberts 2011), there are few studies describing what happens during change processes based on participation and how participants perceive these from a real-time perspective. For example, Klarner *et al.* (2011) noted that it is important to understand how employees cope with change not only after the implementation but also throughout the change process. Furthermore, Schein (2006) stresses the importance of looking at both macro and micro levels and their interdependence to fully understand the complexities of a change process. Therefore, this study draws on an ongoing change process based on broad participation of employees in the City of Gothenburg, where 26 municipal organisations take part in developing a shared process for how to conduct building and infrastructure projects in the City (Shared Construction Guidelines). The purpose of the study is to investigate how a change process built on participation is handled both by management and its participants. More importantly, it seeks to develop a better understanding of the complexities of participatory change within this particular case. The aim of the study is to describe this case, particularly from a participation perspective. Therefore, the main research question is: How is the change process organised at the operational level and how do the participants perceive their ability to affect the change process? Following Schein's line of argument above, an understanding of the change process in connection to its context is needed in order to answer this question. This leads to a second research question: How can this change process be explained at an organisational level so that it can be fully understood?

The paper takes its departure in summarising two main perspectives of organisational change, namely teleological (stage models) and evolutionary (organisational flux). Thereafter focus is shifted to the participation literature. The empirical ground is explored through a qualitative case study of the implementation of the so-called Shared Construction Guidelines (SCG) in the City of Gothenburg. This initiative aims to develop, through collaboration, a shared set of steering and guiding documents that will be mandatory in all building and infrastructure projects within the City. The first analysis focuses on the organisational level and the applicability of the two generalised perspectives on organisational change. Secondly, the operational level is discussed through the concepts found in the participation literature. Conclusions are drawn highlighting challenges involved in imposing change across numerous public organisations as well as shortcomings of the existing change management literature.

ORGANISATIONAL CHANGE

In simple terms the change management literature is dominated by two polarised views. These are commonly given different etiquettes such as teleological vs. evolutionary, planned vs. emergent and scientific vs. adaptive (Kezar 2001). The inherent ontological and epistemological assumptions of these perspectives have been discussed at length elsewhere and further elaboration lies outside the scope of this paper. This section follows these broad distinctions but is narrowed down to differentiate between stage model and process-oriented perspectives. This is done as the concept of stages has long been used in the attempts to understand change and assure its success. However, it is commonly criticised for not fully incorporating the always-ongoing dynamics of change in organisations. These perspectives are then linked to three main concepts found in the literature regarding participatory change.

Stage models

Kurt Lewin is commonly credited for developing the first model for handling planned change in 1946 (By 2005). He divided the process of change into three stages, namely defreeze (create the right environment), change (support change to desired state) and refreeze (reinforce to anchor change). Other authors have made use of this idea and have developed own models with the ambition of making them more practical (e.g. Armenakis 1999 in Armenakis and Bedeian 1999; Kanter 1992 in By 2005; Kotter 1995; Wooddell 2009). When comparing these models, some aspects are more recurring than others:

- Leadership – e.g. Organisational support (cf. Wooddell 2009)
- Vision – e.g. Creating a vision (cf. Kotter 1995)
- Participation – e.g. Active participation by those affected (cf. Armenakis 1999 in Armenakis and Bedeian 1999)
- Institutionalisation – e.g. Reinforce and institutionalise change (cf. Kanter 1992 in By 2005)

In addition to these, internal models evolved describing how people in organisations perceive and react to change. An example is Jaffe *et al.* (1994), who presented a four-stage model including denial, resistance, exploration and commitment (in Armenakis and Bedeian 1999). According to Armenakis and Bedeian (1999), these stages are beneficial for understanding resistance caused by change. Resistance is viewed as a natural part of change (Rothermel and Lamarsh 2012) and as a result, several ways to overcome it have been recommended, e.g. education, participation and facilitation, depending on the situation (Kotter and Schlesinger 2008).

Organisational flux

An opposing, more process-oriented view treats change as natural and ever-present in all organisational life (By 2005). Therefore, in order to understand change another perspective is needed (Tsoukas and Chia 2002). The idea of organisational flux implies that there is never only one reason behind the origin of a change and in addition, many changes occur simultaneously (Clegg *et al.* 2008).

According to Tsoukas and Chia (2002), response to change is contingent on internal conditions even though it might emerge from external pressures. In other words, focus is shifted from the organisational level to the individual level. Consequently, change must be handled at this level, which gives rise to the importance of employee commitment, motivation and satisfaction. Rowlinson and Cheung (2008) argue that commitment to change comes from having the opportunity to influence the outcome, which can be given by reinforcing employees at all levels through participation. Similarly, Seijts and Roberts (2011) found that opportunities to participate along with satisfaction with other members and respect in the workplace was significantly linked to a positive perception of change, which in turn is a predictor for its success.

Participation

Both the stage model perspective and the organisational flux perspective incorporate the idea of employee buy-in and participation. The role of employees is becoming widely recognised as one of the most important factors in the process of change (Schein 2006; Rowlinson and Cheung 2008; Wooddell 2009). Three essential areas have been discovered in the literature regarding employees' ability to participate, namely empowerment, resources and conceptual understanding.

Firstly, empowerment is defined as power-enabling processes that make people feel they have the ability to act upon matters of importance (Page and Czuba 1999). In organisations, empowerment gives employees the ability to contribute to the work without being directly steered, since they have been given the confidence that they are capable of doing so (Herrenkohl *et al.* 1999; Kanter 2008). In connection to organisational change, Kanter (2008) argues that empowerment is the key for large organisations to transform and adapt to today's rapidly changing society.

Secondly, management has to recognise their employees as stakeholders during change and provide them with the resources needed, such as time, information and supplies. Otherwise, employees might not commit to the change but instead become an impediment to its success. (Rothermel and Lamarsh 2012; Wooddell 2009)

Finally, employees who have made sense of the circumstances surrounding a change are less likely to show resistance (Kotter and Schlesinger 2008) and become more prone to commit to the change (Walker *et al.* 2007). Rothermel and Lamarsh (2012) take this even further and argue that all those involved are personally responsible for understanding the change. However, it is vital that employees have the same conceptual understanding as they work towards the same goal (Fiss and Zajac 2006).

RESEARCH METHOD

This research draws on a qualitative case study of an ongoing change process in which a key feature is a bottom-up approach with broad participation. It puts focus on people's perceptions and tries to enhance the understanding of these in connection to the context in which they exist. Therefore much effort has gone into describing the organisational context of the case and particular attention has been given to describe people's perceptions about their ability to influence.

Data have been collected through a survey, interviews and observations. The reason for using several methods is partly to obtain a more holistic ground, but also to better validate subjective data (Starrin *et al.* 1991). The survey was sent to all members of the Steering Committee (SC) and the Workgroups (WG). It contained questions about how they perceive the organisation, purpose and goal of the change, as well as how they view their own participation and its effects. In total the survey was sent to 69 SCG participants and 38 members answered. Representation was tested using two factors, gender and belonging with regard to type of organisation, and was found to correspond well with the overall distribution. Four out of six members of the Process Management (PM) were interviewed since this group was not included in the survey sample. To obtain a better understanding, SC members were also interviewed, adding up to a total of six complementary interviews, each lasting approximately 40 minutes. Finally, during the research period observations were made at two larger information meetings, four WG meetings and one SC meeting. Before collecting data, related survey statements (i.e. survey statements regarding analogous topics that could reveal, or rule out, possible correlations) were identified and grouped in twos and threes. The responses to these were compared and the strongest correlations got analysed further.

THE CASE: SHARED CONSTRUCTION GUIDELINES

The Shared Construction Guidelines (SCG) in the City of Gothenburg, Sweden, is an ongoing change process based on broad participation of employees and involves 26 municipal organisations engaged in or related to construction works. The task is to develop a shared set of steering and guiding documents that will be mandatory in all

building and infrastructure projects within the City. This section draws on Göteborgs Stad (2012) and interviews with PM members.

Background

In 2010, a series of briberies and irregularities were brought into light concerning public construction projects in the City of Gothenburg. As a result, in January 2011 a political decision was made that all municipal organisations active in construction should take on and implement a five-part action plan. The five areas targeted are Internal Control, Shared Construction Guidelines (SCG), Whistle-blower, Rules and Education. This study focuses on SCG, the other areas will not be treated in this paper.

Policies and Guidelines
SCG is a development of what was former known as Policies and Guidelines. This project started in 2006 when a political decision was made to develop construction guidelines for the City of Gothenburg. Initially, only three organisations participated in the project, however all municipal organisations were encouraged to use these guidelines, although they were never compulsory.

Vision

The aim of SCG is to make the local construction industry more professional, safe and transparent through conjunction of processes. This will also increase accountability and ensure, as far as possible, that everybody act according to an agreed-upon standard. Therefore, in contrast to Policies and Guidelines, SCG will be mandatory for all affected organisations. Initially the target was to have all parts of SCG ready to launch in January 2013. This was, however, revised in March 2012 since members from all levels started to anticipate that the ambitious target could not be achieved on time. As a result, the target was made more modest to only include a few parts for implementation at the beginning of 2013.

Organisational structure

To develop SCG, an organisation has been formed including a Steering Committee (SC), a Process Management group (PM) and seven Workgroups (WG) with members from all 26 participating organisations. The nine members of SC are all the highest executives of their home companies. The six members of PM are the only ones working with this process on either half- or full time and serve as a link between SC and WG. At least one PM member is always present at WG meetings to act as an administrative support, e.g. document topics discussed and decisions made. Each WG consists of four to eight middle- and project managers who have been given a directive to put four hours of work into SCG per week. They are assigned to a specific sub-area of the construction process, namely Management, Procurement, Pre-study, Briefing, Design, Production and Delivery/Guarantee. Their task is to compile a set of steering and guiding documents on how to conduct construction projects and consist of an ordering document, checklists, descriptions, and guiding case examples. These are then made available through a web-based database. As stated above, the original target was to have all these parts ready for launch in January 2013. However, the revision meant that the ordering document and the checklists should be prioritised. Descriptions and case examples are to be finalised during 2013 instead.

FINDINGS

In this section the main findings are presented with regards to the organisational level, i.e. vision, internal relations and external support, and the operational level, i.e. empowerment, resources and conceptual understanding.

Organisational level

The change process is based on broad participation through a bottom-up organisational structure. There is a steering coalition at the top, a planning division in the middle and executing workgroups at the bottom. Findings show both accomplishments and challenges in and between these levels.

Firstly, the vast majority of the participants know the overall vision of SCG. Also, a relatively high response was obtained to the statement "SCG is what the City of Gothenburg needs" and several observations were made of members expressing urgency for this process to become successful. However, opinions clearly differed as to whether or not the participants believe that the vision will be fulfilled successfully.

Secondly, the survey shows that WG participants have a fairly high trust in all their superiors. However, several members articulated that they do not know who the members of SC are, neither do they feel they get enough support from them in terms of directions, an opinion that is confirmed by several PM members. Looking top-down, SC shows a low confidence in PM but nevertheless, as an SC member expressed it "PM need to steer more if this process is to be successful". As a result, the latest revision turned this concern into action and PM was delegated more power. In addition, even though WG and PM agree on how the change initiative is to be carried out, i.e. through workgroups with broad representation, SC seems to disagree.

As mentioned above, each member is expected to put four hours per week on SCG. However, the survey revealed that the average time invested is only 2.85 hours. Also, most WG members feel that they do not receive enough support in terms of less workload from their home companies to perform their duty within SCG properly. As stated by an SC member: if time is limited the home company always comes first.

Operational level

According to the survey, almost all WG members claim that influence fosters commitment and in the SCG case there is a high degree of participation. Despite this, they were not equally convinced regarding their actual ability to influence the change process. Also, as much as one-third of the respondents feel that their input lacks significance. To obtain a clearer view, findings connected to the three areas found in the participation literature will be outlined below.

Many statements linked to empowerment received positive responses. The participants of SCG think they have the competence needed to perform their task and are confident in their ability to represent others in the industry. This change process is said to be for professionals, by professionals, and observations revealed that this statement is well accepted among WG since it was used as an argument at several meetings. Almost all members report being part of the decision-making and that they can speak their mind. Also, a vast majority say that they feel comfortable in their particular group.

Responses to statements regarding resources were not as affirmative. As much as one-third of all respondents feel that they do not have the resources needed to fulfil their assignment. Also, this group claimed that they were not as clear on what their assignment is or what is expected of them, compared to those who feel they have

enough resources. Furthermore, lack of time is a recurring factor in the responses. In addition to the issue of support from the home companies presented above, several WG members expressed concerns about how much time and effort it will take to use the resulting documents. Therefore, according to the members, these must become clear and simple. Also, one WG in particular stressed the need of recognising that this kind of comprising documentation will need reserved resources, especially time.

Regarding the participants' understanding of the change, most respondents feel that their involvement is meaningful and believe that SCG is important for the City of Gothenburg. There are a few who disagree with these statements, however common across the groups is that the members always take part in group discussions. The survey also shows that the majority of the WG members reveal if they do not know what is expected of them or their group. On the contrary, a minority answered that they do not ask for guidance in these situations. Furthermore, these respondents are not as sure of their assignment and experience a lack of direction on how to perform it. Similarly, SC members seem to disagree on what their role is; some think they should steer the process, while others want less responsibility. Finally, observations revealed that WG put a considerable amount of time to reach consensus on the meaning of terms and concepts. This concerned them, since other groups and final users will have to interpret the documents as well.

DISCUSSION

This section is structured in accordance to the research questions posed in the beginning of this paper. The second question is treated first in order to clarify the organisational context. Thereafter, the main research question concerning the operational level and participation is discussed.

Organisational level

The studied change process came about as a result of pressures from the local society. The process was initiated before a proper action plan was completed and the only directive given stated what desired achievements that had to be reached in less than two years' time. Having this in mind, it is not surprising to find the change process to be reactive, where directions, relations and even the goal are adjusted along the way. The reactive nature of this case could also explain the shifting answers to what expectations members have of the result. These findings are further elaborated below.

Not only does the organisation seem to have a successfully communicated vision, there is also a high degree of buy-in among all members. This is for example shown by the majority agreeing to the need for a shared construction process in the City and by several members stressing the importance of delivering a result of high quality. However, it is unclear how the participants' commitment will be affected due to the recently revised target since confusion around the meaning of terms and concepts formerly exist. By leaving out descriptions and examples, there is a risk that the confusion grows stronger.

There appears to be a gap between the SC and the rest of the organisation due to a lack of mutual confidence. Whilst WG and PM express confidence in all levels, SC does not seem to share their opinion. PM and WG appear to have a closer and more personal relationship, which could be due to PM's involvement in WG meetings. Also, both levels expressed that they do not get enough directions from SC, which could partly explain why participants do not feel they can fully affect the process. Altogether, it seems as if a steering coalition was formed without further thought of its

purpose, since the view of what SC is supposed to do not only differs between the hierarchical levels, but also between SC's own members.

As mentioned before, the average WG member invests less time in SCG than what the given directive states. One reason could be the lack of support from their home companies. This support must come from the highest level in an organisation, but only nine organisations have highest-level representation in SC. However, these have not managed to give enough support in terms of less workload to WG members from their own companies. Having this in mind, the higher executives outside the process might find it even harder to support SCG members from their organisations.

Organisational change perspectives

Out of the four stages outlined in the stage model perspective, leadership and vision do not correspond with this case. As discussed above, these have been continuously adjusted along the way, meaning they have not been finished off one by one as stage models indicate, but are instead co-occurring. In other words, stage models are insufficient to fully explain how this change process works, a notion that is supported by the many critiques found in the literature. Enthusiasts of the organisational flux perspective claim that organisational change is too complex to be viewed in terms of stability and order, i.e. it cannot be analysed through steps and stages alone (Tsoukas and Chia 2002; Clegg *et al.* 2008). For this case, the organisational flux perspective might seem more appropriate, at least when looking at how the change initiative emerged and how it has been dealt with so far. However, no model is a complete version of reality. The organisational flux perspective advocates looking at the individual, but there are important features at the organisational level that affects the participants as a group, for example the lack of home company support. Some authors have also expressed downsides to this perspective, e.g. a lack of structure, which leads to difficulties in connecting the ideas to performance (Burnes 1996 in By 2005). All critics mentioned describe this perspective mostly through negations, indicating a lack of concepts of what it actually is. Altogether, neither stage models nor organisational flux seem to be sufficient to describe the change process at an organisational level.

Operational level

There are many findings verifying what is said in the participation literature. For example, it has been shown that there is broad participation among the SCG members. They also seem to have a strong sense of involvement and they feel comfortable in their work environment. Despite this, opinions differed widely as to if they actually can affect the change process. The following sections will elaborate on this finding through the three concepts found in the participation literature.

Empowerment can be interpreted as a perception of having the competence needed to participate and in this case there seems to be a high degree of empowerment among the members. WG participants reported a strong confidence in their ability to contribute to the process, which goes in line with Kanter's (2008) notion that empowerment fosters confidence. Furthermore, the more influence the participants have, the more committed they become. This is also confirmed by their persistence to speak their minds and their high level of comfort in their groups.

The participants' need for resources was exposed through the survey. Lack of time seems to be a main issue, since it was identified at several occasions and levels. The finding regarding the usefulness and efficiency of SCG's result shows that resources are not only a concern at a present stage but also regarding the future. Also,

insufficient directives can leave participants short of information. Wooddell (2009) concluded that ideal approaches, which participatory change might be viewed as, become impractical when resources are constrained. Therefore, the lack of resources in this case could be argued to impair the members' physical possibility to participate. This in turn might explain the differing view on their ability to influence.

There were several positive findings regarding how the participants have made sense of the change, e.g. most members understand their role and think that their work is meaningful. However, the issue regarding participants' ability to influence could be connected to the findings concerning the gap between the different levels, as discussed above. It could also be connected to the finding that some members do not ask when they feel unsure about their role and assignment. As Rothermel and Lamarsh (2012) argued, these people do not take responsibility for their own understanding. Another issue is the recurring discussions of the meaning of terms and concepts. Even though the majority feels they understand the vision and purpose of SCG, it seems as the more you get into details, the more difficult it becomes to make sense of it. Altogether, these issues might limit the participants' psychological possibility to participate.

LIMITATIONS

As this study is based on an ongoing case, it is only possible to speculate on what effects current activities will have on the final result. If this study would continue, a vital next step would be to examine the implementation of this process to obtain a more complete picture.

The survey, which was the main data source, had a response rate of 55%. Even though representation was tested, non-respondents could disagree with the sample. Therefore, most findings are articulated as indications of the whole populations' view. Also, only the main findings have been presented, leaving out some complementary data that could have facilitated the understanding of the change process.

CONCLUSIONS

The change process described in this paper is not only based on, but also dependent on, extensive participation. Seven workgroups are responsible for this process as well as being an important link between the home companies and the change process organisation. There are many things in place for this change process to become successful, for example a high degree of buy-in and sense of empowerment among the participants. However, several members feel that they cannot fully affect the process, which might be due to challenges at both the organisational and operational level. There appears to be a gap between the Steering Committee and the rest of the organisation. It has also been shown that members do not receive enough support in decreasing their workload from their home companies. Regarding the operational level, a lack of resources is a recurring matter. The low average time invested by the participants could for example be explained by the lack of support at the organisational level. Finally, the understanding of certain aspects of the change seems to be an issue due to the complexity of the process. Altogether, these issues could be argued to reduce the members' possibilities to fully participate.

No model is a complete version of reality. The stage model perspective lacks sufficient complexity to properly describe ongoing change processes such as the one presented in this paper. The organisational flux perspective seems more appropriate, both in terms of how the change initiative emerged and how it has been dealt with so

far. However, this perspective does not have enough structure, which makes it difficult to apply. On top of this, it is usually described through negations and thus circumvents to describe what it actually is. Therefore, future studies need to theorise on this perspective so it becomes applicable, without losing complexity and orientation towards processes.

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PROCUREMENT

UNDERSTANDING EARLY CONTRACTOR INVOLVEMENT (ECI) PROCUREMENT FORMS

Derek H.T. Walker[1] and Beverley Lloyd-Walker[2]

[1] *School of Property Construction and Project Management, RMIT University, Melbourne Victoria, Australia*

[2] *Victoria University, Melbourne, Australia*

It is widely accepted that contractors have much potential valuable advice to offer at the front-end of project development. This concept is sometimes called early contractor involvement (ECI) and encompasses various relationship-based project procurement (RBP) forms. These are currently being globally adopted and adapted and at times this results in misunderstanding of the finer grained nuances between the forms. This often results in participants having unrealistic expectations of team behaviours and relationships between project parties, particularly what is expected of the project manager and lead sponsor accountable for project delivery. Unrealistic expectations may trigger perceived project failure. This lack of understanding of behavioural expectations of ECI form inhibits those who deliver projects from performing to expectation. Clients choosing an ECI project procurement form would benefit from a clearer definition of behavioural expectations. This paper attempts to set a conceptual behavioural framework for ECI that helps us better establish a way of understanding what ECI and RBP procurement forms offer.

Keywords: project alliances, ECI, relationship-based procurement.

INTRODUCTION

Much of the current construction management (CM) literature focuses on the delivery of a project once the design has been developed where the contractor is expected to deliver the project within the 'iron' triangle' constraints of specified time, cost and quality to deliver its fitness for purpose. This can be seen as the 'traditional' perspective. A client/project owner (PO) defines a need that is to be fulfilled through the vehicle of a constructed facility. That stage involves the PO's representative (POR), design consultants and occasionally a construction contractor organisation that may be called upon to provide advice at the front-end of the project.

Many of the standard textbooks describe the project development process in terms of a two or three phase process. Two phases most commonly described are the project definition and design followed by the project delivery phase. Other texts refer to the

[1] derek.walker@rmit.edu.au

[2] *Beverley.LloydWalker@vu.edu.au*

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operation phase where it is important for CM scholars and practitioners to better understand the life cycle nature of the project and where a sustainability emphasis is called for often a further phase of use and retirement or disposal is often identified.

The business project management literature introduces us to a pre-project process where the strategic need for the project is identified and developed (Morris and Jamieson 2004). The front-end of projects are being increasingly focussed upon for generating value through ensuring that the purpose of the project fits strategically with the PO's organisation and that the project is effectively defined and designed often based on scant information (Næss 2009; Williams and Samset 2010). This has led to the development of a number of project procurement forms that introduce the project delivery contractor's expertise and advice much earlier in the project lifecycle that has traditionally been the case in the construction industry. Forms of this early contractor involvement (ECI) where the contractor collaborates with the POR at early project development stages have been experimented with and evolving over many decades. Mosey (2009) discusses ECI extensively in his book, and it becomes clear from that and other literature sources (Masterman 2002; Walker and Rowlinson 2008), that there are a range of terms used for procurement approaches where collaboration and cooperation between the POR, the project design team and the contractor delivering the project feature strongly. There is, however, a great deal of confusion when using these terms as they vary geographically when comparing lean project delivery (for example Ballard 2008) with project alliancing (Jones 2001; Ross 2003) and across time when comparing constructability (Sidwell and Mehertns 1996) with ECI (Mosey 2009). One term seems to morph into another.

It would be useful if a fundamental framework of dimensions describing expected project team behaviours could be developed that provide an improved way of helping us understand what is expected of teams and reasons why one procurement form may be suitably deployed over another. Such a framework could help us better understand similarities and differences with procurement choice labels used around the globe.

This paper presents two contributions to reduce this confusion. The first is a representation of the project lifecycle in which the various forms of ECI can be conceptually visualised and the second is identification of 10 project team behavioural characteristic dimensions that can be used to map the extent to which any project procurement form can accommodate and encourage desired project team behaviours required to meet the project objectives.

The paper is structured in four sections. The next section briefly describes the project lifecycle model. This is followed by a section that briefly explains how the 10 team behavioural dimensions framework was developed and tested and we then present it. We conclude with suggested implications for practice and concluding remarks.

THE PROJECT LIFECYCLE MODEL

One of the subject matter experts interviewed by the team as part of this research made the valid statement about relationship-based procurement that all business transactions involve a relationship. It is just that some relationships are purely transactional and other forms that involve a need for personal understanding between parties. This concurs with MacNeil (1978) who focuses on relevant future contingency contractual implications of contacts, i.e. needing to build in contingency for uncertainty and risk when contracting for future delivery of goods or services. Construction projects are not immediate dispassionate transactions but are contracts

for delivery of an output that may be varied during the delivery process and are based on assumptions, interpretation of often vague specifications and require joint understanding of precisely what the project involves so that a realistic price can be negotiated. MacNeil (1978) describes 'classical contract law' where all these contingencies are well known and well specified. He describes neo-classical law where a mechanism for appropriate adaptations and contract variations can be incorporated into the agreement. His third contract form is relational contract law which sets up the rules of engagement so that there is a less rigid format to allow mutual adjustment and frequent changes in contracted output specifics so that the parties can mutually and jointly achieve the aims without hindrance of a rigid classical or neo-classical contractual relationship. This relational form comprises the suite of project procurement forms known in the construction industry as design and construct (D&C), Management Contracting, and other ECI forms such as project alliancing and public private partnership (PPP) or public financing initiative (PFI) type forms.

Klakegg *et al.* (2010, p38-39) describes a project life cycle based on several sources including the Office of Government Commerce (2007) gateway concept, the Project Management Institute (PMI) guide to their body of knowledge (PMI 2008) and Klakegg's PhD thesis (Klakegg 2010). This has been modified in Figure 1 to illustrate how ECI can be mapped onto three of the identified four project lifecycle phases.

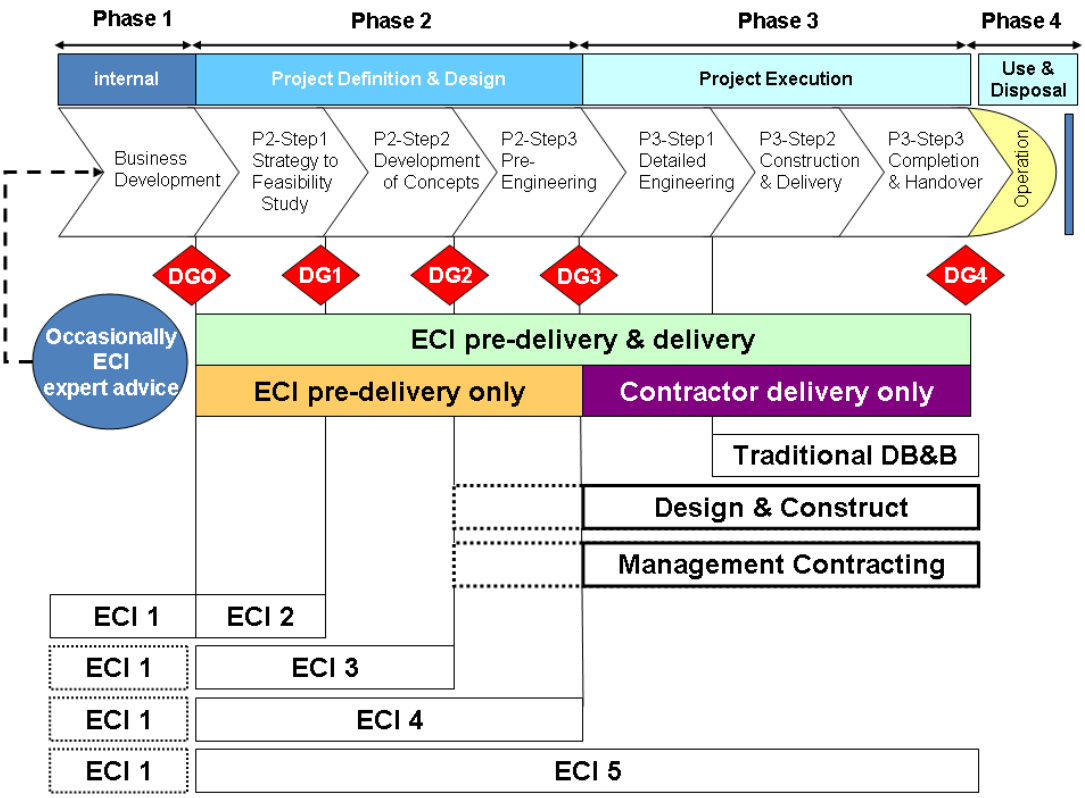

Figure 14 – Project Life CyclePhases: (Adapted from Klakegg et al. 2010, p38-39):

Decision gates: DG0 = formally recognised idea, DG1 = acceptable initiative to investigate, DG2 = choice of concept, DG3 = go/no go, D4 = accept outputs for the operation phase

We take a literal life cycle metaphor because often people talk of a project having a life of its own. Phase 1 represents a strategic idea for a project's changed direction that germinates from an embryonic business development proposal to become an identified potential entity. The embryo of a potential project idea is fertilised by the trigger

mechanism of strategic intent and imperative. A potential project becomes recognised and becomes recognised as being worthy of further development at (DG0).

Phase 2 involves project definition and design. This gestation phase involves three stages with decision gates (DG1, 2 and 3) that represent growing the foetal entity to birth or abortion. Step 1 in Phase 2 develops a fertilised embryonic proposal then tests it for its right to exist. The range of possibilities is narrowed to a generic solution and the feasibility of that form is verified and validated. The general form at DG1 can either continue to develop or be aborted. If it develops into Step 2 then the logical generic form (concept) is further defined to be further tested on its viability and right to exist at DG2. A successfully well developed embryo enters Stage 3 of Phase 2 where it is pre-engineered in readiness for birth at the Phase 3 project execution phase. It is tested for viability at this stage (DG3) and if successful moves to Phase 3.

Phase 3 is the ex-womb growth phase where it goes through three further development stages. Stage 1 is its detailed engineering when all its potential and actual features are hardwired into its maturity trajectory. Stage 2 is where its contact with its environment interacts with its genetic make up and learned responses (construction and delivery) to reveal a productive entity ready to deliver on its programmed potential. In Stage 3 the completed mature outcome is tested for authenticity as a mature and valid product (DG4) and then ‘handed over’ to do what it was designed and programmed to do.

Phase 4, often neglected in project management models, is the transition from potential to actuality by being operationalised. The facility/benefit/change can then ‘bear fruit’. This justifies the project investment and its delivery. When it has outlived its benefit it is disposed of. Contractors tend to have nothing to do with Phase 4.

Figure 1 illustrates procurement forms at Phases 1 to 3. Traditional design, bid build (DB&B) is an option most closely associated with MacNeil's (1978) 'neo-classical contract law' and as he points out due to uncertainty of the future this often leads to high transaction costs of negotiating changed terms and conditions and it leads to the need for a contingency sum to allow for unforeseen cost and time delays. Transaction cost economics (TCE) (Williamson 1979) implies that this can be a serious deficiency in the project delivery process (Winch 2001). The integration of the detailed engineering Stage 1 of Phase 3 is combined with Stages 2 and 3 for the D&C option but with a D&C option usually results in a fixed price/time neo-classical contract but interaction with the POR and client's design team only commences at Stage 1 of Phase 3 and so there is little of no knowledge sharing, collaboration of joint decision making prior to being contracted to deliver the project unless there is some degree of design novation in the D&C (Walker and Hampson 2003b, p16-19). Novated D&C does draw in the pre-engineering stage of Phase 2 with Phase 3. Management contracting is a procurement form where the agent of the POR (the management contractor - MC) is responsible for the project execution and may extend their role to pre-engineering. Under this arrangement the POR collaborates closely with the MC and so there can be greater openness, collaboration knowledge exchange and transparent development and use of a contingency fund (money and time). The MC is paid a fee to manage the packaging, bidding and managing sub-contractor and suppliers to deliver the project (Walker and Hampson 2003b, p19-23).

ECI1 can take place at any or all of Phases 1 to 3. The contractor may have expert advice that cam be useful and accessed for a fee at Phase 1. This may be relevant for highly specialised contractors who can help the PO shape strategy at DG0. In a previous studies we interviewed the chief executive officer of a contractor that

performed this role for pharmaceutical clients who were considering locations for building facilities and needed technical input about country conditions and capacity of sub-contractors as well as highly technical issues where this contractor's tacit knowledge was of vital interest for also undertaking feasibility studies at DG1 in Phase 2 Step 1. More commonly during Phase 2 ECI2 occurs at step 1 and ECI3 at step 2. There may be considerable technical input similar to that just mentioned about the ECI1 example but where advice about the idea feasibility and its development to concept is provided by the contractor at DG1 and/or DG2. There are several forms of this engagement. ECI3 would be involvement and collaboration to the point when a concept solution is tested and ECI4 would involve advice up to the decision to tender (DG3) on a range of procurement forms that could be include DB&B, D&C or MC. The POR may choose at DG3 to engage the contractor (ECI5) on a fee based service or MC basis. The ECI5 form varies from the MC approach in the degree of collaboration and basis for jointly managing risk and uncertainty and the form of incentives adopted as well as the relationship contract arrangements. These could vary from less commitment-integration such as that seen in partnering arrangements or full-blown project alliances. Readers interested in more detail on this aspect should refer to the literature on project alliances (Walker *et al.* 2002; Ross 2003; Davis 2006).

Looking at the project lifecycle from a human metaphor perspective raises interesting issues. The various ECI interventions can be seen as project embryo nurturing and sustenance measures where the project is actively shaped and influenced through access to valuable external resources at the stages so that the best possible outcome at birth is encouraged. The decision gates represent Darwinian test points so that only the fittest project (fitting strategic intent and evolving business/external environment) is allowed to develop. ECI can play a part at the Phase 2 only or at both Phase 2 and 3 or the POR may choose to not access any ECI and simply perform all tasks in Phase 1 and 2 internally or with outsourced design development consultants and then contracting the project execution to a contractor using D&C or MC or DB&B.

This leaves us with quandary of which options to use and on what basis. Clearly, the project context and the availability of skills, knowledge and experience and the attributes that POR-external teams can bring to a project play a part in making this decision about procurement choice. We now offer and explain a framework of 10 behavioural dimensions of a project that influence the optimal procurement choice.

THE PROJECT 10 DIMENSION BEHAVIOURAL FRAMEWORK

We were asked in a previous research study to profile excellence in project managers that had the role of alliance managers (AMs) in delivering projects on a project alliance (PA) form of ECI. This project led us to interview 17 alliance management professionals during 2010 and 2011and our findings from 250+ pages of transcribed interviews were published (Walker and Lloyd-Walker 2011) and presented (Lloyd-Walker and Walker 2011;2012). Reflecting on this and much earlier work on the nature of construction projects (Walker 1995) together with intervening years of studying construction projects led us to propose 10 dimensions that can be used to characterise behavioural attributes of project team members required in response to project procurement choices. These were tested by presenting them to two recognised expert academics published in this area as well as four senior industry experts so that we could gain feedback to refine the framework. This work is in its infancy and so the following can be considered as conceptual but rooted in high quality reflection by the authors and industry and academic subject matter experts. It forms a preliminary stage

in a two year research project on understanding relationship based project procurement undertaken during 2012 and 2013.

The aim of the framework is to guide PORs to more effectively choose a project delivery procurement option that facilitates the required team behaviours to deliver their project. The behavioural framework is based upon a set of assumptions.

- That the PO and POR has an intimate knowledge of the PO organisation's business strategy and context but may need to collaborate with and access knowledge from an experienced contractor at the business development idea DG0 point in Phase 1 of Figure 1.
- That the POR is most likely the best person to lead Phase 2 with close knowledge of, and support from, the PO organisation to guide the development of concepts in Phase 2. However, the POR may have insufficient depth of knowledge of the uncertainty and risks associated with project realisation solutions. The POR will rely on both organisational internal expert advice and external consultant knowledge to bridge the POR's knowledge gaps. As Williams *et al.* (2009) point out, the concept stage is one where there is scant information available and this presents both uncertainty and complexity in foreseeing likely consequences of assumptions being made. In many cases forms of ECI would bridge POR and Figure 1 Phase 2 team's knowledge gaps but that requires collaborative behaviours between the POR and non-owner project team participants (NOPs).
- The project risk literature (Ward 1997;1999; Ward and Chapman 2003) clearly indicates that teams with advanced knowledge and understanding of likely risks and uncertainty should be sourced for complex and complicated projects to identify both a justifiable and realistic contingency for risk and uncertainty. These teams should also plan how to manage that contingency to avoid it being wasted or misused.
- That much of the project complexity issues to be addressed primarily relate to people's behavioural and ability to collaborate rather than purely technical issues. There is a great need for stakeholder engagement on projects these days (Mitchell *et al.* 1997; Das 2005; Holzer 2008). A focus on team interaction is therefore vital. Team members need to understand behavioural expectations.
- It is well known that the PO and POR sophistication is a vital factor in project success (Cherns and Bryant 1984; Latham 1994; Walker 1996;1998).
- Sophisticated POs and PORs and (NOPs) know how to collaborate, communicate and productively and collegially exercise authority to ensure that responsibility and accountability is appropriately allocated.

Based on the above five assumptions we reflected on our past research and the literature to propose the following 10 dimensions of POR and NOP behavioural characteristics measured using a 7 point scale 1 = very low to 7 = very high.

1. Coping with Project Design Instability - extent to which the POR and NOPs cope with design solutions that are ambiguous, incomplete or have conflicting objectives that hinder realistic project delivery bids to be developed and tendered upon that reflecting the PO's prioritised objectives.
2. Coping with Context Complexity - extent to which the project context presents structural, technical, directional, temporal or relational complexity in developing design solutions to deliver the project. Need for taking a range of

perspectives and sensemaking to understand the internal/external and political environment.

3. Embracing Risk and Uncertainty - extent to which the POR and NOPs have the willingness, ability in terms of knowledge, skills, attributes and experience (KSAE) and capacity (institutional support delivered through the procurement approach and governance system adopted) to embrace uncertainty and potential risk/opportunity in developing project design and delivery strategies.
4. Challenging the Status Quo - extent to which the POR and NOPs have the willingness, ability (in terms of KSAE) and capacity (institutional support delivered through the procurement approach and governance system adopted) to embrace an open-mind in interpreting and re-interpreting the project brief.
5. Balanced Performance Value Position - extent to which the POR is willing and able to clarify what benefits the project vision and aims are required to deliver in both tangible and intangible value performance terms.
6. Ensuring Mutual Trust - extent to which the POR and NOPs are willing and able to develop and maintain trust in each other to deliver agreed project performance outcomes as being the prime and overarching priority.
7. Commitment to Best-for-Project Orientation - extent to which the POR and NOPs structure contractual arrangements towards a best-for-project outcome and avoid opportunistic advantage seeking behaviour.
8. Commitment to Consensus-Based Decision Making - extent to which the POR and NOPs have the willingness, ability and capacity to work collaboratively and make strategic and major project delivery decisions that all parties take equal responsibility for in committing to engender a no-blame project culture.
9. Commitment to Knowledge and Ideas Sharing - extent to which the POR and NOPs have the willingness, ability and capacity to raise and discuss ideas and to share knowledge about project design and delivery issues to deliver best-for-project process or product innovation.
10. Commitment to an Integrated Organisational Structure - extent to which the POR and NOPs develop organisational structure/procedures to lead and manage the project through an integrated POR/NOP mechanism binding POR and NOPs into a coherent collaborative structure (both physical and virtual).

CONCLUSIONS AND IMPLICATIONS FOR PRACTICE

How can the framework and Figure 1 model be fruitfully used in practice? We suggest that Figure 1 is useful in helping project initiators visualise how ECI can be more extensively used than is presently used to access valuable practical knowledge about project solution options, their feasibility and the direction in designing a solution that can be effectively executed. ECI1 can be called upon where the client needs specific delivery subject matter expertise when developing project ideas. This can be valid for example for an oil and gas exploration company working with experts in building drilling platforms or developing on-shore exploration or exploitation opportunities. A real estate developer contemplating a new suburb or a mixed-use office, residential, and hotel complex may avail itself of ECI1 services to scope planning, market conditions and/or technical delivery matters.

ECI2 services may be called upon for specific benchmarking and independent advice during the project definition and design Phase 2 stages 1 as illustrated in Figure 1 where the PO/POR needs to assess the project idea's feasibility. ECI3 services can be used when the POR intends to leave convergent decision making about concept options open and independent of the ECI entity. ECI4 could apply where the client

wishes pre-engineering input and advice perhaps on buildability issues as is the case with MC services that include both buildability advice but also value engineering and value analysis (Thiry 1997; McGeorge and Palmer 2002; Male *et al.* 2007). ECI3, 4 or 5 services can be accessed when a full alliance type arrangement is envisaged that stretches from project definition through to project execution.

Project alliancing is a contract form in which the POR engages with NOPs including the contractor in an integrated organisation through a three limbed contract (Ross 2003). One limb defines the basis for cost reimbursement for direct on-site management expenses as well as payment of subcontracts and supplier delivery project costs. Another limb comprises the commercial contract for the NOPs agreeing fees, accountability and performance including determining the level of painsharing and gainsharing incentivisation and the target outturn costs (TOC), target delivery time and other key performance measures to achieve project objectives and outcome aims. The final limb defines a behavioural contract that governs the relationship between project delivery parties. This alliancing approach has become highly popular in Australia (Wood and Duffield 2009; Mills and Harley 2010) but it does require specific collaborative behavioural competences of all parties that need to be present for the relationship contract to be effective (Walker and Lloyd-Walker 2011).

The degree of integration of project team (POR and NOPs) of these organisation's commitment to a best-for-project versus a home-base performance primacy in part determines whether the ECI for is an alliance or another form of embedding the contractor into project strategy, design and delivery decision making with the POR. Another important distinguishing feature is the extent to which consensus amongst the POR and NOPs drives a sink-or-swim together mentality which results in a no-litigation contract clause in alliances (the only exception being for criminal activity or mal intent) (Walker *et al.* 2002). Lesser forms of ECI collaboration include various forms of partnering where the level of mutual commitment may be enshrined in a partnering charter but does not extend to a sink-or-swim together linkage of all parties sharing pain or gain (Walker and Hampson 2003a).

The 10 Dimensional Behavioural Framework provides a way of mapping the level of ability of the POR and NOPs to collaborate to solve the variety of complex problems and issues facing project alliances. Contractors can bring valuable risk and uncertainty management expertise, opportunities for innovation in project delivery and a sound reality check. There is a danger that contractors in an ECI relationship can take advantage of the POR and other NOPs and it is for this reason that Project Alliances uses painshare gainshare incentivisation arrangements based on joint-and-several POR/NOPs responsibility and accountability for project. A weaker relational procurement approach is partnering but while it aspires to many of the 10 behavioural framework values at the 'high' level, project teams often maintain a high priority for their home base organisation's interests over the project interest. The 10 behavioural framework could be useful in visualising behavioural expectations of all parties, POR and NOPs as well as forming the basis for a behavioural measurement tool.

This paper presents nascent results from a two year research project on understanding relationship-based procurement. The framework has been pilot tested using subject matter experts and draws upon complete studies and thus uses a meta-study approach to consolidate and refine findings on ECI research. Figure 1 and the 10 behaviours framework make a contribution toward clarity in understanding ECI and RBP.

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A PROCESS ACCOUNT OF CONSTRUCTION MEDIATION

Julian Sidoli del Ceno

Birmingham School of the Built Environment, Millennium Point, Birmingham, B4 7SG

This paper seeks to argue that construction mediation has hitherto been viewed and evaluated in a relatively narrow fashion. It suggests that whilst there are numerous and well-known benefits to the process, although these are not always accepted by all academics or practitioners, in such things as the speed of the potential settlement and lower cost implications there are other valuable benefits, benefits that tend not to be considered but have real value. The central claim is that construction mediation has the potential to become a transformative process. It argues that greater emphasis ought to be placed on the 'process' of dispute resolution and the attendant benefits that can result in the construction professional undergoing a developmental and maturing experience through engagement with mediation. These benefits ought to be then considered alongside other, more traditional accounts, of the strengths and weaknesses of mediation. The argument will be developed through reference to currently recognised models of mediation. It will conclude that through the use of mediation in dispute resolution the construction professional can develop both a range of important attributes such as more developed communication skills as well as important mental and social attitudes that can engender empowerment and may serve as an aid to cultural change in the industry.

Keywords: mediation, education, professional practice, transformation.

INTRODUCTION

This paper seeks to argue that mediation has been hitherto conceived in the construction industry, and indeed by practitioners in other related disciplines, as largely a 'problem-solving' mechanism. Mediation for many seems to exist only in opposition to litigation and other forms of adjudicative dispute resolution rather than being conceived and evaluated on its own terms. Whilst settlement is clearly an aim of mediation there is also the danger that the value of mediation is conceived in these terms alone. If this is the case, then its value, or 'success,' is conceived very narrowly. The aim of this paper is, then, to argue that there are wider values to mediation in a construction setting. These values can be considered as a 'group' of related attitudes, skills and perceptions that can positively affect the persons and organisations involved. By affecting growth in individuals an organisational change may follow. This, in turn, can result in a significant 'cultural' change in the industry itself, and associated professions, as a whole as well as having a positive impact on construction education. The paper begins by an overview of the development of mediation and proceeds to consider its current use of mediation in construction. It then considers the

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question of how mediation success is conceived. The paper argues that both the current practice of construction mediation and the way in which its success is measured are too narrow. It argues instead that a wider understanding of mediation is required, one that shows awareness of the wider range of benefits and values that mediation enshrines.

CONSTRUCTION MEDIATION: A BRIEF 'HISTORY'

Some attempts at outlining the history of ADR go back a matter of merely a couple of decades. This, however, presupposes a narrow conception of ADR firmly rooted in Western, indeed largely anglo-american assumptions. A more historical view is taken by Roebuck (2012) who in a number of works has examined different types of ADR in various phases of largely western European history. This awareness of non-western approaches to ADR has been the focus of the work of a number of scholars. Nader is particularly significant in this regard and her work has been widely discussed and cited. Other academics have focussed more particularly on one specific cultural or ethnic view of ADR. Goh (2002), focussing on China, argues that there is strong resistance to litigation in Chinese culture originating from Confucian teachings. Correspondingly, there is a very strong emphasis on settling disputes outside the structure of the courts. Whilst a rather more narrow account of the subject's history predominates among the majority of scholars Menkel-Meadow (2000) however sees a large variety of sources as she seeks to trace the intellectual foundations of ADR.

British 'historical' accounts of ADR are more limited in scope and tend to not look far beyond the Latham Report (1996) and Lord Woolf's Access to Justice Report (1996) although occasionally ventures into the 1970s are made. The story in the United Kingdom can largely be read as a narrative concerning the gentle but continuous encouragement of ADR in general and mediation by policy-makers and the judiciary from Woolf, for example, through to the recent reports by Lord Justice Jackson, Review of Civil Litigation Costs Review (2010) in England and Wales and Lord Gill (2010) in Scotland. In both these latter reports there was an emphasis on the efficacy of mediation as a speedy, cost-effective method of resolving disputes. Alternative dispute resolution has in its broadest in the guise of arbitration has been important to the construction industry since at least the 19th century. However, many have questioned whether, in fact, arbitration has become in recent times 'litigation without the wigs' (Speiaght and Stone 2004) due to its increasingly adversarial approach and its similarity to traditional litigation with its attendant cost implications (Latham 1993, Uff (2009). In the UK, despite this discontent there was little evidence of the widespread use of mediation in a number of studies from the 1990s (Gould and Cohen 1998; Brooker and Lavers 1997, 2000). A factor in this may have been the increasing use of statutory adjudication following its introduction in the Housing Grants, Construction and Regeneration Act 1996 following the recommendations by Latham (1994). There is evidence that there has, though, been some growth over the past decade or so possibly encouraged by a number of well-documented cases such as Halsey v Milton Keynes in the light of the implantation of the Civil Procedure Rules in 1998. Brooker (2010:164) suggests that "between 170 and 300 construction mediations [are] taking place annually." Thus, whilst still small this is not a negligible figure. A recent study, however, by Gould *et al.* (2009) suggests that construction mediation may actually be more prevalent than was previously supposed. With there being a lack of any overarching reporting mechanism then the precise numbers of construction mediations can then only be estimated. Mediation clauses can now be inserted into a number of standard form contracts. The JCT Design and Build 2005

(section 9) specifically mentions the option of mediation whilst the ICE Conditions of Contract 2004 (clause 66) has the option of 'amicable resolution' (i.e. mediation) alongside adjudication and arbitration.

MEDIATION IN PRACTICE: ADVANTAGES AND CONCERNS

There are a number of well-documented reasons for the gradual increase in the popularity of mediation. A number of authors have noted the particular strengths of mediation over traditional litigation. For instance, Brett *et al.* (1996) noted the speed and cost savings in relation to both arbitration and litigation. The privacy of mediation, so useful in commercial settings, is also another important benefit although this, of course, also applies to other forms of alternative dispute resolution (Blake *et al.* 2010). Mediation may also bring particular benefits to disputes where there is an on-going relationship to preserve: this is often characterised as being largely the preserve of family or domestic relationships, however, many commercial relationships, from landlord and tenant to employment disputes benefit from the preservation and enhancement of ongoing relationships and construction is no different in this respect (Kurtzberg and Henikoff 1997; Lowenstein 2000; Ezzel 2001). Feinberg (1996) notes its informality and flexibility. This flexibility, which could be termed creativity, is described by Boulle and Nesic (2001):

"...Parties may agree on outcomes which could never be available as a court remedy. Thus they may agree upon one party performing a personal service for another, on a dismissed employee being re-employed in another branch of the firm, or on one party giving the other an employment reference." (p.40)

Further, a number of studies have reported high levels of user satisfaction with mediation in a number of different areas of dispute (Guthrie and Levin 1998, Wissler 2004). Whilst these benefits are not universally applicable to all construction disputes there appears to be at least the potential for mediation to be a valuable dispute resolution tool in some construction disputes and therefore a prima facie case for its validity as a method of construction dispute resolution has been made.

Clearly, whilst there are many advantages there are others who have sounded a cautionary note. Many of these objections are based around the role of lawyers and other professional advisors in regard to mediation. Genn (2005), for example, noted that some lawyers use their litigation skills in mediation. This can result in an inherently litigious and adversarial approach and one more akin to arbitration. Brooker and Lavers (2005) found that:

"Lawyer interviewees also report tactical advantages from engaging in mediation. These range from providing the opportunity to examine the strengths and weaknesses of the case to testing witnesses and evidence. The data suggests that lawyers are developing new practices in mediation, such as proposing the process in order to provide proof to the courts of willingness to compromise or participating in mediation in order to send messages to the opposition." (pg 161)

A number of concerns were found by Sidoli del Ceno (2010) in a study of commercial lawyers including those who engaged in construction work. The respondents' perception that mediation was not 'real law' was noted as was the fact that the designation 'mediator' lacked status in comparison with 'solicitor' or 'barrister.' Further, there was ignorance of the possibilities of mediation and a feeling that traditional legal culture which emphasised the virtues of conflict and litigation were

additional factors that discouraged many from recommending the process and hence may hinder mediation's future growth and development.

MODELS OF MEDIATION

There are a number of differing conceptual models of mediation. Indeed, mapping the conceptual ground of mediation appears to be very much a work in progress as there appears to be is no agreed schema. For example, Menkel-Meadow (1995) derives eight models of mediation from existing literature whilst Boulle (2005) recognises four models and Alexander (2008) describes six 'meta-models'. In jurisdictions where construction mediation is in its infancy a facilitative model tends to be favoured whereas those with a longer history of construction mediation (the UK and Australia are cited as examples) an evaluative model is often although not exclusively adopted (Brooker and Wilkinson, 2010: 193). Riskin (1996) describes the facilitative approach:

"The mediator who facilitates assumes that the parties are intelligent, able to work with their counterparts, and capable of understanding their situations better than the mediator and, perhaps, better than their lawyers. Accordingly, the parties can develop better solutions than any the mediator might create. Thus, the facilitative mediator assumes that his principal mission is to clarify and to enhance communication between the parties in order to help them decide what to do." (P.24)

Facilitative mediation, then, fits the description provided by Menkel-Meadow (1993) as "pure" mediation in that there is no adjudicative direction of any kind or any assumption of substantive expertise by the mediator. This can be contrasted with evaluative mediation. Brown (2003) states that:

"The evaluative mediator's tasks include finding facts by properly weighing evidence, judging creditability and allocating burden of proof, determining and applying relevant law, rules or customs and rendering an opinion." (p.290)

Both these predominant models appear to implicitly depend on an 'outcome' being achieved. They can therefore, perhaps, be labelled as 'pragmatic' forms of mediation. The outcome is either the final settlement of the dispute or, at the very least, a partial settlement through a narrowing of the issues. Both of these models fail to consider, or at least, appear to ignore other strengths or possible advantages of mediation. Other models, which can be termed 'idealist,' attempt to move away from this. Transformative mediation is one widely recognised approach that seeks to emphasise the value of the process itself and which distances itself from the rather narrow results driven conceptions discussed above:

"The transformative approach instead defines the objective as improving the parties themselves from what they were before. In transformative mediation, success is achieved when the parties as persons are changed for the better, to some degree, by what has occurred in the mediation process." (Bush and Folger 1994: 84)

An understanding of these models, their premises and what they seek to achieve is central to the issue of what constitutes mediation success. The two issues are, in fact, closely entwined.

MEDIATION AND SUCCESS – A CONTESTED NOTION

Success in mediation success is usually considered on a 'pragmatic' or 'outcome' model. Fisher and Ury (1981) which focuses on negotiated outcomes is an example of

this approach. This pragmatic model is typically based around the number of cases that 'settle.' This view is also exemplified in numerous empirical studies. It appears that the 'fact' of settlement is considered to be central in most cases rather than any perceived qualitative aspect to the settlement itself. For example, Prince (2004) in a study of court-based mediation at Exeter County Court found that 70% of cases referred to the small-claims track in her study settled. This implicitly focuses the 'success' of mediation in terms of the rates of settlement although Prince does later raise other criteria and importantly notes that "there is not an obvious correlation between settlement and satisfaction." (p76). Wissler (2004) in a survey that examined ten separate small claims mediation studies found again that "virtually all studies examined the rate of settlement in mediation." However, other aspects were also examined. For instance, a number of studies sought to explore the impact on the parties' relationships with each other. Further, many studies surveyed sought to consider the views and perspectives of the parties themselves. It is this aspect of mediation 'success' and the wider value or values that emerge from it that is perhaps the most enigmatic and hence the hardest to assess.

Importantly, Shepherd (1984) divides the concept of mediation success into two aspects – process and outcome. Clearly, it is the latter that has been the focus of most mainstream empirical studies which has understandably led to the process aspect being somewhat under-considered. Furthermore, it is this outcome based approach with what can be termed its 'concrete' aspect of whether an agreement has been made or not that has come to dominate judicial thinking as was noted above. This fundamental assumption that outcome or settlement is the only driver of mediation has also been the basis of many fundamental critiques of mediation as noted earlier. It is perhaps reasonable to agree with Bercovitch (2007) in a study of mediation success where he concludes:

"Success in conflict management is an elusive quest. Often what appears as successful to one person may be seen as unsuccessful by others. What is more, mediation may seem successful at one time, only to be seen as totally unsuccessful months or years later. We face considerable challenges in thinking about success or evaluating mediation outcomes. As suggested above, there are different perspectives of thinking about success. It seems odd that so many of these perspectives define success in terms of some other equally complex abstract notion. The challenge we face is in recognizing the multiplicity of perspectives, and the different conceptions of, and approaches to, success." (Pg 301)

It is this process-centred perspective that will now developed within the construction context. It will aim to demonstrate that mediation success, which has been largely been conceived hitherto either as something that focuses on measuring rates of settlement or as something concerned almost solely with personal growth, can actually be considered from both perspectives and that there therefore exists a false dichotomy between 'pragmatic' and 'transformative' models of mediation.

MEDIATION AS PROCESS

The argument then has attempted to show that the two most widely used 'pragmatic' models of mediation in construction, the facilitative and the evaluative, are both fundamentally outcome or settlement based. These approaches largely ignore the process aspect alluded to above (Shepherd 1984). Whilst outcome and settlement are clearly goals of mediation it can be argued that mediation to be properly considered and utilised as a tool for dispute resolution in construction ought to be conceived more

widely. This emphasis on process and on the long-term benefits that can ensue from engaging in a non-confrontational and empowering process ought to be given more consideration by both scholars and construction professionals. The wider benefits that can emerge from the process of mediation have largely not been noted in relation to the field of construction or where they have they have been they have been dismissed (Oberman 2005) although they have been greeted with approval by many in other areas of dispute most notably in the context of domestic mediation.

Brooker and Wilkinson (2010:11) argue that transformative and therapeutic mediation "are unlikely to be used extensively in construction mediation" although they concede that "some mediators may adopt some of the techniques within their practice." The argument appears to be that for these more substantial changes in attitude to take place then more sessions of mediation over a greater time-frame are required and that these are unlikely to take place in a pressured commercial scenario when time is of the essence (Waldman 1998). If one assumes that these methods and processes are mutually exclusive then that may be the case. However, there is little to suggest that a facilitative approach which keeps outcomes as a central focus need ignore the value of the actual process. There is no reason why then they must be seen in opposition. Indeed, by giving greater emphasis to this process aspect, and the wider values that they enshrine, an increase in the actual rate of settlement may ensue as participants gain greater understanding of the issues, drivers and motivations of others (Bush and Pope 2002).

Whilst it is easy to agree that there are at least two parts to mediation – process and settlement – there is perhaps really a third. This can be termed 'post-settlement' factors. It is what is taken away from the mediation as a whole including both the process and the outcome. Another model is not being offered however nor is an appeal to the active adoption of an 'idealist' model. It is, instead, an argument that mediation properly conceived as facilitative mediation carries with it - implicitly - the wider values argued for by scholars such as Bush and Folger (1994) and Daicoff (2006). Greater emphasis ought then to be given to understanding, assessing and quantifying these 'further' benefits of mediation and giving them a more concrete identity rather than dwelling on the potentially abstract notions of 'transformation' or 'therapeutic jurisprudence'. Bush and Folger are aware of this criticism of abstraction but their attempt to move beyond it nonetheless remains substantially wedded to jurisprudential notions of 'empowerment' and 'recognition' rather than overtly practical goals that can apply directly to commercial concerns. It is perhaps better, then, to use the term 'developmental' as this term is more accessible to those not versed in philosophy or jurisprudence. Further, it carries with it the notion of continuous learning that is widely understood and supported by professional bodies. Mediation has the capacity, then, to provide an opportunity for the construction professional to learn and to grow. These are values that are innate but also can provide clear, practical benefits that can be added to the already well-established benefits of mediation as discussed earlier. These benefits, their scope and quantification is a separate task but in order to initiate the discussion some brief examples will be offered.

Communication

Communication is considered to be an important attribute and, indeed, a central value in construction management (Dainty *et al.* 2006). There are many issues inherent within a construction context that make effective communication particularly problematic, for example, the uniqueness of each construction project and the

intensity and short time-scales involved in many contracts, (Loosemore *et al.* 2003). There is also the possibility for misunderstanding because of different 'vocabularies' (Delisle and Olson 2004) and issues of cultural preferences appears to be widely noted (Muller and Turner 2004). This is set only to increase in the light of increasing internationalisation. Mediation is a communicative process first and foremost. By engaging with the process of mediation construction professionals may develop better, more nuanced communication skills which in turn can lead to wider personal development.

Personal and professional development

Mediation also typically involves reflection not just upon the dispute itself but also related issues that may have had a causal link to the dispute. Things such as record keeping, the handling of professional relationships and an awareness of the perspectives of others are matters that may be relevant to the dispute but are also of general relevance to a construction manager. Engaging with the process of mediation may allow the reflective professional to engage with many of these issues and may aid the development of important mental and social attitudes that create for mutually empowered and productive relationships. Education is key to fostering this.

Construction education

Construction Education necessarily involves the transferring of knowledge and the acquisition of practical skills (Senior 1998). Beyond the level of basic trade training however there is a widespread belief that construction education ought to encourage a variety of other skills. Ahn *et al.* (2010) are among many that have attempted to categorise the various elements required in a graduate level construction programme. They include leadership, problem-solving, collaborative skills, ethical issues amongst others. Many if not all undergraduate and postgraduate students study law as an element of their course. Litigiousness and procedure predominate. Mediation properly integrated into construction education has the possibility of changing the value set of construction managers. A widespread adoption of such values may subsequently contribute to wider cultural change within the industry.

Cultural change

The value of changing cultural norms and the varieties of ways in which this happens has been noted by, among others, Meyerson and Martin (1987). Mediation because of its strong emphasis on communication and on understanding the perspective of other party is ideally placed to help foster such change. The value of partnership and co-operation in construction has already been recognised by a number of authors (McDermott *et al.* 2005). With the construction industry having already changed significantly over recent decades (Greed 1997) and with more change likely mediation might also have a formative role in this by fostering a collaborative approach to dispute resolution and professional practice generally. Mediation might have a particularly important role in the growth of building information modelling (BIM) where there is inherently a shared reserve of 'knowledge' or 'activity'. Possible legal problems with BIM have already been identified (Arensman and Ozbek 2012). Further, this collaborative and non-litigious approach might appeal particularly to women and other unrepresented groups (Gilligan 1998, Alberstein 2009). Change here should be considered as more than merely individual or organisational change. Rather it is a cultural transformation of the industry as a whole.

CONCLUSION

Society tends to have a settled view that the 'Law' in all cases is about, or ought to be about, 'justice'. Justice tends to be conceived as an unchanging, pyramidal structure with the judge or arbitrator delivering a top-down judgment with the parties being no more than bystanders to the process. This view of justice is not by any means the only one. Mediation, for example, works on a different paradigm:

"In mediation, justice can be understood as the justice that the parties themselves experience, articulate, and embody in their resolution of dispute" (Rock, 2006, 347)

If this account is accepted, at least in part, then this ought to open the gates to a consideration of mediation from the point of view of its process. The process of mediation, separated conceptually from any outcome or settlement that it might achieve, allows for individual professional development, organisational development and industry change. Those active in construction education might wish to reflect on this fully and consider how it might influence their practice. Finally, it can be argued that modern 'rights' discourse that feeds the insatiable growth of litigation has gone too far. We must try to address this by creating the necessary foundations for achieving a wider cultural change away from perennial conflict and towards a more conciliatory view of human interaction. On a mercenary note, profitability is likely to be increased by just such a move.

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A PRELIMINARY METHOD OF CLASSIFYING COLLABORATIVE CONTRACTUAL BEHAVIOUR IN HIGHER EDUCATION CONSTRUCTION PROJECTS

Paul Crowe[1] and Chris Fortune [2]

School of Built Environment, University of Salford, 4th Floor, Maxwell Building, The Crescent, Salford, Greater Manchester, M5 4WT, UK

The Browne review combined with the current economic conditions has provided a catalyst for change in the funding arrangement, for the higher education sector in the United Kingdom (UK). Consequently, Institutions will place a greater focus on their supply chain to offer services that best fit their requirements, during the construction and refurbishment of their physical assets. The construction industry will need to offer innovation, value for money and other benefits associated with the collaborative procurement movement, which has been gathering pace since the 1990s. This has resulted in the insertion of a multitude of collaborative features into construction contracts. Literature explored in the paper relates to collaboration and its associated contractual procedures. Reflective practice in the higher education estates and property sector relates the literature to real life experience of primary supplier side stakeholders. The research uses a postmodern philosophical paradigm that expands the existing knowledge base using an inductive approach; and a case study strategy with its foundations in an ethnographic study of lived experiences over a cross sectional time horizon. The data source comprises of three interviews with senior management that have independent viewpoints of the same socially constructed artefact. The data's narrative identifies mixed perceptions when it comes to contractual mechanisms achieving their desired benefits. The deliverable of the research is a preliminary method to classify and select contractual mechanisms based on three-dimensional reasoning in relation to risk, motivation and implementation. The value of the research is in the method it provides, which will facilitate further research into the perceived appropriateness of contractual procedures.

Keywords: collaboration, procurement, contracts.

INTRODUCTION

The Bank of England (2012) has seen reduced confidence levels in UK investment between 2007 and 2011. The reduced confidence has fuelled the UK's Coalition Government to undertake reforms in the way it funds the Higher Education (HE) sector in light of Lord Browne's review. The quality of the overall deliverable of the UK's HE sector has international, economic and social implications. Economic implications include issues in relation to job creation, additional tax receipts and

[1] p.crowe@edu.salford.ac.uk

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development of industry through research (OECD 2011). Social implications include issues in relation to empowering people by developing their skills and the provision of a skilled workforce. The knowledge transfer provided by the HE sector is also significant in the way it makes people feel in themselves, for example, it can improve life situations through personal development and research. If the UK is to remain one of the international leaders of higher education provision then its supply chain will need to offer services that best fit its overall deliverable in relation to the construction and refurbishment of its physical assets. There are reports published in the 1990s (Latham 1994; Egan 1998), which identify that collaborative behaviour was lacking in construction, which hindered its performance in relation to client expectations. There have been numerous contractual mechanisms developed to promote collaborative behaviour. The deliverable of the research is a preliminary method to classify and select contractual mechanisms, for the purposes of achieving the objectives of the HE property and estates sector, during the procurement of services relating to the construction and/or refurbishment of their capital assets. There is no attempt in the research to offer scientific generalisation of its results.

CONTEXTUAL INFORMATION

Risk Rational

Research that reviews the benefits of the collaborative procurement agenda in the 1990s includes that by Bresnen and Marshall (2000), which explores information flow, communication and decision-making. Chan *et al.* (2003) undertook a quantitative exploration of perceived benefits using an interpretive epistemological paradigm into collaboration, otherwise known as partnering. The study started out by identifying thirteen trends in twenty-nine sources of literature published between 1990 and 2002. The literature was then related to partnering projects in Hong Kong using seventy seven interviews, which reviewed the perceived benefits on a five point likert scale (1 = Strongly Disagree and 5 = Strongly Agree). During the interview process, the benefits associated to risk mitigation and management expanded to a broader spectrum of twenty-four statements. The mean rating for all respondents for the benefits fell between 2.91- 4.03 and the standard deviations between 0.62 - 1.11, which suggests that there was not a strong consensus among the interviewed practitioners of the perceived benefits claimed in the literature.

Implementation

In the executive summary of 'Constructing the Team', (Latham 1994: vii) there are recommendations for change in the UK Construction industry, which have achieved mixed levels of perceived success over the last 18 years. One recommendation is that best practice should start with clients that come together in forums. Bakker, *et al.* (2008) explores collaboration at a strategic client level when triangulating 33 explorative interviews that collected empirical data. The data triangulates itself with literature and government agency reports published in the UK. The reports include that by the 'Office of the Deputy Prime Minister', 'Beecham', the 'Audit Commission', and the 'NHS Purchasing and Supply Agency'. The forms of collaboration between client organisations included professional networks, lead buying, shared services, piggy backing, third party advisory, third party purchasing, and third party outsourcing. There was a limited attempt to link the data back to practitioners' perceptions of their lived experience, and as such, it is difficult to ascertain the perceived success of the forums. Successes in the recommendations can however be seen, for example, in the popularity of adjudication and the incorporation of Co-

ordinated Project Information (CPI) into contracts (JCT 2011a), through a standard methods of measurement (RICS 2000). The CPI ethos is now progressing into Building Information Modelling (BIM) with the support of Paul Morrell the Governments Chief Construction Advisor.

Following the publication of 'Constructing the Team', came 'Rethinking Construction' (Egan 1998), that proposed the collaborative movement move away from contractual behaviour towards a paradigm more similar to that found in the car industry of partnering and performance management. In response to 'Rethinking Construction', the Joint Contracts Tribunal (JCT) indicated by the RICS' 2007 Contracts in Use Survey, as being a key player in the publication of construction contracts in the UK, released Practice Note 4 as its first document to refer to partnering (JCT 2001: 1). The document identified three prescriptive ways to promote collaborative behaviour and the development of soft sills. Garrett (2005: 15) refers to soft skills as including integrity/trust, verbal and non-verbal communication, leadership interpersonal relations. The JCT's first and preferred way (in 2001) involved the use of a non-binding charter separate from the main contract. The non-binding charter included a series of statements to promote collaborative behaviour including acting: in good faith; in an open and trusting manner; in a cooperative manner and in a way to avoid disputes by adopting a no blame culture; fairly towards each other; and in a way that values skills while respecting each other's responsibilities. The non-binding charter signified limited integration of collaborative contractual mechanisms in binding contracts. A recommendation from 'Rethinking Construction' considered in the charter is the use of performance indicators.

The second way identified by the JCT included the use of a binding charter with an adapted form at project or at strategic level, for example a framework. The 2011 suite, of the JCT's contracts includes a framework agreement with such collaborative features as a communication protocol, sustainable development, value engineering, change control, early warning and team approach to problem solving. The third way identified by the JCT is a specifically drafted agreement/contract. The contract recommended by 'Constructing the Team' was that published by NEC. The contract contains mechanisms to promote proactive collaborative behaviour in line with the recommendations, for example, its use of easily comprehensible language, proactive approach to change and express provisions for payment. The contract does not comply with all the recommendations, for example risk allocation decided at project level and separation of the role of project manager from the client's representative. With Lloyd, a former judge of the UK Technology and Construction Court identifying NEC's project manager as having a primary appointment to look after the employer's interest (NEC 2009).

There is an evident paradigm shift in construction procurement, towards collaborative behaviour in binding agreements (RICS 2007). For example, the RICS 2007 survey indicates an increased use of procurement systems that promote supply chain integration into design; and an emergence of contracts associated with collaborative behaviour. The JCT further moved towards contractual collaborative behaviour by simplifying the format of its contracts in 2005 (Davison 2006); publishing its Constructing Excellence Contract in 2006; and in 2009 incorporating tools associated with collaborative behaviour into the Standard Form of Contract, as supplemental provisions. The incorporation of contractual tools associated with management promotes a shift in practice towards contractual behaviour.

Motivation

Winstead *et al.* (2009) identifies that in business management there is not only a requirement for technical explicit knowledge, but also for the soft skills more related to tacit knowledge and associated with communication, teambuilding and leadership. There is clear evidence that the need for soft skills exist in construction contracts, to align behaviour in practitioners to achieve clients' deliverables. It was found when Cicmil and Marshall (2005) explored two-stage tendering, that collaborative procedures can be insufficient to ensure team integration and further research should be undertaken on the procedure as a social object. This indicates that motivation for human behaviour, in instances, is something different from a contractual procedure.

Maslow (1970) identifies a basic need hierarchy that starts at 'physiological' and works its way to 'safety', 'belongingness and love' and 'esteem' and finally ending up at 'self-actualisation'. Once there is a degree of satisfaction at one level of needs in the hierarchy, the organism (or practitioner) focuses on the next level (Maslow 1970: 17). Contractual mechanisms can result in practitioners achieving different degrees of satisfaction and as such be positioned at different levels within the hierarchy. For example, contractual mechanisms that promote conflict can inhibit needs associated with esteem, in relation to confidence and respect. This restricts the practitioner from providing the benefits achieved through self-actualisation, including those associated with morality, spontaneity and acceptance of facts. Failure to accept facts will cause disputes. More seriously, contract mechanisms can cause practitioners not to achieve safety and physiological needs. For example, the allocation of risk items that are outside the control of the practitioner may cause the failure to achieve safety needs in relation to employment. Should such risk items be located even lower in the needs hierarchy then it may cause failure to achieve physiological needs in respect of health.

RESEARCH METHODS

The research for this paper was undertaken using an interpretive methodological stance similar to the postmodern movement and the work of Lyotard (as Seidman 2008: 163-166), to understand the motivation in the application of explicit and tacit knowledge during the execution of practice. The research reviews the current phenomenon of collaboration and its aim is to turn relevant tacit knowledge, into explicit knowledge, in a similar manner to Kolb's four-stage cycle as explored by Sheehan and Kearns (1995: 10). The research does not go as far as implementing the knowledge in practice. Participants have concrete experience in that they were each a key decision maker, within supplying organisations, to higher education property and estates departments. The reason for selecting key decision makers was to facilitate a high-level discussion, of the phenomenon in the light of the broad spectrum of deliverables, expected from a manager in the context of their business organisation.

The case studies explored, are the employer organisations of the participant practitioners. Key characteristics of the three participants providing the data are: (MC1) director, contractor, national organisation with an international parent company; (PM1) director, project manager, national consultancy; and (MC2) director, contractor, small to medium enterprise with less than 250 employees. Participants interviewed provided an ethnographic understanding of reflective observations of their lived experience. The interviews had minimal structure so that participants were able to reveal their tacit knowledge in the subject area. Practitioners had the option to explore collaboration around two diagrams of potential collaborative strategies (with 11 strands) and potential collaborative tools (with 10 strands) that they were provided

with and which were developed from the initial literature review. Although given the option the participants did not reject the networks set out in the diagrams, instead they chose to rank the significance of them and make minor amendments. All three participants ranked in relation to their aspirations, collaborative strategies as more important than collaborative tools. The data were inductive and qualitative in nature and offered a cross-sectional time horizon taken between December 2011 and January 2012.

DISCUSSION OF DATA

During data collection, different perceptions regarding the usefulness of collaborative strategies and tools were evident, between data sources and at different points of interviews with the same data source. Three themes from the interviews indicated a three dimensional approach to the selection of collaborative tools and strategies. The themes are risk rational, implementation and motivation.

Risk Rational

MC1 indicated that a project undertaken in a collaborative and less adversarial manner tends to finish on time, to a better quality, with a more satisfied client and practitioners happier in their job. With PM1 and MC2, considering that the way practitioners are managed during current economic conditions, as having an effect, on motivation levels to work collaboratively. MC1 indicated that the client needs to set the tone in order to achieve collaboration on projects. Where "the client is hardnosed and is more concerned with the bottom line and is not particularly bothered of what he considers to be fluffy stuff, he just wants the project done in the quickest time, shortest period you may not get that spirit of collaboration" (MC1). PM1 supported this point when suggesting that where the client wishes a project to be collaborative they need to go further than instructing the team to act in that nature, to a position of where they are leading the supply chain by example, rather than searching for "every contractual route open to them". Although all three practitioners could see the benefits of collaborative procurement there was some scepticism of reports published that associate themselves to best practice. PM1 showed scepticism when referring to Egan's Rethinking Construction report, stating that some of the members of the task force show less than ethical behaviour in the way they manage their supply chain, indicating following them would possibly not signify best practice for industry. MC2 also indicated that with hard collaborative tools, such as performance management, in many instances, it does not appear to be what clients want and there is a lack of training in their use. With contractors often asked to produce documents that have little obvious use and not referred to during the project (MC2).

Implementation

PM1 describes a traditional process of the designer putting their interpretation into the specification, the contractor sending their interpretation to the supply chain and the supply chain forced to comply. Both MC2 and PM1 identified that the traditional procurement route may not offer the best solution for supply chain integration into design. All three practitioners could see the benefit of collaborative integration of supply chain knowledge into the design. However, MC2 indicated that sometimes contractors feel disempowered during design input. MC1 indicated the integrating of other stakeholders into the design results in improved performance against and an understanding of project deliverables. MC2 reflected on a particular case study that needed careful health and safety management. Pre-construction and a lesson learned

meetings allowed his organisation to understand the client's requirements. MC1 also identified collaboration to pre-construction when discussing a two stage tendering design and build project with a guaranteed maximum price (GMP). MC2 indicated practitioners could be more motivated to achieve client requirements when they are empowered by a process such as two-stage tendering. However, he discussed a case where a contractor had tendered a rate of minus five percent for their organisation's overheads and profit, which by the nature of businesses activity needed to utilise non-collaborative behaviour to recoup what would otherwise be an overall project loss (MC2). PM1 indicated, that there were contractors with a traditional mind-set he would be able to partner with and contractor selection was more important than the procurement route. Both MC2 and PM1 believed that design and build is not always associated with collaboration in respect of agreeing post contract changes.

MC1 indicated that there are benefits to inter-contractor collaboration and discussed the formal mechanism of communication that they use with similar organisations in relation to health and safety. PM1 discussed efficiencies through standardisation achieved through the communication of similar professions. MC2 indicated that competitive bidding restricts knowledge transfer between competing organisations. Both MC1 and MC2 indicated that inter-competitor communication needs careful implementation to remove any concern of collusion. PM1 indicated that for clients to receive the benefits of collaboration, senior management support is required throughout the supply chain, preventing disputes from passing up the ladder. MC1 extended this to say how senior management support was particularly important in relation to the selection of sub-contractors on a different basis than cost. PM1 recognised that it is difficult to manage the complete supply chain due to the social constraints during tender.

Both MC1 and MC2 identified the importance of informal mechanisms to manage sub-contractors and risk. MC2 discussed an instance where a client's relationship with the supply chain had allowed his organisation to obtain competitive rates on high value equipment, with improved payment terms on a particular project. MC1 discussed how his organisation formally manages sub-contractors into three categories, namely: one, used on a regular basis; two, used but not quite ready for category one; and three, those worked with in the past but do not have a relationship with the contractor organisation. MC1 indicated that feedback sessions that form part of supply chain management can offer organisational improvements, however, client organisations appear to lean toward offering feedback in one direction and move away from a reciprocal organisational improvement process.

PM indicated that within the last ten to fifteen years there has been a shift in the design of works from client side consultants to contracting or subcontracting organisations, possibly due to skills movement in the supply chain. MC1 suggested that regular formal and informal meetings starting at an early stage with sub-contractors, consultants, clients and stakeholders are important, for investigation into innovative solutions and the management of the project, along with the expectations of the deliverable. MC2 identified incentives as an option to encourage contractors to achieve clients' requirements. In contrast, MC1 suggested that supply chain integration is achievable during design without payment, with incentivisation coming through the trust associated to long-term relationships. PM1 recognised the importance when using tools such as value engineering and value management to link users with the supply chain through relevant control mechanisms. MC2 indicated that in instances value engineering achieves savings using unfair contractual practice.

MC1 indicated that true value engineering is a collaborative tool whereas cost cutting gets more towards the adversarial way of working.

Motivation

MC1 indicated that wellbeing and collaboration during a project was a consideration when bidding for work, in that it encourages contracting organisations to "go for jobs". In contrast, PM1 indicated that wellbeing was not a significant issue when selecting collaborative methods. All three practitioners focused on soft skills referred to as attitude or trust as being the underpinning element to collaboration. PM1 indicated by sketching a drawing during the interview that a hierarchical structure existed in relation to collaborative enablers, with soft skills underpinning and enabling strategies; and strategies underpinning and enabling tools. MC1 indicated that a good way to start relationships was with team building exercises, examples contemplated included events where participants could build rapport with one another and share their objectives for a project. MC2 could see the benefit of events similar to that described by MC1, however, recited a particular case from a national contractor, where practitioners would be entertainment at the start of the project to induce a good relationship and it would break down by the end. This was due to an inconsistent approach to collaboration during the project. MC2 identified that in instances collaborative tools are undertaken in such a manner that they are an exercise that wastes resource with little or no effect on the overall project deliverable. PM1 recognised that this feeling was present and suggested that a way to avoid it may be to have specific collaborative focused workshops facilitated by a mentor throughout the life cycle of a project. During the workshops, practitioners would develop collaborative behaviour together avoiding wasted resources. MC2 identified the importance for everybody to understand what the other persons perspective is in terms of risk. PM1 identified this as an ideal objective for the initial meeting, which would facilitate agreement and understanding in relation to collaboration along with its associated tools. PM1 and MC1 identified the importance of having regular review meetings with senior practitioners from organisations to reinforce that agreed at the initial meeting and avoid disputes.

MC1 indicated that the incorporation of softs skills into contracts is a positive move forward with the NEC form of contract being a more of a collaborative than other forms. In contrast, PM1 wondered if the incorporation of soft skills in to contracts could end up sacrificing some of the soft things you need in the interest of providing something a solicitor could write. MC2 identified that there is often an unofficial GMP forced onto contractors that they have not agreed too. MC1 indicated that frameworks and collaborative charters were not a prerequisite to collaborative working as collaboration is present in other forms of contract, for example a traditional project, stating "where the team work well together, from an early stage, to me is collaboration". MC1 said, "if you have a group of people that really want to work collaboratively and together, then it does not matter that there is not a formal process in place".

MC1 indicated that BIM offers improved collaboration but is not a prerequisite and that it needs upfront investment to be started on day one in relation to the work associated to the BIM model; with both MC1 and MC2 seeing an investment in education as important. PM1 identified that some practitioners say in instances it is more complicated than what is required and recalled a case, where, he had worked on a project where software compatibility between consultants caused issues. MC2

indicated a scepticism of the software in that there have been previous similar initiatives that have failed in the past. MC1 identified the success of software associated to BIM being an almost essential collaborative tool, which saves time and is a portal to share information. PM1 added to this by indicating that BIM is a good collaborative tool in particular to encourage people to act in an auditable manner.

All three practitioners indicated good change management is associated with collaborative procurement. PM1 also identified performance management as important to undertake on every project. In addition, MC2 indicated that quantitative performance management was often unfair as it does not take into account all factors and is undertaken in a qualitative informal manner. MC1 associated risk management to collaboration with high risks managed by the team from the project. PM1 and MC1 indicated practitioners should move away from a defensive strategy towards more of a place where they feel empowered to discuss failures for continuous improvement. MC2 identified risk management as a worthwhile tool often undertaken as a formal exercise abstract from the construction process, concurrent with an informal process with much more apparent value. All three practitioners associated alternative dispute resolution to non-collaborative behaviour. MC1 understanding that with the "old adversarial approach the price may be lower, but, due to all the disputes the prices ends up being higher because of delays, disputes, claims".

DISCUSSION AND PRELIMINARY CLASSIFICATION METHOD

During the 1990s such reports as 'Rethinking Construction' indicated that there was a perception among clients that the construction industry was underperforming and improvements were available by following practices from other industry sectors. There appears to be limited empirical evidence of the perceived benefit of particular collaborative tools; however, the case studies indicate that the suppliers can relate to the benefits of working in a collaborative manner, being keen to deliver value during the execution of their services for clients. The reports presented ways to move away from explicit contractual methods towards behaviour that was fairer and client deliverable focused. The collaborative movement has gained momentum in the procurement of construction related services since the 1990s, which has resulted in the formation of a complex framework of tools into explicit contractual mechanisms. Figure 1 presents a method to review the mechanisms against three-dimensional reasoning namely, the themes of risk, implementation and motivation. The themes made themselves evident during data collection.

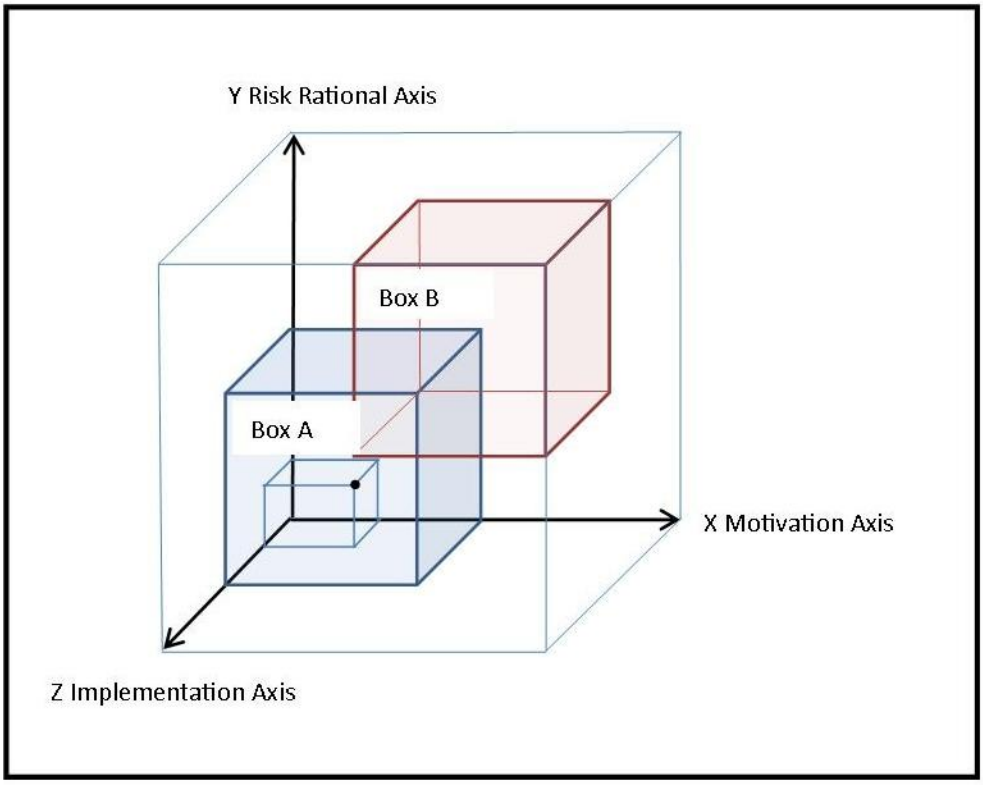

Figure 1: Rationalised Selection of Collaborative Mechanisms

Box B represents high levels of scoring against risk, motivation and implementation, which is the desirable location within the scatter diagram. Box A represents low levels of scoring against the same and is the undesirable. The black dot represents a mechanism that sits within the scatter diagram; it is an undesirable mechanism. There is a need for further research to identify and calibrate the features/factors that are likely to populate the axis.

CONCLUSION

The bespoke nature of construction appears to restrict the ability of contracts to move away from a reactive approach to often adversarial practice, towards more proactive collaborative approaches. However, the case studies indicated that there is not a direct correlation between the contractual mechanisms and perceived collaborative behaviour. The current contractual trend appears to manage behaviour associated with tacit knowledge with contractual mechanisms. Further legal doctrine research needs to be undertaken to explore the enforceability of some of the contractual mechanisms, which appear to contrast with the recommendations of Latham to make contracts more complicated. During the data collection process, there was a sentiment that the implementation of the tools is (in instances) undertaken in such a way that they have limited value in relation to the client's deliverable, being more suitably achieved, through the application of tacit knowledge. In addition, during data collection, a three-theme approach was evident for the selection of collaborative tools and features. The discourse in data suggested that the selection of collaborative tools is more suited to a flexible process that employs tacit knowledge rather than prescriptive explicit methods. Future research needs undertaking to review the implication of collaborative contractual mechanisms in contracts over a longitudinal timescale and in other industrial sectors.

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MULTINATIONAL CONTRACTING INTO AUSTRALIA: DEVELOPING DUNNING'S THEORY AND CASE STUDY DESIGN

Azmeri Rahman[1], Adrian J. Bridge[1], Steve Rowlinson[2] and Tom Kwok[1]

[1]*Civil Engineering and Built Environment School; Queensland University of Technology, GPO Box 2434, Brisbane, Queensland, 4001, Australia*

[2]*Department of Real Estate and Construction, The University of Hong Kong, Hong Kong*

In response to the need to leverage private finance and the lack of competition in some parts of the Australian public sector infrastructure market, the Australian Federal government has demonstrated its desire to attract new sources of in-bound foreign direct investment (FDI) by multinational contractors. This study aims to update progress towards an investigation into the determinants of multinational contractors' willingness to bid for Australian public sector major road and bridges. This research deploys Dunning's eclectic theory for the first time in terms of in-bound FDI by multinational contractors into Australia. Elsewhere, the authors have developed Dunning's principal hypothesis to suit the context of this research and to address a weakness arising in this hypothesis that is based on a nominal (yes or no) approach to the ownership, location and internalisation (OLI) factors in Dunning's eclectic framework and which fails to speak to the relative explanatory power of these factors. The authors have completed a first stage test of this development of Dunning's hypothesis based on publically available secondary data, in which it was concluded tentatively that the location factor appears to have the greatest explanatory power. This paper aims to present, for the first time, a further and novel development of the operation of Dunning's OLI factors within the context of multinational contracting, as well as a preview of the design and planned analysis of the next empirical stage in this research concerning case studies. Finally, and beyond the theoretical contributions expected, other expected contributions are mentioned concerning research method and practical implications.

Keywords: case study design, Dunning's eclectic paradigm, multinational contracting.

INTRODUCTION

In Australia and amidst concerns on the issue of a lack of competition, the Federal government has noted its desire to see new foreign construction entrants into the Australian public sector major infrastructure market (Infrastructure Australia 2011).

[1] azmeri.rahman@student.qut.edu.au

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On this basis, an investigation into the determinants of multinational contractors' willingness to bid for Australian public sector infrastructure projects appears important from both the perspectives of government and contractors with an interest in the Australian market - both contractors contemplating Foreign Direct Investment (FDI) into Australia and those contractors domiciled in Australia. More fundamentally, this investigation is of value to any multinational contractor contemplating FDI into any location.

In pursuance of explaining the determinants of multinational contractors' willingness to bid for Australian public sector infrastructure projects, the authors summarize the relevance of Dunning's eclectic paradigm of internationalisation (Rahman, Bridge and Rowlinson 2010; Rahman *et al.* 2011a; Rahman *et al.* 2011b; Rahman *et al.* 2012). In brief, Dunning's eclectic paradigm has prevailed as the dominant analytical framework concerning the determinants of FDI and multinational enterprise for over two decades to date. Although Dunning's eclectic paradigm is the dominant theory of internationalization, it has received little attention and testing in the context of multinational contracting. Dunning's principal hypothesis that is based on four conditions (ownership "O" advantages; location "L advantages; internalisation "I" advantages; and a condition concerning the firm's business motivation) and which are all considered in nominal terms (satisfied or not satisfied) in determining the likelihood of FDI in a multinational contracting context. The authors translate Dunning's corresponding generalised predications within the context of this paper to reflect a lack of in-bound FDI by multinational contractors into Australia (reverse of Dunning's original stated hypothesis and predications) as follows: the more Australian-based multinational contractors relative to other multinational contractors possess desirable O advantages, the lesser the incentive other multinational contractors have to internalise (I advantages) rather than externalise their O advantages, the less other multinational contractors find it in their interest to access or exploit them in Australia (L disadvantages), then the less Australia is likely to attract in-bound investment by multinational contractors. This paper aims firstly, to present a further development of the operation of Dunning's OLI factors or framework within the context of multinational contracting and secondly, to preview the design and planned analysis of the next empirical stage in this research concerning case studies.

OLI FACTORS IN MULTINATIONAL CONTRACTING

This study is delimited to contractors bidding and delivering projects as head contractors as a single entity bid or as co-head contractor in a collaborative bid. As a result of this delimitation, the further development of the operation of Dunning's OLI factors is based on the practical exclusion of the conventional alternatives to FDI namely pure export and licence. These alternatives become muted in light of the fundamental peculiarity in multinational contracting and which concerns the imperative for the multinational contractor to establish a physical presence in the host location, in this case Australia. That is, the multinational contractor is required to commit some degree of internalization and FDI (concerning the contractor's core activity of planning, procurement and coordination of on-site construction) if this firm is to bid and deliver a major public sector road and bridge construction project in Australia. This situation arises mainly out of geographical specificity/the immobile nature of construction works. This study is also delimited to FDI comprising entry modes that involve some degree of equity participation on the part of the multinational contractors and in new entities designed to bid and deliver projects, for example, sole or joint venture projects or companies, as well as the entry mode of acquiring more

than 50 percent of the shares of a local contractor. Beyond explaining the actual and observed level of FDI, the OLI framework can be deployed to explain the level of the attractiveness of the host location and as an upstream proxy of FDI as indicated in Figure 1. This is particularly useful in cases like Australia with very low level of incidence of multinational contractors and FDI. That is, a focus on the level of the attractiveness of the Australian market instead of a focus on actual FDI is a more realistic approach to the dependant variable for the vast majority of multinational contractors not committing FDI in the Australian market and offers a more sophisticated analysis of the relationship between the OLI factors and the dependant variable.

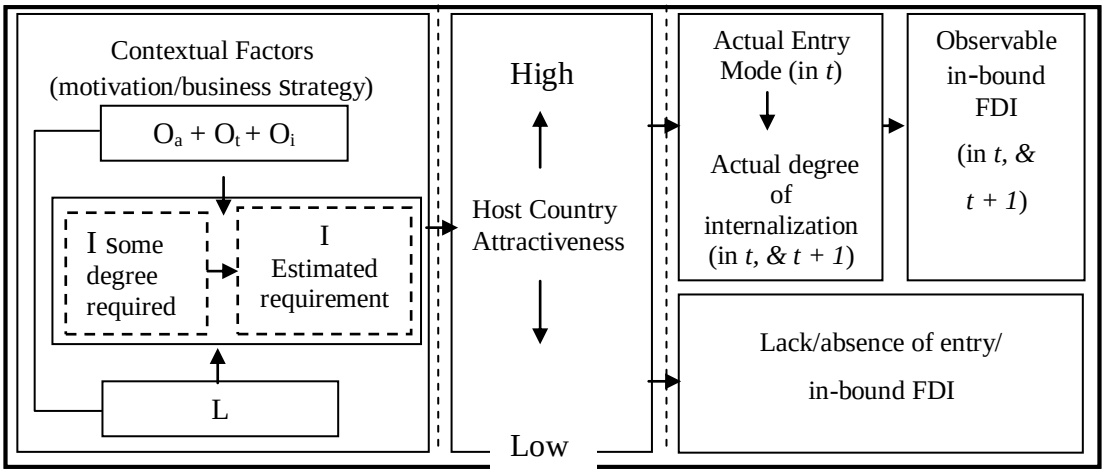

Figure 1. OLI framework in multinational contracting

In Figure 1, the I factor is taken as a given or constant as some degree of internalisation and FDI is required, Thus, Figure 1 shows that the I factor occupies a central occupation in the mindset of the multinational contractor and in terms of the role it plays in contributing towards determining the attractiveness of the host location. More specifically, the multinational contractor needs to initially estimate its preferred and/or acceptable level of internalisation required to enter the host market and on this basis whether or not it then wishes to proceed into the host market and commit FDI. In order to do this, the multinational contractor needs to consider the operation of the O and L factors. In summary, Figure 1 depicts a number of key moves undertaken by the multinational contractor to determine whether or not it enters a host market and if so, the level of internalisation and which is based on its assessment of the corresponding O and L factors.

The first move concerns the O factor. Having assessed its ownership strengths, relative to rival home contractors vis-à-vis the host country/Australia and relative to potential rivals from other competing home counties vis-à-vis the host country/Australia, as well as relative to rivals already established in the host country/Australia, if the prospective multinational contractor feels it can win a contract to construct a major road and bridge in Australia, some further analysis of the costs and benefits of doing business in the host location/Australia is warranted. In the second move, the focus is broadened to incorporate the L factor. That is, a further analysis of the costs and benefits of doing business in the host location/Australia and which comprises an assessment of institutional distance including the affect of home-host induced distances and in particular cultural; administrative; geographic and economic distances. These distances of various kinds affect the level of investment

and set-up costs in melding the prospective multinational contractor's ownership advantages and capabilities and particularly its institutional advantage (Oi) with the host location. On the face of it, and if the host location/Australia continues to remain attractive, then at this point a much deeper exploration concerning a detailed estimate of the degree of vertical integration required (mix of internalization and coordination of supply chain – subcontractors and suppliers) is justified.

This detailed estimated of internalisation and FDI required in the host market is unique to each prospective multinational contractor and represents the level of control and internalization the prospective multinational feels it would need to ensure the delivery of the project(s) whilst maintaining its reputation and retaining a level of returns it would normally set for a major road and bridge project in its home country. This detailed estimate may involve a greater degree of internalisation than the multinational contactor deploys in its home market and/or greater than the host market norm if the multinational contractors assesses the risk of hold-up by local subcontractors and suppliers as significant and in conjunction with its initial lack of familiarly with the local market and initial lack of a pipeline of work to check opportunistic behaviour by subcontractors and suppliers. As Coase (1937) anticipated though, too much internalization can lead to inefficiencies arising out of bureaucracy costs and low power incentives. These internal/management transaction costs are crystallized in the prospective multinational contractor's internalised activities and the greater the prospect of these internal/management transaction costs, then the reduced attractiveness of the host location (Dunning and Lundan 2008). The key issue to highlight here is that ex ante, or before the multinational contractor actually commits any FDI, the research question amounts to one of horizontal integration in which the prospect of transaction costs arising internally, or hierarchical failure, acts to deter horizontal integration or internalisation and FDI in the host market.

In the instance of an unfavourable analysis of the costs of doing business in the host country and on the basis of the prospective multinational contractor's detailed estimate of internalisation and FDI associated with bidding for projects as head contractor, this host market may still be attractive by virtue of a favourable analysis of the benefits of entering the host country. That is, the prospective multinational contractor may consider a third move concerning alternative initial entry modes (in time "t") that do not involve the prospective multinational contractor bidding as lead/head contractor and which mitigate the costs and risks of doing business in the host market in order to pursue, in due course (time "t +1"), a desirable level of demand and/or level of profits/returns in the host market relative to the prospective multinational contractor’s home market and other possible competing host markets. More specifically, these alternative initial entry modes offer an interim step and period in which the prospective multinational contractor is able to develop its management capability internally, as well as externally in coordinating the supply chain (and eventually shaping the supply chain itself) whilst being protected from unacceptable levels of risk of investment losses. Here, the role of competent counterparts is crucial and in terms of sharing the responsibilities of the lead/head contractor role. For example, a partnership/joint venture mode with an already established local contractor, such that the prospective multinational contractor is bidding as a co-lead contractor, as opposed to a single entity wholly responsible for the outcomes, may be considered. Extending out this third move, "t + 1" envisages the situation in which the multinational contractor after entering a host market develops familiarly with the host market and

may well develop beyond its initial entry mode and/or shed some of its initial internalised activities, as it begins to fashion and shape the local market.

The fully established multinational contractor's presence and its degree of internalization and FDI now become fully observable and measurable. An I factor analysis can now be effectively conducted to explain the degree of internalization and the extent to which this is attributed to market failure (potential affect of hold-up) including the deployment of independent variables pertaining to Transaction Cost Economics (Dunning and Lundan 2008). In other words and ex post, the question is now one of vertical integration. And in contrast to the question of horizontal integration above, this time transactions costs act to encourage internalisation and not discourage internalisation. This further promotes the rationale for using market attractiveness as the dependent variable instead of actual FDI in this study and in conjunction with a focus on the explanatory power of the O and L factors. That is, there is a severe lack of multinational contractors in the Australian market upon which to observe a range of actual FDI and conduct a range of full internalisation or I factor analyses.

On the explanatory power of the O and L factors, the authors have developed the notion that the O and L factors can display differential explanatory power - as depicted in Table 1.

Table 1: Propositions 1 and 2

Roads and Bridges in Australia (AUD>50million)	Home country A	Home country B	Home country C	Home country D
Operating/expressing an interest in Australia				
Group 1	☺	☺	☺	☺
Not Operating/expressing an interest in Australia				
Group 2	😐	😐	😐	😐
Not Operating/expressing an interest in Australia				
Group 3	☹	☹	☹	☹

Key: ☺ = O advantages in comparison to contractors of other nationalities/local contractors in serving the Australian market; 😐 = O advantages and disadvantages in comparison to contractors of other nationalities/local contractors in serving the Australian market; ☹ = O disadvantages in comparison to contractors of other nationalities/local contractors in serving the Australian market

In doing so, the authors seek to address a weakness in Dunning's principal hypothesis that takes a nominal approach (Rahman, Bridge and Rowlinson 2010; Rahman *et al.* 2011a; Rahman *et al.* 2011b; Rahman *et al.* 2012). Table 1 uses a facial symbol to reflect similarities/differences in O attributes and illustrates the outcomes from two propositions. That is, by adopting extreme positions and observing differences in the range of the reported level of overall attractiveness in the host market Australia down the four columns of multinational contractors with different O attributes in the same home country/location (Proposition 1) and in contrast to the range of the reported level of overall attractiveness in the host market Australia across each of the three

rows/groups of multinational contractors with similar O attributes but in different home countries/locations (Proposition 2), evidence is generated to indicate the relative importance of O and L factors vis-à-vis roads and bridges in Australia. Such that, if a greater range in the reported level of overall attractiveness in the host market is observed across the rows than down the columns, then this indicates that the L factor is more important and has more explanatory power than the O factor and vice versa. In terms of helping to reveal the relative importance of O and L factors, it is expected that the relative strength of the correlation/level of statistical significance of the O and/or L factors/dimensions generated from a final Proposition 3 will be consistent with the outcomes from Propositions 1 and 2, again vis-à-vis roads and bridges in Australia. In the next section, the attention turns to the research approach and which begins with a brief overview of the entire research plan designed to test the above three propositions above and which comprises multiple methods of data collection and analysis. The focus in the next section, however, is on a preview of the next stage in the empirical work in this study concerning case studies.

Preview of Case study design and analysis

The research plan comprises three stages. That is, secondary data; case studies; and a survey. The secondary data stage and the case study stage concern four home countries, namely China; Japan; Spain; and US vis-à-vis the infrastructure sector selected (roads and bridges over AUD50 million) in Australia - as the host market. These first two stages seek to surface corroborating evidence concerning ownership advantages and location advantages to test the first two propositions illustrated in Table 1. Whilst the survey stage is designed to assess the extent to which key findings from the secondary data and case studies are generalisable globally in pursuance of testing the third proposition mentioned above. Engineering News Record (ENR) is used as the basis of a sample frame for the survey and upon checking ENR (2010) listing of the world's top 225 contractors and in conjunction with visiting the websites of these contractors, where available, 181 contractors were identified as operating in the transport sector and will be invited to participate in the survey. In total, this approach harnesses the relative strengths of multiple methods of collecting and analysing data and answers Dunning and Lundan's call that "...the firm and national level analysis on the influence of institutions on MNE behaviour need to be linked and treated holistically." (2008: 142).

The first stage investigation concerning secondary data in the public domain has been completed and has started to speak to the relative importance of the O and L factors envisaged in Table 1, as reported by Rahman *et al.* (2012). On the O factor, it was noted that there are number of contractors from the home countries (for example, Acciona from Spain and Fluor from US), that have subsidiaries in the sector in Australia but which are not amongst the leading few contractors in their home country (ENR 2010). This suggests that there are other contractors from these home countries that are capable of winning road and bridge projects in Australia and that factors other than O advantages, could be more important. With regard to the L factor an analysis was conducted of its two dimensions concerning risk (home-host induced culture; administrative; geographic and economic distances and along with home-host induced distance concerning business uncertainty and sufficiency of demand to justify risk) and return (home-host distances pertaining to industry competitiveness as a proxy for profitability) and using Porter's (1985) five forces model. On the L factor, the secondary data provided sound evidence of these distances and this source of data displayed strength in assessing the L factor at a national level. In summary, the

secondary data provided strong evidence that China and US represent much greater distances than Japan and Spain with respect to Australia as the host country. As such, this suggests contractors from China and US may face higher country specific investments (risks) in setting-up operations and take a much dimmer view of these set-up costs/risks than contractors from Japan or Spain. This analysis of secondary data pertaining to the risk dimension in the L factor corroborated observations on the dependent variable (in this Stage 1 of this study the dependent variable is actual FDI). That is, there is a much lower incidence of Chinese and US contractors in the Australian roads and bridges market and especially as China and US account for largest number of contractors in the 181 contractors that make-up the previously mentioned sample frame in this study. Having reviewed the secondary data pertaining to O advantages and which comprise mainly contractors' websites and including company reports and financial statements, it was clear that this source of data is, on its own, is insufficient to develop an assessment of the facial symbols in Table 1 and as such insufficient to fully test the first two propositions. The conclusions from the secondary data are, therefore, tentative in suggesting that the L factor may have more explanatory power than the O factor. In contrast, it's anticipated that the relative strength of case studies in the next empirical stage of the study will be seen in terms of more clearly testing the explanatory power of O factor.

The case study approach comprises two questionnaire instruments to be administered face-to-face via interview and the collection of private secondary data/documents. The first questionnaire is designed for local contractors headquartered in Australia and the second of these questionnaires is designed for overseas contractors headquartered in China; Japan; Spain and US. At the time of writing, both questionnaires are in the process of being administered and it is planned to complete the collection of this case study data and analysis by end of November 2012. The essential purpose of the local questionnaire is to create reference points to facilitate the identification of the facial symbols shown in Table 1. That is, a number of local contractors are selected from Australia's National Prequalification System (NPS) and comprise three reference groups. That is, at least two or three contractors are selected from approximately the top-half of the NPS financial level ("F150 plus") to represent Group 1; at least two or three contractors are selected from approximately the bottom-half of the NPS financial level ("F-150 plus") to represent Group 2; and at least two or three contractors are selected from the NPS financial levels ("F150" and "F100") to represent Group 3.

A set of objective measures are used to assess these contractors' attributes and which include attributes corresponding to criteria in the NPS, along with other attributes deemed important by contractors in terms of winning contracts and identified from the website search in the first stage investigation. On each attribute, an average of the responses from contractors within each group is taken to represent the group and the group average ranked either 7; 4; or 1. That is, 7 equates to the group that derives the greatest advantage from the attribute concerned and 1 equates to the group that derives the least advantage from the attribute concerned. On each attribute, a set of measurements can now be interpolated and to represent the remaining points 2; 3; 5; and 6. Such that entire 7-point scale is created on each attribute to compare the average score for each of the local groups with scores provided by case study contractors headquartered in the four home countries. A radar map is then planned to present these outcomes and for illustrative purposes and hypothetically only this is shown in Figure 2 in terms of the three local reference groups only. Given that all the attributes are either directly connected to the NPS criteria and/or derived from details

from contractors' websites, then all of the attributes are considered valuable in terms of contributing towards winning a contract. Beyond this valuable variable, the other Resource-Based Theory (RBT) variables concerning rarity and costly to imitate are used to assess the extent to which the different groups are leveraging certain attributes to attain either a possible temporary competitive advantage or a possible sustainable competitive advantage. That is, in addition to the objective measures on the attribute used to rank the three groups, each contractor in a group is asked to give perceptual responses on 7-point scales in terms of how rare amongst their main rivals and how costly to imitate by main rivals are their measurements on the attributes.

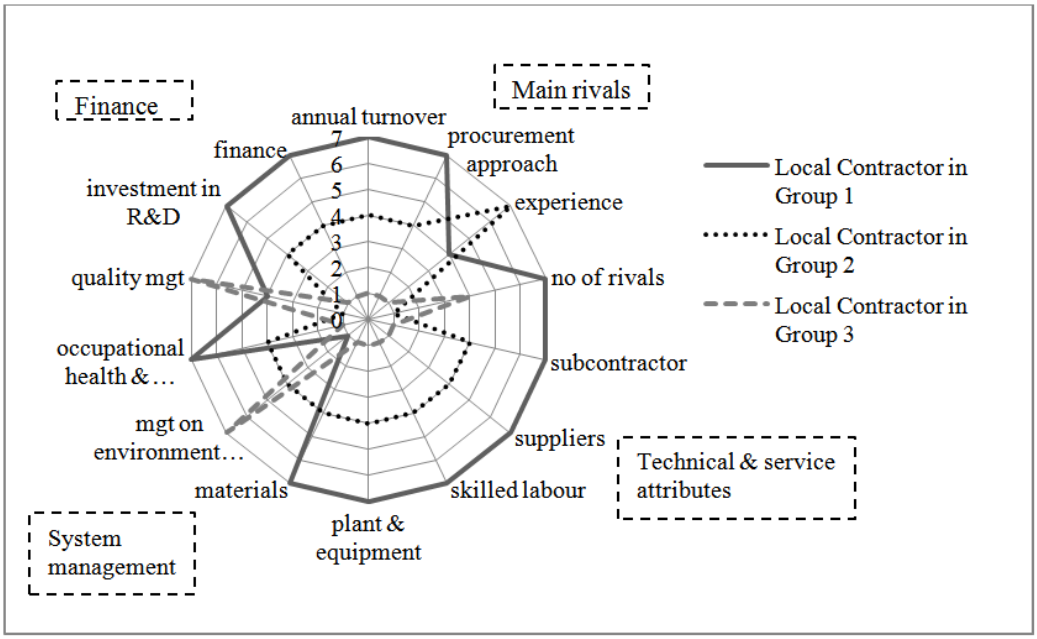

Figure 2. Reference radar map of local contractors

This assessment will be shown by colour coding either temporary competitive advantage (high rare score) or sustainable competitive advantage (high rare and high costly to imitate score) either on the portion of line from point 1 to 4 and/or point 4 to 7 on any of the attributes where one or two of the groups out of the three groups on the attribute concerned consider that they have a competitive advantage. Such that, this analysis will also show if and where/on what attribute(s) the competitive strength of the each group lies and how much this is specific to the local case study group or occurring in other contractors in that group. In the process of generating the three local reference groups on a radar map, the local questionnaire takes the opportunity to assess perceptions pertaining to Porter's five forces model to corroborate secondary data in Stage 1 concerning the risk dimension of the L factor. The local questionnaire also includes questions concerning internalisation in seeking to generate empirical evidence to test the notion that powerful local subcontractors and suppliers may be a source of competitive for locally established head/lead contractors and by inference a deterrent to entry/internalisation to a new multinational contractor (on the issue of horizontal integration). And at the same time, some critical subcontractors and suppliers may encourage internalisation by established local lead/head contractors (on the issue of vertical integration).

As mentioned, the second questionnaire is designed for overseas contractors. It is a non-probability or purposive approach to identifying the case studies and which deploys the logic in Table 1. In order to allow the effect of variations in location

advantages on the overall attractiveness of the Australian market to be most effectively observed (looking across the rows in the Table 1), two of the home countries with contrasting construction industries are selected from Australia's region (China and Japan), whilst the other two home countries are from outside Australia's region (Spain and US). In order to create the greatest opportunity to observe deviations in ownership advantages (denoted by the facial symbol) and to assess the effect of variations in ownership advantages on the overall attractiveness of the Australian market (looking down the columns in Table 1), three groups of contractors will be sought. The contractors in Group 1 (one from each home location) are selected on the basis of having the highest levels of overseas revenue in roads and bridges and the highest level of connection to Australia. In contrast, Groups 2 and 3 in Table 1 comprise the most successful (amongst the top half) and least successful (amongst the bottom half) of multinational contractors again with reference to overseas revenue in the sector in each of the four home locations but not operating in Australia. The same attributes targeted in the questionnaire for local contractors are also deployed in the overseas questionnaire. Such that a radar map for each overseas contractor can be plotted on the reference radar map comprising the three lines for the three groups of local contractors.

The symbol ☺ is given to an overseas contractor whose radar map falls mostly above the local Group 1 map and the symbol 😐 is assigned to a home contractor whose radar map falls mostly between the local Group 1 map and the local Group 2 map. The symbol ☹ is given to a home contractor who scores at Point-0 on any attribute pertaining to the NPS criteria. This contractor is effectively being assessed as unlikely to achieve prequalification and win any road and bridge project greater than $50 million in Australia. Again, RBT variables concerning rarity and costly to imitate and included in the overseas questionnaire and designed to allow a more accurate assessment of the extent to which the overseas contractor is matching local contractors particular sources of competitive advantage and whether this is peculiar to the overseas contractor or whether there are other contractors in the overseas contractors home country that would similarly match local contractors' particular sources of competitive advantage. This questionnaire also seeks to surface indications of profitability in the overseas contractor's home market and this overseas contractor's perceptions of profitability of the Australian market using Porter's (1985) five forces model. A very broad question concerning the overseas contractor's perceptions of set-up costs or investment/risks is included and designed to provide corroborative evidence to more detailed assessment made previously in the first stage secondary data investigation. Again, questions are included concerning internalisation to explore the negative effect of transactions costs ex ante in terms of deterring FDI and in contrast to encouraging internalisation ex post and once the overseas contractor has committed to a market. Finally, a suite of questions are included to surface the overseas contractor's perceptions of the attractiveness of the Australian market relative to other overseas locations in which the overseas contractors is currently operating and all other competing locations worldwide, along with questions concerning the overseas contractor's international business motivation.

CONCLUSIONS

This paper has presented for the first in Figure 1 a novel operation of the OLI framework in multinational construction. Additionally, an overview of the entire research plan designed to test Figure 1 was given before previewing the next and second stage of empirical investigation concerning case studies. Harnessing the

relative strengths of the completed analysis of secondary data and planned case studies and survey and then triangulating the outcomes these methods, will provide strong evidence upon which to conclude the relative of importance of O advantages versus L advantages in the context of this research and which is progress that Seymour (1987) indicated would be very valuable and difficult to achieve. The research will also contribute to method. To the authors' knowledge, this will be the first operationalisation, in this context, of the RBT in terms of O advantages in the planned case studies and TCE on the issue of risk as part of the L factor in the review of secondary data mentioned in this paper. Furthermore, the research will yield some very important practical contributions including a global map of the relative attractiveness of the Australian market. This map is useful to Australian government and also to local contractors. That is, this map allows local contractors the opportunity to help display their relative competiveness and productivity and may help form the basis of future business strategy. The research will also identify aspects of the location factor that can be influenced by government, as well as surfacing any misconceptions of the Australian market. Finally and more fundamentally, this research and its approach to articulating the overseas bidding decision is of value to any multinational contractor headquartered within or outside of Australia.

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PROBABILISTIC PRE-REQUISITES CONTRIBUTING TO SUCCESSFUL HOUSING ASSOCIATION PARTNERING

David Liguori[1], James Sommerville[2] and David Manase[3]

School of Engineering and the Built Environment, Glasgow Caledonian University, Cowcaddens Road, Glasgow, G4 0BA, United Kingdom

The achievement of value for money has been paramount during the current economic climate. The reduction in investment into social housing projects has forced Housing Associations to further minimise waste and pursue the maximisation of value. The success of the continually endorsed utilisation of partnering arrangements to produce value for money is dependent upon the implementation of various pre-requisites. An in depth critical analysis was therefore undertaken to identify these necessary pre-requisites that facilitate a successful partnering outcome. This paper forms part of a wider research and provides a thorough review of the industry perceived pre-requisites to facilitate a successful partnering arrangement. This will enable an empirical assessment of the level of importance placed specifically by Housing Associations on the reviewed factors in future research and in the process contributes to a conceptual model for effective Housing Association partnering arrangements, however the model has not been considered in this paper. It is envisaged that the wider research, upon which this paper is based, will assist Housing Associations maximise value for money by increasing the likelihood of a successful partnering outcome through gaining an understanding of the most important pre-requisites to be implemented into the arrangement from a Housing Association perspective. It is also expected that this research will enable the differentiation between the most and least important pre-requisites identified within the literature, thus clarifying the necessary factors for Housing Associations to implement.

Keywords: housing associations, partnering, pre-requisites, procurement.

INTRODUCTION

Housing Associations in Scotland were established in the mid-1970s to provide high quality and affordable rented housing. A recently published report from the Scottish Federation of Housing (2011) highlighted that currently, Housing Associations and co-operatives own and manage approximately 47% of Scotland`s affordable social housing stock. This translates into 279,144 dwellings, which equates to approximately 11% of all Scottish homes. The indicative value of Scottish Housing Association

[1] David.Liguori@gcu.ac.uk

[2] j.sommerville@gcu.ac.uk

[3] David.Manase@gcu.ac.uk

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assets is approximately £7.6 billion. Delivering socially owned rented housing or maintaining existing stock within a Housing Association is an important and necessary function within society, especially during the current economic conditions. A recent report by Gibb and Leishman (2011) emphasised the reduced funding available for new build social housing. These reductions will exacerbate the need for more social housing in Scotland. The Housing Minister in the Scottish Parliament, Alex Neil Scottish Government (2010), highlighted to Housing Associations, that achieving value for money was an essential element to underpin the Scottish Government`s future investment programme in housing. In recent times, partnering has been advocated as one of the preferred procurement methods for new build and maintenance works commissioned by Housing Associations.

Housing Associations have been encouraged for some time to utilise partnering arrangements as the preferred procurement method for delivering construction and maintenance projects. The Housing Report Forum (2002) encouraged Housing Associations to embrace partnering via long term strategic supply chain alliances. The success of partnering is significantly dependent on specific pre-requisites. Eriksson *et al.* (2008) noted that increasing the awareness of the pre-requisites that facilitate successful partnering arrangements is vitally important when adopting partnering. A plethora of research has been conducted to identify the key pre-requisites associated with successful partnering arrangements within the construction industry generally. There is however limited literature available that focuses on pre-requisites considered by specific client groups. The characteristics that differentiate Housing Associations from other clients highlight the importance of focussing exclusively on their needs. This research will therefore assess the appropriateness of the identified partnering pre-requisites from the sole perspective of Housing Associations. Unveiling the fundamental pre-requisites for Housing Association partnering will provide guidance on effective partnering and subsequently increase the probability of achieving value for money. A potential consequence is assisting Housing Associations commission more maintenance and construction projects as the capital invested will be more effectively utilised.

LITERATURE REVIEW

Housing Association Characteristics

Even though Housing Associations are private organisations, they are still non-profit bodies who are regulated rigorously by government departments. A substantial proportion of funding to enable the construction of new dwellings comes from grants provided by the government. These differences separate Housing Associations clients from private sector counterparts. A consequence of the thorough regulation is the requirement to demonstrate competitiveness. Fisher and Green (2001) highlighted that if partnering is to be followed, then those charged with public spending need to be equipped with appropriate tools to identify and provide sanctions to protect against anti-competitive behaviour that can result from partnering agreements. Another differing characteristic is that procedures implemented by the public sector can often work against the mutual trust and open relationship, which forms the prerequisite of partnering (Woodrich, 1993). Funding mechanisms also differ between Housing Associations and private sector clients, as tenants' rent and government grants are the drivers for investing in maintenance and new build. Another significant difference is that Housing Associations are not-for-profit bodies, who are committed to providing low cost social housing, as opposed to private sector organisations that may primarily

focus on profit. Housing Associations may also be prevented to include within the arrangement a provision to share savings with the contractor (Housing Forum, 2000). According to Burnes and Coram (1999), another barrier is the risk-aversive nature of public sector organisations that is embedded within the ethos. These inherent characteristics separate Housing Associations from private sector counterparts, therefore effective implementation of partnering arrangements must be exclusively focussed on from this perspective.

Housing Association Use of Partnering

Egan (1998) recognised that the construction industry was underperforming, particularly in terms of cost, time and quality, and specifically identified social housing providers as a client group that could benefit from adopting partnering agreements. Housing Associations that adopt partnering believe there is a higher likelihood of achieving specific benefits. Loraine and Williams (2000) stated that partnering for Housing Associations is based on a number of key objectives, which include: cutting out waste; increased predictability of out-turn cost and time; reducing the impact of traditional client/contractor procedures; improve the experience of the user/tenant; secure life-cycle cost benefits; utilise innovation and technology to maximise resource potential.

During these challenging economic conditions, Housing Associations are faced with a procurement dilemma. The first option is to diverge away from collaborative partnering and revert back to more traditional single stage tendering to capitalise on low market prices for a single project. Strongly opposing this strategy, Latham (2008) emphasised that if clients abandon best practice, close down frameworks, stop partnering, and return to lump-sum, single-tender contracts, based solely on lowest price, the industry will go back to its undesirable practices. The second option is persevering with the advocated use of partnering arrangements to strive for long term value for money and uphold the philosophy that lowest price does not represent best value. Should Housing Associations persevere with partnering, it is important that the arrangement functions as effectively as possible. There are necessary pre-requisites to be incorporated into the arrangement for all parties to gain from a partnering agreement. Identifying the essential pre-requisites specifically for Housing Association partnering arrangements will increase the likelihood of achieving value for money and could justify the perseverance of partnering throughout the challenging economic conditions.

PROBABILISTIC PRE-REQUISITES

The literature contains a substantial volume of pre-requisites that facilitate the achievement of the theoretical benefits of partnering. The following pre-requisites are based on the construction industry generally, without focus on a specific client group. The validity and appropriateness of these pre-requisites will be tested in subsequent research, within a focussed Housing Association context.

Commitment from Stakeholders

Commitment from stakeholders is a common factor identified within the literature. Stakeholders entering a partnering arrangement must commit to partnering and should not initiate a partnering arrangement unless absolute commitment is evident from all parties. Black *et al.* (2000) believed commitment was of significant importance when implementing a successful partnering arrangement and that the organisations that developed experience of partnering always rated management commitment higher

than organisations without experience of partnering. Concurring, Bresnan and Marshall (2000) identified long term commitment as the willingness of the parties involved in a partnering agreement, to integrate continuously to ensure unanticipated problems arising are rectified as effectively and timely as possible. Housing Associations embarking on a partnering arrangement must ensure that their respective management structure commits to the partnering arrangement, which is filtered to all personnel involved in the process. The outcome of a partnering arrangement will be significantly compromised, with an increased risk of claims and disputation, should commitment from stakeholders be absent.

Mutual Trust between Parties

Adopting a partnering arrangement requires a deviation in philosophy and attitude, from seeking to fully maximise individual gains to the comprehensive and continual search for an outcome which benefits all parties. A large case study by Kaluarachchi and Jones (2007) highlighted that mutual trust between partners was a fundamental component of a long-term partnering arrangement. Partners should trust that others associated with the partnering arrangement are trustworthy and capable in fulfilling the requirements of the partnering agreement in a mutually trustworthy relationship. When considering trust in a construction context, Wong and Cheung (2004) argued that contrary to traditional types of trust, construction may rely on "system-based trust", embracing the notion of legally binding agreements. The difference in philosophy between a quasi-public sector Housing Association and a private sector contractor could subsequently result in difficulties when forming a trusting relation. However, if establishing mutual trust between the parties is achieved, it will facilitate the destruction of partnering barriers and will greatly enhance the exchange of information and mutually rectify arising difficulties that produce beneficial outcomes to all partners.

Effective Communication

Communication between parties involved in a partnering agreement must be effective, as the expectations of each partner must be clearly understood and recognised. Research conducted by Black *et al.* (2000) highlighted that effective communication was one of the most important factors associated with a successful partnering project. The partnering philosophy embraces the ethos of sharing and distributing information in an open and honest manner. When considering the extent and methodology of communicating information in a partnering arrangement, Beach *et al.* (2005) highlighted that the partners must carefully consider the forums and processes of communication, which will be most effective. The processes and forums of communication could be more challenging for Housing Association partners, due to complex departmental arrangements. Housing Associations normally comprise of procurement, technical and maintenance teams, who all liaise with housing managers and tenant committees. Managing the dynamics of a Housing Association partnering arrangement could be challenging.

Equitable Relations

Beach *et al.* (2005) considered equity as the basis of the partners' relationship, and not the win-lose attitude associated with traditional relationships. Ng *et al.* (2002) emphasised that equitable relations will create mutual goals, with a commitment to satisfy each partners` requirements and continually search for solutions that confirm with the evolving expectations throughout the project. Establishment of an equitable relationship between Housing Associations and contracting partners can facilitate the

manifestation of mutual motivation and encourage parties to work together to ensure all objectives are met. The current economic conditions could tempt the manifestation of over powerful partners demanding control of the terms and risk distribution of the partnering arrangement.

Mutual Objectives

Formulating mutual objectives for parties involved in a partnering agreement, is a key element of the partnering philosophy. Partners should work together to ensure all objectives are successfully met. Swan and Khalfan (2007) highlighted the importance of mutual objectives and investigated the types of objectives established in public sector partnering. The importance of mutual objectives was emphasised by Ng *et al.* (2002), asserting that mutual objectives must be developed to satisfy each stakeholders requirements for a mutually successful project. The utilisation of mutual objectives will incentivise Housing Associations and contracting partners to work together to ensure a successful partnering arrangement. However, the mutual objectives must be communicated to all levels of the Housing association and partner to ensure a collective attempt of achievement, as failure to work towards mutual goals could ultimately result in the failure of the arrangement.

Continual Evaluation and Improvement of Performance

There is a consensus within the literature that continual evaluation and improvement of performance is a necessary pre-requisite that contributes to a successful partnering arrangement. Beach *et al.* (2005) identified continuous evaluation of a partnership would ensure that the agreement developed in accordance with the expectations of the parties involved. Continuous improvement techniques were identified by Kaluarachchi and Jones (2007) as a fundamental element of the partnering process and considered effective communication and coordination as key drivers for a sustained improvement of performance. The effectiveness of the continuous evaluation and improvement method is dependent on the regularity and format of conducted evaluation processes, ensuring objectives are on target, identifying improvement areas and measuring success. Housing Associations and the contracting partners should dedicate a team to continually monitor and evaluate key performance indicators to strive for betterment throughout all stages of the arrangement.

Conflict Resolution Process for Disputes Arising

Conflict between parties within a construction project regularly occurs. Parties normally seek to reconcile disputes as quickly as possible, without resorting to potential mediation or legal proceedings. Lu and Yan (2007) noted that the ethos of partnering can effectively facilitate the resolution of problems and conflicts, without destroying the harmony between partners. Throughout the literature, there is general belief that a successful partnering arrangement should incorporate a dispute resolution process. Partners should not however need to resort to the partnering charter, as the ethos of working collaboratively should defuse any potential disputes early. Should this not transpire, Housing Associations should ensure the existence of a partnering charter and conflict resolution processes as a safeguard.

Early Involvement of Key Participants

The early involvement of key participants has generally been identified as facilitating the success of a partnering agreement, as important decisions, which could affect the project, can be decided at the outset, thus mitigating escalating costs and time. Scott (2001) suggested that early involvement could seriously enhance the success of

implementing the partnering agreement. Concurring, Beach *et al.* (2005) highlighted the importance of early involvement of key participants to enable the involved partners to utilise the accumulated knowledge and expertise to facilitate and maximise the success of the project. This will only facilitate the partnering arrangement if key stakeholders understand the partnering process and scope of works. Should the knowledgeable Housing Association key personnel be involved from an early stage, there is scope for the removal of waste ad poor value prior to project finalisation.

Stakeholder Strength and Enthusiasm

Ng, *et al.* (2002) emphasised that partnering organisations must operate beyond acceptance to a level of true commitment and leadership, therefore actively promote the ultimate working relationship. Strength and leadership should be evident from the stakeholders to encourage and motivate all levels of the partners to achieve the mutual objectives. Cheng *et al.* (2000) emphasised that one of the most important pre-requisites for successful partnering was that team members should provide strong leadership and problem-solving skills, which increases team spirit. Should there be any scepticism of partnering by Housing Association personnel, the potential benefits that could be received will be compromised. Key Housing Association participants should champion the partnering process and spread the enthusiasm among all parties and personnel. Stakeholders' strength and enthusiasm can facilitate the success of the partnering process, and provide other parties with the example of how to function within a partnering agreement.

Partnering Workshops

Partnering workshops are utilised to facilitate the communication between stakeholders, identifying the mutual objectives from the outset, and then evaluating the success. The Partnering workshops provide a forum for communication. There is criticism that a "one-off" workshop, prior to commencement is not enough. Bayliss *et al.* (2004) emphasised that regular workshops were one of the most effective tools to effectuate the partnering approach. The number of partnering workshops that should be conducted is intrinsically linked with specific circumstances, including level of experience, stage of the overall arrangement and the scale of project. Housing Associations and contracting partners should assess the reasonable number of workshops that are necessary from the outset. Each workshop should contain clearly defined objectives and points of discussion.

Acceptance of Mistakes

Mistakes occurring in construction project are not unusual. The effect of the mistake is heavily dependent on the actions and processes adopted for the rectification. Ng, *et al.* (2002) believed it is paramount for stakeholders to be accepting of other parties mistakes, as stakeholders can learn from each other's mistakes and improve efficiency in future relationships. As Housing Associations place significant importance on the satisfaction of their tenants, it may be more difficult to tolerate and accept mistakes. The adversarial nature of traditionally procured projects, can inadvertently promote stakeholders to take advantage of mistakes made, which is the antithesis of the partnering ethos.

Shared Project Risks

The sharing of risks associated with a construction project is a significant element of the underpinning philosophy of partnering arrangements. Partnering was emphasised by Lu and Yan (2007) as sharing the project risks, which contradicts the traditional

adversarial nature of the construction industry, where risk is always attempted to be placed with the other stakeholder, for a substantial price. Chan *et al.* (2004) highlighted that the sharing of risk was a contributory element to one of the critical factors associated with successful partnering. The theory associated with apportioning risk to the partner more able to respond is logical, however, in the event of over powerful partners forming, the majority of risks could be transferred to the weaker partner. Housing Associations must ensure that any risks that a contracting partner is more able to reduce and control, are transferred from the outset.

METHODOLOGY

This stage of the research has been conducted on the basis of an extensive review of the existing literature. This review of literature focuses on the perceived pre-requisites associated with a successful partnering arrangement. From the identified pre-requisites, a subsequent conceptual model will be developed, however has not been considered here. An empirical assessment will be undertaken to identify the levels of importance placed by Housing Associations on the reviewed pre-requisites within this paper. It is envisaged that a ranking technique will be utilised in subsequent fieldwork, to ascertain the Housing Association perspective on the most important pre-requisites that must be translated into partnering arrangements. Housing Association procurement personnel will be targeted as the most appropriate respondents to participate in the research. Understanding the necessary pre-requisites to be included into Housing Association partnering arrangements could assist in the achievement of value for money during the challenging economic period.

DISCUSSION

The review of literature highlights an array of important pre-requisites that will assist successful partnering outcomes. Each of them positively contributes to a partnering arrangement. Pre-requisites such as commitment, trust and communication appear essential elements that underpin the partnering ethos. Continual evaluation and improvement of performance could be another important factor for Housing Association as best value should be demonstrated for tenants. The literature did however unveil other pre-requisites that may not be essential to Housing Association partnering arrangements. Equitable relations reflect the ethos of partnering however, Housing Associations may not consider this as a vital element to assist the success of the agreement. Mutual objective was a factor vociferously argued within the literature as being vital for the attainment of an effective partnering arrangement. Conversely, the current economic conditions and lack of investment from the government by (Gibb and Leishman, 2011) may shift Housing Associations priorities and mind set to focus more on their objectives. Early involvement of key participants was also considered as an essential pre-requisite. However within the specific context of Housing Association partnering arrangements, there may be a consensus that this is not necessary as there may be hesitance to commit the required level of resources at an early stage to effectively implement the project. Share project risks is a pre-requisite that Housing Associations may struggle to embrace as there is an inherent risk averse philosophy within public sector organisations (Burnes and Coram, 1999). The reviewed pre-requisites and potential barriers are illustrated in Figure 1, which differentiates between the barriers more applicable to Housing Association as a result of their inherent differing characteristics, as opposed to conventional private sector clients. The level of importance placed by Housing Associations will be ascertained in

subsequent research and will contribute to a conceptual model for effective Housing Association partnering arrangements.

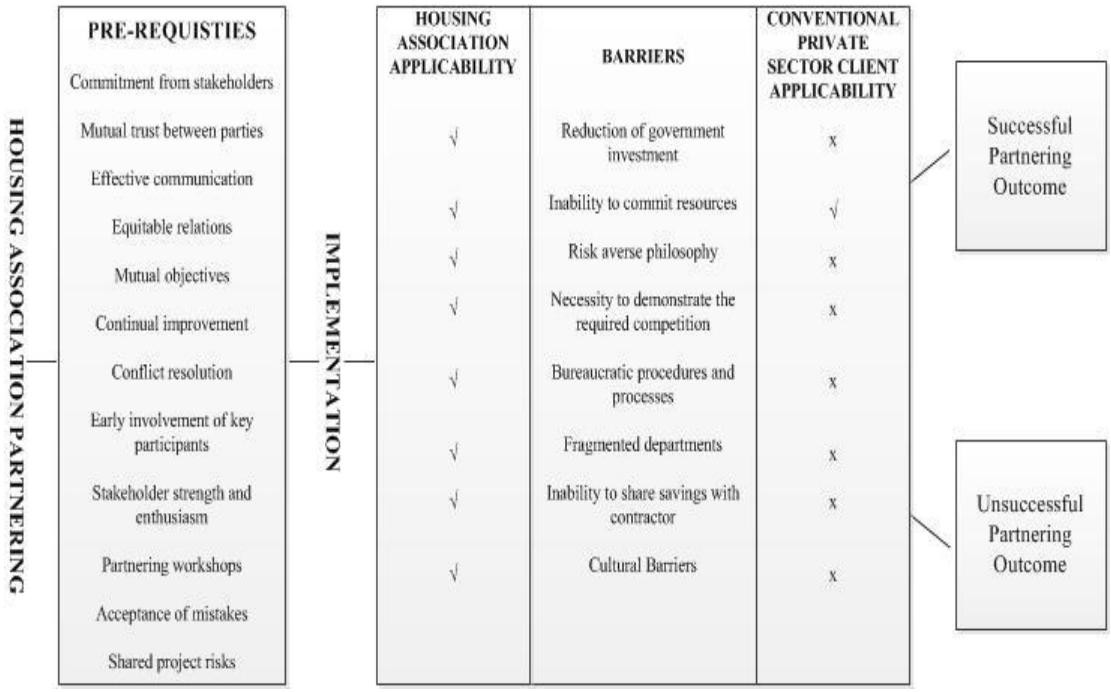

Figure 1: Identified Pre-requisites and potential barriers for Housing Associations

The evaluation of pre-requisites that contribute to a successful partnering outcome was based on literature associated with construction partnering generally. There is limited literature that focuses on specifically Housing Association partnering arrangements, as previously conducted research tends not to focus on a sole client group. The outlined factors that differentiate Housing Association clients from private sector clients highlights the need to establish the essential pre-requisites of partnering for solely Housing Associations, due to differing characteristics. There may be an argument however that these differing characteristics of Housing Association clients could prevent partnering from effectively functioning. The reviewed barriers associated with public or quasi-public sector partnering could compromise the success of a partnering arrangement. It is therefore important that the pre-requisites that contribute to a successful partnering outcome, specifically for the needs of Housing Associations, must be unveiled to increase the probability of obtaining value for money. The subsequent research will address any divergence in the considered levels of importance between the existing literature and the view of Housing Associations.

CONCLUSIONS

This stage of the research required a review of the literature to identify the dominant pre-requisites that assist effective partnering. The reviewed pre-requisites will be validated by Housing Associations in subsequent research to determine the most important pre-requisites from this exclusive perspective. The pre-requisites that commonly featured within the literature were commitment, trust and effective communication. These appear essential elements of the partnering mechanics however, there were other factors argued as being essential contributors to successful partnering. As the plethora of publications lack focus on specific client groups, there was minimal correlation between the pre-requisites and Housing Associations. It is therefore important to understand the pre-requisites essential to exclusively Housing

Associations and subsequently increase the probability of successful partnering. Achieving better value could assist more efficient utilisation of funds and consequently could enable additional construction or maintenance projects to be commissioned. Housing Associations that persevere with partnering during the challenging conditions should be made aware of the necessary pre-requisites that apply to these arrangements. The research will provide guidance to Housing Associations on the necessary pre-requisites and processes that must be incorporated into all partnering arrangements.

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HOUSING ASSOCIATION PREFERRED FORM OF PARTNERING

David Liguori[1], James Sommerville[2] and David Manase[3]

School of Engineering and the Built Environment, Glasgow Caledonian University, Cowcaddens Road, Glasgow, G4 0BA, United Kingdom

Partnering has been implemented by many Housing Associations as the procurement arrangement to maximise value. There are two dominant forms of partnering being utilised, namely strategic and project partnering. The ethos of strategic partnering is long term collaborative working for a series of projects, as opposed to project partnering, based on short term collaboration. There are conflicting views on the appropriateness of each form of partnering and the value that can be achieved. This creates ambiguities for Housing Associations when attempting to implement a partnering arrangement, who may be confronted by a dichotomy between long term value and short-term savings induced by market prices. The form of partnering currently implemented by Housing Associations must be identified. Distinguishing between each form of partnering and the rationale for selection will assist Housing Associations with their decision-making process to implement the appropriate form. The methodology adopted was a fusion between quantitative and qualitative fieldwork. This integrated the numerical data for the frequency of use and the conducted interviews to achieve an understanding of the reasons for selection. Furthermore guidance has been provided to Housing Associations on the form of partnering being implemented within their sector and the perceived benefits that can be achieved. The findings unveiled that the strategic form of partnering is the preferred arrangement for Housing Associations due to the longer term benefits being achieved through continuity of relationships.

Keywords: housing associations, partnering, procurement, project, strategic.

INTRODUCTION

In an attempt to improve an inadequately performing construction industry, the United Kingdom (UK) Government and major clients advocated the implementation of construction partnering. The emergence of partnering within the construction industry was in the late 1980s and is now, a primary management strategy which is believed to improve both the project performance and organisational relations. The UK government endorsed a "Client-Driven" change, which was perceived as improving the ailing construction industry. Egan (1998) advocated the divergence of the UK

[1] David.Liguori@gcu.ac.uk

[2] j.sommerville@gcu.ac.uk

[3] David.Manase@gcu.ac.uk

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construction industry away from the traditional fragmented philosophies to a focus on a collaborative working ethos, which can be translated through partnering. The UK social housing building sector was specifically identified as a potential beneficiary of the partnering ideology. Egan compliance measures were introduced by the Housing Report Forum (2002), which specified the utilisation of Key Performance Indicators and a commitment to partnering. There are two dominant forms of partnering currently being utilised within the construction industry, namely strategic and project partnering. Strategic partnering embraces the notion of collaboratively working on a series of project over time. Project partnering is normally implemented on a single project basis. Upon reviewing the literature, there appears to be a divide in opinion on the appropriate form of partnering to be utilised. In support of strategic partnering, Jones and O'Brien (2003) suggested that the strategic form addresses the limitations of project partnering by building more synergistic and collaborative relationships and improving processes over a longer period of time. Opposing this view, Loraine (1994), believed that project partnering could maximise best value through embracing the ethos of partnering whilst stimulating competition and promoting market entry.

When considering the appropriate form of partnering for Housing Associations to implement, specific factors must be considered. Firstly, Housing Associations are quasi-public sector organisations regulated by the government therefore the necessary level of competitiveness during the tendering process must be demonstrated. Fisher and Green (2001) highlighted that partnering arrangements need to be equipped with appropriate tools to identify and provide sanctions to protect anti-competitive behaviour that can result from partnering agreements. The difficulty for Housing Associations is to ensure that there is a degree of competitiveness in accordance with Official Journal of European Union (OJEU). Even though some critics consider partnering to be more effective through long term strategic partnering arrangements (Love *et al.* 2002; Jones and O'Brien, 2003 and OGC 2007) perhaps a project partnering approach will actually be more suited to Housing Associations at this current moment. Differing characteristics of Housing Association clients compared with private sector counterparts, including prevention to include a provision to share savings with the contractor (Housing Forum, 2000) and their inherent risk-aversive nature (Burnes and Coram, 1999), could also jeopardise long term collaboration, with Housing Associations opting for one off project partnering. The project partnering approach would ensure the required level of competition was evident. Housing Associations could also capitalise on the low price construction market induced by the challenging economic conditions. With both partners aware of the single project arrangement, the manifestation of complacency could be mitigated and the partnering contractor would be incentivised to perform effectively as there is no assurance of future work. Identifying the form of partnering that complements Housing Association partnering arrangements could contribute to achieving best value. The research will therefore attempt to identify the form of partnering that is currently being utilised by Housing Associations and the dominant reasons for selection.

STRATEGIC & PROJECT PARTNERING

The ethos of strategic partnering is continuity of relations and long term collaborative working for a series of projects. At the forefront of the partnering revolution, strategic partnering was viewed as establishing closer, long term and more synergistic relationships that would enhance the performance of construction projects (Bennet and Jayes, 1995 and Egan, 1998). According to Love *et al.* (2002), strategic partnerships are intended to prolong over significant periods of time and should include several

projects to seek gains for the long-term. In support, Jones and O'Brien (2003) suggested that strategic partnering addresses the limitations of project partnering by building more synergistic and collaborative relationships and improving processes over a longer period of time. OGC (2007) described strategic partnering as the integrated supply team and the client organisation working together on a series of construction projects to promote continuous improvement. Collaboratively working together over a prolonged period of time could increase efficiencies and produce cost savings, as long as trust is maintained (Black *et al.* 2000). A significant contributing factor for these savings could be increasing the effectiveness of systems and operations over a long term working arrangement. The OGC (2007) also stated that strategic partnering can produce significant savings, of approximately 30% in the cost of construction.

Project partnering is based on limited co-operative relationships involving two or more parties seeking short-term project related benefits, which is unlikely to extend to long term co-ordination and collaboration. OGC (2007) described project partnering as involving the integrated supply team and the client working together on a single project, usually following a competitive procurement. In support of project partnering Loraine (1994) suggested that this form of partnering may have greater long-term significance than strategic partnering for reasons including; It does not restrict market entry; price features somewhere in the relationship, allowing success and improvement to be more easily monitored; and there is still a stimulation of competition. Beach *et al.* (2005) noted that many organisations will experiment with project partnering and wait for provable, positive results before initiating any strategic partnering relationships. Project partnering is characterised by short term project related benefits received from a single project. OGC (2007) stated that project partnering can achieve savings of 2-10% in the cost of construction, in contrast to the potential 30% saving associated with strategic partnering. This shortfall highlights that perhaps investing in the processes to implement a long term strategic partnering arrangement may provide Housing Associations with more value for money. The notion of partnering is underpinned by long term commitment and continual improvement (Egan, 1998; Jones and O`Brien, 2003; OGC, 2007). It may therefore be unlikely that Housing Associations maximise best value, which is necessary during the challenging economic conditions, through implementing a project partnering arrangement.

The performance of a large scale strategic partnering arrangement for UK social housing, known as the AMPHION initiative, was observed and assessed by Jones and Kaluarachchi (2007). This initiative comprised of 15 separate Registered Social Landlords (RSLs) partnering with one contractor to deliver 2000 homes over a four year period. The Key Performance Indicators (KPIs) measured to identify the success of the initiative highlighted that the performance was disappointing compared to the UK house building sector. Consequently, during the AMPHION initiative, Jones and Kaluarachchi (2007) noted that the strategic partnering arrangement began to fragment into a series of smaller "project partnering" arrangements as these were considered easier to manage. This reversion to project partnering suggests that Housing Association clients may actually be more suited to these short-term partnering arrangements. Despite some of the AMPHION Housing Associations moving towards project partnering, Osei-Mensah *et al.* (2008) identified long term strategic partnering as providing significant benefits to Housing Associations, including a balance between low costs, high productivity and successful outcomes.

As Housing Associations are regulated by the government and are non-profit organisations, full compliance with all procurement competition legislation is vital. Implementing project partnering, as opposed to strategic, could therefore be beneficial as projects are procured on a "one-off" basis. For this reason, Woodrich (1993) believed that project partnering would be utilised within public sector procurement arrangements. Based on the AMPHION initiative, Kaluarachchi and Jones (2007) unveiled specific factors considered to have affected the social housing strategic partnering model, which included: a lack of communication; failure to share information; and a lack of understanding of the partnering process. The risk averse nature of quasi-public sector organisations (Burnes and Coram, 1999), in conjunction with the factors that affected the AMPHION social housing strategic partnering arrangement, could produce significant barriers to the effective implementation of strategic partnering. The conflicting social housing research findings, the quasi-public sector characteristics and the challenging economic conditions all highlight the need to clarify the current Housing Association position on the form of partnering arrangements being implemented and the reasons for selection.

METHODOLOGY

The reviewed literature induced a mixed method approach to identify the forms of partnering being utilised by Housing Associations and the reasons for use. The conflicting view from the literature of the partnering form implemented by Housing Associations emphasised the necessity to clarify the current level of usage for each arrangement. Undertaking interviews with the personnel responsible for procurement within the Housing Associations provided a deeper and robust understanding of the main reasons for selecting a specific form of partnering. A questionnaire was compiled and distributed to Housing Association procurement personnel. This questionnaire was produced to identify the number of Housing Associations that implemented each form of partnering, calculate the proportion of work commissioned on this form of partnering and assess the level of importance placed by Housing Association on utilising a specific form of partnering. The survey sample was compiled by utilising the Scottish Federation of Housing Associations information on the current Housing Associations operating in Scotland. The investigation enabled the identification of 90 Housing Associations in Scotland that possessed the capabilities of answering the questionnaire. From the 90 surveys distributed, 52 responses were received, providing a response rate of 57%.

A series of structured interviews were also conducted to gain an understanding of the reasons for selecting a specific form of partnering and the subsequent benefits. Upon examining the Scottish Federation of Housing Associations information on the size and types of project that the Housing Associations are involved in, a list of eight possible interviewees was collated. These interviewees were key personnel working within the procurement section of the Housing Association. The Housing Associations are all anonymous therefore within the research are named Housing Association A to H. The template approach was utilised to examine the interviews, identifying common themes and sub themes.

QUANTITATIVE FINDINGS

Form of partnering utilised by Housing Associations

The initial question for Housing Association participants was to understand the form of partnering currently being utilised when procuring construction or maintenance

projects. The results of the quantitative analysis identified that strategic partnering is the most frequently used partnering arrangement by Housing Associations, with 32 of the 52 Housing Associations utilising strategic partnering, representing 62% of responses. The results conclusively identified that even during the challenging economic conditions the majority of Housing Associations have been persevering with strategic partnering. Project partnering represented 25% of Housing Associations, equating to 13 out of the 52 respondents, highlighting that the temptation of competition during the low price market conditions has not been completely resisted. Seven Housing Associations appear not to have engaged in any partnering, representing 13% of participants. Figure 1 illustrates the graphical representation.

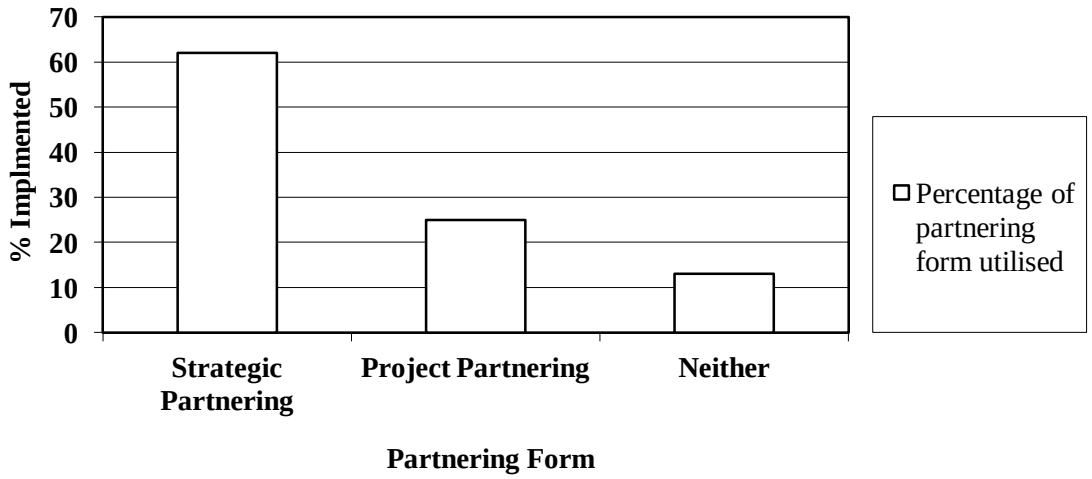

Figure 1 Most Frequently Used Partnering Arrangement by Housing Associations

Percentage of work commissioned on their selected form of partnering

The quantitative data for the percentage of Housing Associations` that commission projects on the basis of their preferred form of partnering, highlighted that the mean percentage of work commissioned through adopting their preferred partnering arrangement was a substantial 71%. This demonstrates that Housing Associations are utilising their favoured form of partnering when procuring works. A mode was calculated at 70% for the percentage of work commissioned on the basis of the Housing Associations selected form of partnering. This highlighted a significant proportion of work is being procured by Housing Associations on their favoured form of partnering. The results suggest that even during the challenging economic conditions, Housing Associations are placing faith in the long term benefits of partnering.

Housing Association importance levels

Housing Associations were asked to rate the level of importance associated with selecting their preferred form of partnering to understand if differentiating between each form of partnering is a key issue for Housing Associations and subsequently validate the necessity for undertaking the research. The results indicated that 37 of the 52 Housing Associations considered that adopting their preferred form of partnering was either important or very important. The results highlight that prior to Housing Association procuring a construction or maintenance project, significant consideration is given to the appropriateness of each form of partnering. 12 of the 52 Housing Associations regard the selection of a specific form of partnering as either very unimportant or unimportant, which includes the seven Housing Associations that

appear not to utilise partnering. Only three Housing Associations did not consider the selection of a specific partnering arrangement as important or unimportant.

QUALITATIVE FINDINGS

Form of partnering implemented

Housing Association participants were initially asked to identify the form of partnering that they utilise for construction and maintenance projects. Housing Associations A,C,D,E,G,H all implement strategic forms of partnering. Housing Associations B and F opt for the project partnering form.

Reasons for strategic form of partnering

Higher quality through continuous improvement
Receiving a higher quality through Housing Associations collaboratively working with contractors for a series of projects was viewed by Housing Associations C,G and H as being an important benefit of strategic partnering. Housing Association C and H both highlighted that the quality achieved for maintenance projects significantly increased as working with the same contractor over a series of projects developed the understanding of the Housing Associations expectations. Housing Association G believed that the effective communication between the parties enabled the Housing Associations standards to be adhered to and defects were rectified quickly.

Better Key Performance Indicator Results
Housing Association A believed that measuring the performance of the kitchen replacement cyclical contract with the contractor improved the performance each year, as the mutual objectives were clearly defined and the contractor fully understood the output expected from them. Housing Associations D and E both considered the measurement of key performance indicators for each year of a five year maintenance cycle and the continuity of relations with their respective contractors as key factors that continually improves performance. Housing Association C commented that tenant satisfaction surveys increase as the contractor is committed to providing high quality finishes over the duration of strategic partnering arrangements.

Long term cost savings
Housing Association A and C both commented that cost savings have been made through their respective partners offering discounts to the initial agreed costs after the first year of the partnering arrangement, as they are provided with continuity of future workload and the contractor becomes more efficient executing the work. Housing Association D also highlighted that long term contracting parties also suggest the utilisation of alternative materials or processes that provide the same function at a cheaper cost, thus providing savings.

Potential community benefits from long term partnering arrangements
Housing Associations G and H both received community benefits from long term partnering. A number of apprentices, who were tenants of the Housing Associations, were employed by the partnering contractor. Housing Association G noted that the long term commitment between the parties enabled the contractors to employ apprentices, who subsequently finished their training and became qualified tradesmen.

Effective execution of partnering processes
A common theme identified from Housing Associations A,C,D,E,G,H was that a partnering arrangement needs a prolonged period of time to set up operating systems and effectively implement the process. The consensus from the Housing Associations

was that partnering over a series of projects enabled partners to build trusting relations, commit to mutual objectives, more effectively communicate and continually strive to improve the partnering outcome.

Reasons for project form of partnering

Competitive market prices received
Housing Associations B and F believed that receiving competitive market prices for "one-off" partnering projects was a fundamental factor for selecting project partnering. Both commented on the current low price market and the need for them to capitalise to produce savings. Housing Association F commented that the savings made from low price competitive tendering for the partnering arrangement outweighed the potential long term savings gained from strategic partnering.

Competition easily demonstrated
Housing Association B emphasised the need to demonstrate the necessary level of competition in accordance with European procurement legislation. The respondent believed that project partnering offered the required level of competition at competitive prices. Housing Association F also highlighted the ease of adherence to procurement legislation through adopting a competitively tendered partnering project for individual projects.

Safeguards against complacency
Housing Associations B and F implement project partnering to safeguard against complacency entering into the arrangement. Housing Association B believed that project partnering incentivised contractors to optimise performance, attempting to extend the contract. Housing association F considered project partnering as taking the positives of partnering while mitigating the risk of complacency.

DISCUSSION

The quantitative analysis initially attempted to identify the form of partnering being utilised by Housing Associations. Gadde and Dubois (2010) believed that a rapid shift to strategic partnering was unrealistic. The research however challenges this view as 62% of the participating Housing Associations utilise strategic partnering, as opposed to the 25% that implement project partnering arrangements. Interestingly, despite the clear endorsements to implement strategic partnering forms (Bennet and Jayes 1995: Egan, 1998; and OGC, 2007) a quarter of Housing Associations are utilising project partnering. The interviews conducted suggest that driving costs down is the main reason for this. The percentage of work commissioned on the Housing Associations preferred partnering form equated to a substantial 71%, highlighting that Housing Associations are persevering with partnering during the challenging economic conditions. Latham (2008) emphasised that if clients abandon best practice, stop partnering, and return to lump-sum contracts, based solely on lowest price, the industry will go back to its undesirable practices. It would appear that Housing Associations have subscribed to this procurement ideology and are persevering with long-term partnering. The validation of the necessity for the research was evident as 37 of the 52 Housing Associations considered that adopting their preferred form of partnering was either important or very important.

The qualitative analysis attempted to understand the reason for selecting a specific partnering form and the perceived benefits. From the eight Housing Association interviewees, six utilised strategic partnering and two opted for project partnering, echoing the quantitative data for the form of partnering utilised. The first common

reason and perceived benefit for strategic partnering was the potential for Housing Associations to receive higher quality through continuous improvement. A consequence of Housing Associations achieving higher quality was the increased key performance indicator (KPI) results achieved. One of the important KPI results was the increase in tenant satisfaction, believed to be attributable to the continuity of employing a single contractor over a long period of time, as they are more aware of the objectives of the Housing Association and their tenants. The conducted interviews challenges the AMPHION initiative as Kaluarachchi and Jones (2007) indicated that the quality of product suffered as the number and severity of defects were amongst the worst performing KPIs within this large scale strategic partnering arrangement. Long-term cost savings was also identified by Housing Associations as a benefit of strategic partnering. The interviews highlighted that as the partnering contractor becomes more efficient through undertaking a series of projects, savings have been offered to Housing Associations.

This research supports the findings of Osei-Mensah *et al.* (2008), who identified that lower costs were achieved through long term Housing Association partnering. Also, more effective value engineering is suggested by contractors to provide savings for alternative materials and processes with the same function. Housing Associations receiving cost savings through strategic partnering supports the assertions from Black *et al.* (2000) and OGC (2007) that substantial cost savings can be achieved through strategic partnering. Community benefits were also identified by housing Associations as an important driver for strategic partnering as Housing Associations can request that the partnering contractor employs and trains apprentices, who are tenants of the Housing Association. The main reasons for Housing Associations use of strategic partnering was that long term arrangements could improve the partnering process through building trusting relations, commitment to mutual objectives, more effectively communicate and continually strive to improve the partnering outcome. This view supports Jones and O'Brien (2003) suggestion that strategic partnering provides more synergistic and collaborative relationships and improving processes over a longer period of time.

Two of the eight Housing Associations did however utilise project partnering. One of the main drivers was the competitive market prices received during the challenging economic conditions. Both Housing Associations considered the low prices as outweighing the potential long term benefits of strategic partnering. This supports the view of Lorraine (1994) who highlighted that price features somewhere in the project partnering arrangement, allowing success and improvement to be more easily monitored. Another driver for project partnering was the ease of demonstrating the required level of competition, in accordance with procurement legislation. This concurs with Bygballe *et al.* (2010) who considered tendering procedures and public procurement arrangements as the main factors contributing to short term procurement arrangements. Another perceived benefit of project partnering considered by Housing Associations was the safeguard against complacency entering into the arrangement. They believed that short term project partnering utilised the partnering mechanism and protected the freshness and enthusiasm as there was no guarantee that the contracting partner would receive any future work. The notion of complacency within long term partnering arrangements was highlighted by Cartlidge (2002) as a significant limitation that could compromise the benefits of partnering.

The quandary for Housing Associations is between long term value against short term gains. This dichotomy has been discussed for decades and it would appear to even

apply to partnering arrangements. The question is, can short term "one-off" partnering arrangements for Housing Associations, embrace the true ethos of partnering, incorporating fundamental processes such as continual improvement, mutual trust and commitment? Previous research that focussed on social housing partnering suggests that this is feasible. Jones and Kaluarachchi (2007) highlighted that during the AMPHION strategic partnering arrangement, there was an implementation shift towards project partnering to assist the performance of constructing new build social housing. This research appears to disagree, highlighting that even during the challenging economic conditions, Housing Associations are persevering with long term collaboration and receiving long term value.

CONCLUSIONS

The research attempted to identify the form of partnering being utilised by Housing Associations and to understand the reasons for selection during the challenging economic conditions. The research identified that strategic partnering is the dominant form of partnering currently being implemented by Housing Associations. The main reasons for this are the identified long-term benefits that include higher quality, significant cost reductions and community benefits. The research has challenged the findings of previous research within this sector of the construction industry, as Housing Associations appear to have embraced and persevered with strategic partnering during the current economic climate. Project partnering was still utilised by a quarter of Housing Associations, predominantly to receive more competitive prices and more effectively safeguard against competition regulation and complacency. This research has importantly clarified to Housing Associations that strategic partnering has been persevered with during this economic period and has also highlighted the perceived benefits of each form of partnering from an exclusive Housing Association perspective.

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HOW TO PROPORTION CAPABILITY AND FEE PERCENTAGE FOR TEAM COMPARISON IN COMPETITIVE EARLY INVOLVEMENT

Pertti Lahdenperä[1]

VTT Technical Research Centre of Finland, PO Box 1300, FI-33101 Tampere, Finland

Early involvement of the construction team is increasingly utilized in challenging projects to incorporate versatile expertise in their planning. For public owners this is a challenge since they are obliged to use competitive, transparent team selection based on the 'most economically advantageous criterion' which ensures that both price and quality viewpoints are taken into account. In the case of early involvement, the price component naturally does not include the total price, but may consist only of the fees of competing service providers. This study examines such a selection situation and seeks to find a way to integrate the fee component in a multi-criteria selection system and determine reasonable fees for different levels of capabilities. The study builds on the productivity difference between different competences, derived from a survey of practitioners, and determines an indifference curve arithmetically for the planning of a selection method. The influence of the owner's risk attitude and risk premiums are also taken into account based on the pricing methods of the theory of finance.

Keywords: alliancing, early involvement, contractor selection, partnering, procurement.

INTRODUCTION

It has long been the custom in construction to select service providers, especially contractors, solely on the basis of the lowest bid. The practice has led to adversarial relations and created problems in the sector thereby impeding its development. Pressures to renew the principles of implementer selection come also from a broader cultural change: a value-added strategy is now being pursued also in infrastructure construction and more collaborative, relational project practices are increasingly applied. A collaborative approach often also means early involvement of the key parties to the building process since traditional, sequential involvement of the parties does not allow mutual exchange of information and collaboration for the benefit of the project. Early involvement has also become part of governments' strategies (Valkenburg *et al.* 2008; Government Construction Strategy, 2012).

As if it were not difficult enough to use price-inclusive multi-criteria selection in the later stages, applying it to early involvement is even more challenging. At that stage,

[1] pertti.lahdenpera@vtt.fi

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the project is fraught with too much uncertainty which makes it difficult to estimate costs reliably. Due to the resulting risk premiums, it is not sensible to organize normal price-inclusive competition and fix the price in the early stages of project development.

Instead, the solution is to strive for an open, transparent process where the price (target cost) is set later after a joint development phase by the owner and the team involved. However, it is not reasonable to ignore the cost and price elements totally even then and give the service provider disproportionate power to price the project subsequently. Actually, it is necessary especially for public owners to set constraints and/or a mechanism for price formulation also in the case of early involvement in order to comply with procurement directives (e.g. Directive, 2004) and their *most economically advantageous tender* criterion.

In this respect, the fees of participating companies are in key position. Although the direct costs cannot be estimated yet, it should be relatively easy to agree on percentage (or fixed) fees that include company overheads and profit considering that there is common understanding of which cost items are compensated as direct costs and which are not. The fee can represent the price component in competitive selection. The challenge is, however, that the direct costs of competing companies or teams cannot be expected to be the same which makes the decision-making situation different from the more usual total price plus quality competition. Yet, the system has to support the maximisation of value for money. For that, it also has to be objective and impartial to entice tenderers and incentivise them to do their best – not only play 'lottery'.

This study aims to respond to the last mentioned challenge by developing a method to include the fee component in a selection system that covers team capability as a qualitative measure and fee percentage only as a price component. The objective is to override the typical problem of approximation by grounding the approach on a strict, reasonable mutual relationship between price and value and keeping the system as simple as possible.

The target application is a project alliance (see Department, 2011; Lahdenperä, 2009) team selection (for an infrastructure project in Finland) where the fee component covers both overhead costs and profit of the service providers, and is based on the team member companies' fees weighted by their expected cost shares; team members are selected as a group including both design and construction resources, not separately. The study skips the examination of the quality/capability/competence assessment system assuming that it can take the form of a multi-criteria evaluation resulting in an overall score that will then be taken in account in the method resulting from this study to combine the fee and quality components.

STATE OF THE ART AND RESEARCH DESIGN

The challenge of selecting the best service providers for a project has generated a lot of research. Suffice it to say that Holt (2010) has completed a relatively comprehensive review of the multifaceted research on contractor selection. Considering the mass of studies on supplier selection, relatively few studies have focussed on the question of how to sensibly combine overall quality assessment and price for the determination of the best option in each case. Yet, Drew *et al.* (2001), Dreschler (2009) and Waara and Bröchner (2006) have examined the methods used in practice. None of them, however, deal with the situation examined in this study.

Moreover, current methods typically seem to follow an approach where the tenderer earning the highest total points is selected and the component scores for competitors are calculated in relation to the lowest price or the highest quality tendered. Chen (2008) points out that the approach results in serious shortcomings in the system's functioning and calls it a *ranking paradox*. Telgen and Schotanus (2010) state the same in even less uncertain terms: relative scoring methods will never guarantee that the selection is in line with the preferences of the buyer, as their exact form and position depends on the bids coming in; as such, relative scoring methods replace the preference of a buyer by a lottery. Chen (2008) concretizes his presentation by introducing the extra concept of *independence of irrelevant alternatives* reminding that the relative ranking of two alternatives must not be affected by a third alternative. Thus, it is quite clear that literature does not contain relevant awarding systems and the quality-price relation should be determined directly in terms of *value for money*.

While the value for money approach has generally been neglected, in the case of fee-inclusive competition (excl. total prices) its application is even more challenging due to the difficulty of price estimation. Here, the remarks by MacCall (1970) and Rosenfeld and Geltner (1991) about the need to view the cost plus fee market side-by-side with the more common fixed price (competition) market are appropriate. As a result better players are available to cost plus fee projects only if they can expect to earn the same profit they would make in alternative markets, where the price level is basically the same for efficient and inefficient players. This results in fee differences.

Therefore, in order to determine the *indifference curve* needed for the design of a selection method, the performance difference between the best imaginable, but realistic, and the weakest qualified performers (market extremities) is determined in an indifference situation where the value and price to the owner are both standardized (only direct costs and fees differ). A calculation method for that is developed in the next study stage and presented in the next section.

The performance difference cannot, however, be easily measured in the real world of one-off projects where various other factors tend to contribute to any existing data. For that reason, the study is based on a survey of experienced practitioners who were educated for the very same selection situation as in the study in the first of its kind procurement in the target market as explained above. Besides, the risk related to competing alternatives needs to be analysed and taken into account on a more theoretical basis since the owner may consider the acceptance of a higher fee risky.

The study constrains itself to the examination of a formula for drawing a conclusion based on overall capability evaluation and a fee proposal; it does not focus on detailed examination of capability more than is necessary to (conceptually) determine the extreme performers. The capability assessment is assumed to be trustworthy as it is based, for instance, on the methods and procedures used in a project in which the survey respondents participated, which has been reported by Lahdenperä (2012). The qualitative criteria used are numerous, diverse and intangible and would require much more detailed discussion than is possible in this summary.

BASIC FEE ELASTICITY CALCULATIONS

Deriving the basic formula

This section focusses on the cost efficiency difference between the supposed extremities, the 'weakest' and the 'best' performers. The target is to design a calculation model that allows determining a reasonable fee difference to be

incorporated in the actual selection model that corresponds to the capability range. Figure 1 should clarify the presentation.

Let's start by looking at the case where a project is to be implemented by the weakest performer. Then, the direct cost (C_W) plus the team's fee percentage (F_W) would form the cost to the owner (P_W):

$$P_W = C_W * (1 + F_W) \qquad (1)$$

Correspondingly, if the best performing team is able to construct the project at lower cost without compromising quality, it can be said to have an efficiency advantage (E_Δ [%]) over the weakest performer while doing the same work at the cost of P_B:

$$P_B = C_W * (1 - E_\Delta) * (1 + F_B) \qquad (2)$$

If the best performer is allowed to reap the entire efficiency benefit, its fee can be significantly higher than that of the weakest performer. In such a case the alternatives would also be of the same cost to the owner, i.e. P_W would equal P_B. Since this assumption ignores risk attitude, as will be explained later, the situation is purely hypothetical – thus, F_B is replaced by F_N in Formula (2) to depict that 'neutral' case:

$$C_W * (1 + F_W) = C_W * (1 - E_\Delta) * (1 + F_N)$$

$$\Rightarrow 1 + F_W = (1 - E_\Delta) + (1 - E_\Delta) * F_N$$

$$\Rightarrow F_W + E_\Delta = (1 - E_\Delta) * F_N$$

$$\Rightarrow F_N = (F_W + E_\Delta) / (1 - E_\Delta) \qquad (3)$$

In practice it is, however, unlikely that a conservative (public) owner selects the best performer on paper if it costs relatively as much as another option: the cost-oriented owner is not willing to pay that much for extra value, and moreover, there is no guarantee of better performance – which may require novel, still non-existent innovative approaches – yet the higher fee percentage would be fixed. In other words, the owner carries the risk related to the expected production efficiency. In such a case the owner may well require compensation for doing that in accordance with the general business practice.

A compensation, or absolute risk premium (R_A), means that the expected price of the best performer in the above case has to be lower than that of the weakest alternative:

$$P_W = P_B + R_A \qquad (4)$$

Basically, the absolute risk premium is calculated as a share, i.e. relative risk premium (R_R), of the underlying risk (U_R) – which, again, is the price difference (resulting from different fee percentages) when the best performer is no better than the weakest one in terms of direct costs ($E_\Delta = 0$ and C_W is, therefore, valid for both teams):

$$R_A = R_R * U_R = R_R * [C_W * (1 + F_N) - C_W * (1 + F_W)]$$

$$\Rightarrow R_A = R_R * C_W * (F_N - F_W) \qquad (5)$$

If we return to Formula (4), and replace its parameters with the equivalent parameters of Formulas (1), (2) and (5) respectively, it rewrites to

$$C_W * (1 + F_W) = C_W * (1 - E_\Delta) * (1 + F_B) + R_R * C_W * (F_N - F_W) \qquad (6)$$

By dividing both sides of Formula (6) by C_W and by entering F_N of Formula (3) in it, the following ensues:

$$\Rightarrow 1 + F_W = (1 - E_\Delta) * (1 + F_B) + R_R * ((F_W + E_\Delta) / (1 - E_\Delta) - F_W)$$

$$\Rightarrow 1 + F_W = 1 - E_\Delta + (1 - E_\Delta) * F_B + R_R * ((F_W + E_\Delta) / (1 - E_\Delta) - F_W)$$

$$\Rightarrow F_W = - E_\Delta + (1 - E_\Delta) * F_B + R_R * ((F_W + E_\Delta) / (1 - E_\Delta) - F_W)$$

$$\Rightarrow (1 - E_\Delta) * F_B = E_\Delta + F_W - R_R * ((F_W + E_\Delta) / (1 - E_\Delta) - F_W)$$

$$\Rightarrow F_B = (E_\Delta + F_W - R_R * ((F_W + E_\Delta) / (1 - E_\Delta) - F_W)) / (1 - E_\Delta) \qquad (7)$$

This is the way to determine the reasonable fee for the best performer (F_B) in relation to that of the weakest performer (F_W) in an even case when actual estimates of efficiency advantage (E_Δ) and risk premium (R_R) exist.

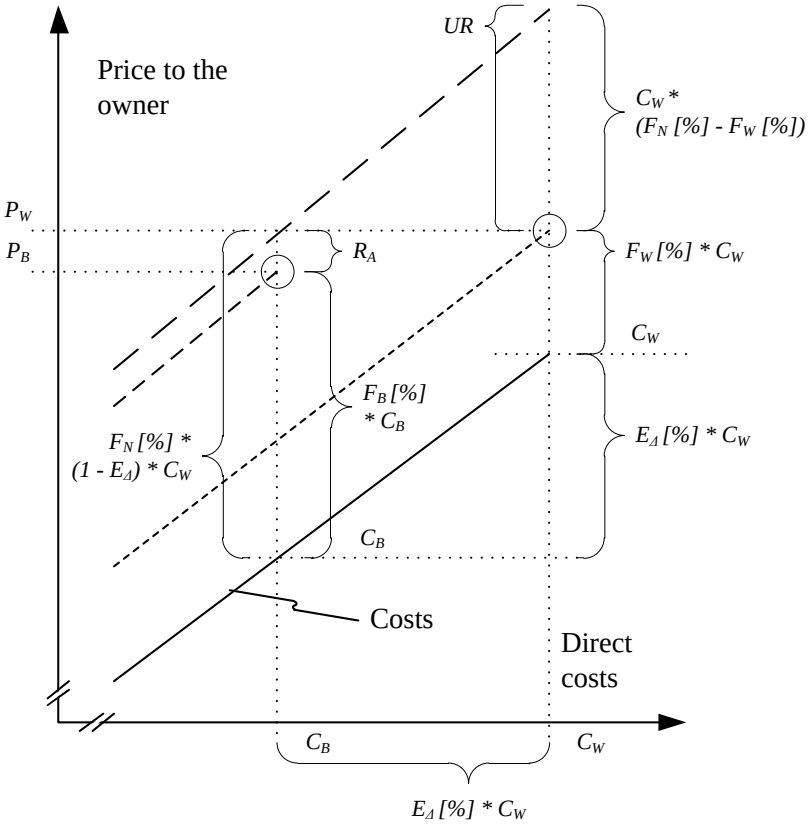

Figure 1. An illustration of fee elasticity calculations.

Defining the risk premium

Underlying price risk (U_R) can be considered the amount the owner has at stake when selecting the potentially best performer, i.e. a sum the owner expects to receive a return on. In finance, the capital asset pricing model (*CAPM*) is used to determine the required rate of return on an asset (e.g. Fama and French, 2004). It determines the return as the sum of a risk-free rate of interest and the product of systematic risk and the difference between the expected market rate of return and the risk-free rate of return:

$$E(R_i) = R_f + [E(R_M) - R_f] * \beta_{iM} \qquad (8)$$

where $E(R_i)$ = the expected return on asset i

R_f = the risk-free interest rate

$E(R_M)$ = the expected market rate of return

β_{iM} = the market beta of asset i

$E(R_M) - R_f$ = the equity risk premium (*ERP*), i.e. expected market rate of return in excess of the risk-free rate

In other words, the expected return on any asset is the risk-free borrowing rate plus a risk premium. In this work we are not interested in pricing assets but only in finding a relative, industry-related estimate for operation risk which is (tentatively) given by the product of beta and the market risk premium in Formula (8) above. The risk-free component can be ignored since the time-value of money has no meaning here: the owner does not make an actual deposit and the payment to an alternative service provider actualizes on the same schedule and, moreover, the payment is tied to an index in most cases also in multi-year contracts.

Therefore, in terms of the above parameters, the relative risk premium is simply as follows:

$$R_R = ERP * \beta_{iM} \qquad (9)$$

ACQUISITION OF INITIAL DATA

Literature survey for determining risk premium

There seems to be no unanimity about how risk premiums should be determined. Moreover, there are significant differences between time periods, sectors, sizes of business, and geographical areas and/or countries. While detailed discussion on the topic is beyond the scope of this summary, the study rests on the following findings:

In recent decades equity risk premiums (*ERP*) have been about half of the last century's average of 6−10% (e.g. Damodaran, 2011). Besides, the average view of chief financial officers (over a 10 year investment period) has typically remained within 3−4% in recent years (Graham and Harvey, 2010).

In engineering and construction the range of (unlevered) betas (β) has been from ½ to 1½ (Damodaran, 2012). However, it has been suggested that the so-called total beta be used for undiversified owners of businesses, which would give us approximate total beta values from 1 to 4, respectively.

Considering expert opinions and the recent trends against the long-term historical trend, the average range of *ERP* is 3−5%. The relatively short duration of the typical construction project for which the risk premium is defined would suggest a lower figure. Moreover, contracted work does not involve the risk of getting deals which is built in *CAPM* pricing. On the other hand, an individual project is subject to significantly bigger risk than a portfolio of projects where the projects tend to vary in terms of success; their successes and failures often roughly offset each other. The initial range can be considered appropriate.

As concerns the value of beta, here we deal with a stand-alone asset, to which total betas are applied (due to the risk related to it that cannot be diversified): values 1−3 tend to be reasonable. In summary, multiplication of the extreme beta and equity risk premium values according to Formula (9) produces a wide range (3%−15%) that yields a middle or basic value of 9% for further calculations.

Questionnaire survey for determining performance levels

A questionnaire survey was conducted to gather the practitioners' views on the estimates on the efficiency advantage (E_Δ) of the above formulas and the likely actual range of fees. The target group consisted of the key personnel involved in the first ever project alliance competition in Finland which used the type of selection criteria

that are the subject of the study. Thus, the respondents can be considered to be familiar with the subject and the decision making situation in general. Altogether 74 owners' representatives, owner's consultants, and competing designers and contractors were sent a link to an Internet questionnaire. A total of 32 responses were received.

The overall survey covered a considerably broader field than is dealt with here, but the questions relevant to this study were the following (in condensed form):

Question 1. If the goal was to reap the added value generated by the best team only in the form of project cost savings (excl. implementer fees) other quality and value factors remaining the same, how much lower would the costs [%] of the best, realistic implementation team be compared to the weakest possible one that nevertheless meets the suitability criteria of a demanding project?

Question 2. In the case of a typical project suitable for delivery under an alliance contract in a normal economic situation, what is the broadest realistic average range of fee percentages [a%−b%] for different bidding consortia (considering that a quote is requested at the end of a laborious selection phase when polite and test bids are unlikely)?

Table 1 presents the results of the survey. As to efficiency advantage (E_{Δ}), 17% is a reasonable basic value for the analysis based on the survey. Yet, the calculated margin of error (for 95% confidence level) makes it necessary to extend the analysis to include also the extremity values of 13% and 21% (i.e. basic value ± margin of error). The suggested fee range is from 10% to 20% in the studied case.

Table 1. The results of the survey.

Question	1	2a	2b
Parameter	Efficiency advantage	Lowest fee%	Highest fee%
Number of responses	26	24	24
Average response	16.84	10.21	20.25
Standard deviation	10.02	5.45	8.58
Margin of error	3.85	2.18	3.43

RESULTS OF THE STUDY

The basic solution

By using the above determined Formula (7) together with estimates for efficiency advantage (E_{Δ}) derived from the survey (17%) and the relative risk premium (R_R) produced by the theoretical examination (9%), a reasonable F_B can be calculated as a function of F_W as presented by the solid line in Figure 2.

The figure shows how the difference between F_W and F_B in an indifference case – or *fee elasticity* in terms of the study – is nearly a constant 20 percentage units across the scale irrespective of the magnitude of F_W, which is an important observation from the viewpoint of the development of the selection method. Varying of the parameters (E_{Δ}, R_R) up to the extreme values (as a consequence of the margins of error of the survey and the ambiguousness of the risk premium examination) provided other estimates for F_B as illustrated by the broken lines of the figure. Thus, fee elasticity could be lower or higher than the suggested basic 20 percentage units. Sensitivity analysis shows that the reliability of the study is not excellent and much room for speculation still remains as becomes obvious in the next section.

Correspondingly, the *indifference curve* is any line from a point defined by the lowest performance level and a certain fee to a point defined by the highest performance level and a fee that equal to the former fee plus the fee elasticity. Thus, application of the research result is basically very simple. For instance, if the competing teams are evaluated based on their capability on a scale from 0 to 100 points (P_C) equalling relevant industry extremities (not extreme tenderers), the same scale is used for scoring the fee (P_F) as follows:

$$P_F = 100 - 100 * (F_I - F_L) / A_F \qquad (16)$$

where F_I = the fee (of tenderer *I*) to be scored
F_L = the lowest fee tendered
A_F = fee elasticity

Fee elasticity has to be decided project-specifically based on the above numbers (and considering the comments below). The highest total points (P_C+P_F) scored determine the best option, and no weighting is needed, which maintains the targeted simplicity. The model is transparent and allows tenderers to calculate the score for any potential performance combination in relation to other options thereby avoiding the *reference paradox*. Moreover, the method as an entity is based on *value for money* thinking.

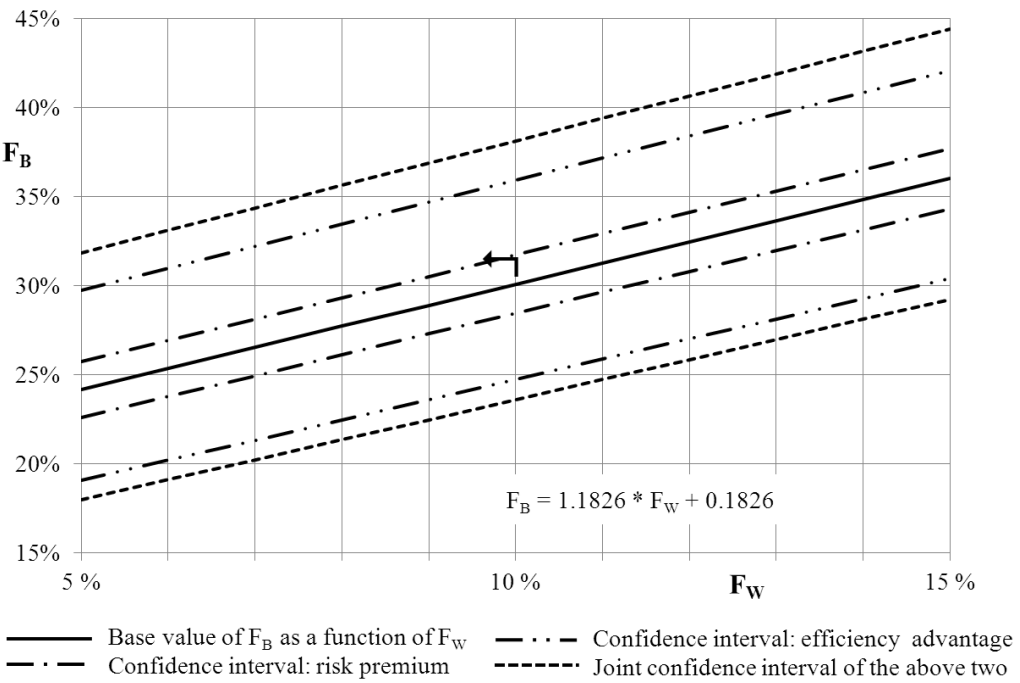

Figure 2. Fee ranges equivalent to capability variation.

Adjusting the solution for practical applications

The respondents to the survey were experienced professionals and obviously also aware of the targeted decision situation where their views would be made use of since they had just participated in a similar competition. Yet, the relatively wide deviation in views resulting in a wide margin of error in the combined estimate tends to lower the reliability of the study. And verification of the estimate is not easy due to the lack of relevant comparison views and/or data.

This being the case, public owners may well prefer lower fee elasticity than suggested by the basic value since they tend to be risk adverse considering the tradition of price-oriented selection and public accountability. In other words, the owner is likely to be

conservative in valuing the anticipated better performance itself since it is not guaranteed while the possibility of loss, once the fee (percentage) has been accepted, becomes irreversible. Even then the owner should not accept less than 15 percentage units according to the study, since it has already taken the risk into account and the uncertainty is mainly related to the magnitude of the estimated efficiency advantage.

Although there is no exact means of estimating the direction of the possible error in the fee elasticity estimate, it is also possible that the respondents, although experienced practitioners, are not able to distinguish a team-related performance variation from other accidental or project-related variations whereby the estimated cost efficiency advantage becomes unreasonably large. That also speaks for a lower fee elasticity which should not be a problem either since 15 percentage units would still be more than the anticipated practical fee range according to the survey. Slightly lower fee elasticity is also suggested by the basic value of the *value-add* examination carried out in parallel with the presented *efficiency advantage* approach, but not reported in this summary (i.e. 18 percentage units instead of 20).

DISCUSSION AND CONCLUSIONS

There seem to be strong indications that early involvement of the key players of a construction project is often worthwhile in case of large, highly complicated and risky projects. There the candidate teams' capability and potential are subjected to a thorough review. Performance in reference projects, skills and the chemistry within the project team, management and project development approaches and, first and foremost, the ideas for improvement and cost savings will be examined thoroughly. Only then can a reasonable, knowledgeable decision on the service providers be made.

Yet, that it is not enough. If early involvement is chosen, it is certainly better to fix the fee than leave all components open to negotiation with selected service providers. Therefore, both capability and the fee become criteria for competitive selection. In fact, that is the only way public owners usually are able to apply early involvement in major projects due to procurement rules and/or probity auditing.

This being the case, a balance has to be found between the fee and capability components in an award system so that any change in them impacts the overall score in proportion to its real impact on the owner's value for money ratio – a fact forgotten in many academic and practical 'lottery' applications. Only then, however, the system can truly serve decision making based on the *most economically advantageous* criterion, incentivise the industry for better performance and enhance the actualization of the owner's objectives. And this is where the study at hand steps in with its relatively simple method, aimed to be easily understood and accepted by practitioners.

The results, or actually the numeric values for fee elasticity, are not definitive or universal solutions, but can be applied at one's discretion to the selection of an alliance team for the design and construction of Finnish transport infrastructure projects. For other projects, market areas and industries the figures may have to be adjusted. All in all, there are plenty of challenges for construction management research in filling the void of rational practices. The evaluation and scoring system for capability must also be developed very carefully – it was excluded from this study.

The survey completed as a part of the study also indicates that practical fee variation may not be as wide as could be justified by the variation in the candidate teams' performance. That leads to capability being the primary means of competition and key determinant of awarding the contract when the method of this study is used in

selection. That, again, means that the owner can expect to attract highly competent teams for his/her projects and benefit from the procurement system. This being the case, use of the system indirectly fosters also development of the sector.

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UNDERSTANDING POST-CONTRACT CHANGES IN PARTNERING PROJECTS: AN ETHNOGRAPHIC APPROACH

Clare Shipton[1]

[1] *School of Construction Management and Engineering, University of Reading, PO BOX 219, Reading, RG6 6AW, UK*

Partnering continues to be widely used in the UK. However, the partnering literature often presents polarised views of reality, which has stunted our understanding of the enactment of partnering as an informal and emergent practice. Power permeates social interactions and potentially affects partnering relationships in ways that contradict best practice guidance. However, understandings of power in partnering projects are limited. Post-contract changes (PCCs) are a common source of conflict on projects around which to explore interactions. Power relations and interactions are embedded practices that must be understood within the context of the project. Therefore, the aim is to adopt an ethnographic approach to explore how individuals interact on projects when managing PCCs and to explore how power affects these interactions. As part of ongoing doctoral research, preliminary findings from a public sector partnering project are discussed. There is a strong reliance on the contract to manage PCCs, which partly removes the power from individuals to negotiate changes. However, PCCs involving specialist information are less constrained by the contract. There is evidence of the Client adapting the contract to their preference and the Contractor opportunistically using the Client's dependency to overprice PCCs, despite claiming to have amiable relations. These seemingly contradictory behaviours emphasise the complexity of interactions around different PCCs, involving different individuals.

Keywords: ethnography, partnering, post-contract changes, power, procurement.

INTRODUCTION

The construction industry is frequently criticised for poor performance, which is partly attributed to supposed high levels of adversarial behaviour. Since the 1990s, the UK Government has advocated the use of partnering as a way of overcoming this problem, and their figures suggest that partnering can significantly improve the time and cost performance of projects (National Audit Office 2005). However, such figures tend to be based on best practice projects and it is unclear whether claimed outcomes are a result of a shift towards developing more collaborative relationships or if they can be attributed to other 'indirect' factors (Bresnen and Marshall 2000a). Moreover, the dominant structuralist approach in the construction management (CM) literature

[1] c.shipton@pgr.reading.ac.uk

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reduces partnering to a static outcome that is achieved or not achieved, which hinders our understanding of partnering as a negotiated, evolving practice based on interactions between individuals (Larsen *et al.* 2008). This raises challenges about understanding how actors interact in partnering arrangements and the underlying influential factors that help to explain why actors interact in these ways.

Large, repeat clients are amenable to partnering framework agreements due to their ongoing programmes of work. These clients are considered to have strong buying power and are often at the centre of partnering success stories (Green 1999). Despite best practice guidance reporting the success stories of large clients, they also claim that partnering helps to facilitate more equal and less one-sided relationships (e.g. Bennett and Jayes 1998). Clearly, this simplifies the complex power relations and interdependencies between participants in the project team and wider stakeholders that are constantly being renegotiated. Moreover, actors may take advantage of their powerful positions and act adversarially in partnering projects (Dainty *et al.* 2001, Packham *et al.* 2003, Wood and Ellis 2005, Alderman and Ivory 2007), which contradicts the purported ethos of partnering and its aims of reducing adversarial behaviour. This raises interesting questions about the potential impact of power relations on interactions in partnering projects. Post-contract changes (PCCs) are a common source of conflict on projects and how individuals interact when managing them potentially provides insights into how individuals make sense of partnering and highlight how factors, such as power, influence these interactions.

The aim is to explore how individuals interact on projects when managing PCCs and to explore whether, and how, power affects these interactions. There is a clear policy requirement for this research as partnering continues to be widely used as a preferred method for UK public procurement. A better understanding of how individuals interact in partnering arrangements and the factors that influence these interactions may provide insights into how policy guidance can address shortfalls in practice. This aim will be addressed first, by assessing the existing partnering literature and highlighting shortcomings in the current polarised views of reality. Second, the conceptualisation of power in construction procurement will be explored with the aim of revealing inherent contradictions in the partnering philosophy. Third, the shift towards exploring construction using ethnographic methods is developed along with the relevance of this approach for the study. The contribution of this paper is a research design and preliminary findings that form part of ongoing doctoral research.

PARTNERING IN THE CONSTRUCTION INDUSTRY

Partnering is widely regarded as “a long-term commitment between two or more organizations for the purpose of achieving specific business objectives […] The relationship is based on trust, dedication to common goals and on the understanding of each other's individual expectations and values” (Construction Industry Institute, 1991: iv). Much literature has focused on producing definitions and lists of tools and components as requirements for successful partnering (e.g. Bennett and Jayes 1998, Nyström 2005, OGC 2007, Eriksson 2010) with varying degrees of prescriptiveness and flexibility. These approaches can help to focus understanding and subsequent research efforts. However, it ultimately reduces practices into discreet components, which are achieved or not achieved, and provides a simplified understanding of the enactment of partnering from the perspective of ‘the project’ where individual perspectives are “overlooked or at best diluted into a group consensus” (Larsen *et al.* 2008:40). Partnering research has also focused on first-hand accounts of project

participants' experiences of partnering (e.g. Bresnen and Marshall 2000b, 2000c, 2002, Dainty *et al.* 2001, Wood and Ellis 2005, Alderman and Ivory 2007) and it is these accounts that highlight some of the complexities of enacting partnering and contradictions with best-practice policy.

There is a tendency in the partnering literature to present polarised views of reality. Relationships are typically characterised as either 'collaborative' or 'adversarial'. Some writers keenly express that in reality relationships do not conform to rigidly defined labels but instead consist of overlapping characteristics that are developed in ways that suit the project (e.g. Uzzi 1997, Cox and Ireland 2002). However, the lack of explanation of relationships that emerge between 'pure' categories and how these evolve over time stunt our understanding of partnering as an enacted practice. Studies suggest that actors develop collaborative relationships based on an estimation of the potential economic benefits (Bresnen and Marshall 2000b, Dainty *et al.* 2001, Packham *et al.* 2003), indicating that commercial self-interest is the cornerstone of partnering. However, in ongoing relationships social expectations of behaviour overlay the relationship providing social incentives to abstain from adversarial behaviour (Granovetter 1985, Nyström 2007). Fletcher and Watson (2007) emphasise the importance of avoiding 'either/or' styles of analysis. Their ethnographic study found that individuals in exchange relationships were influenced simultaneously by motives that were self-interested and altruistic due to a range of competing interests. In summary, the enactment of partnering is complex and polarised views are inadequate. Multiple motives influence how individuals interact and interactions do not conform to rigid categories of 'collaborative' or 'adversarial' behaviour.

POWER AND DEPENDENCY

Power is central to the understanding of social exchanges (Blau 1964) as it affects an actor's ability to influence decisions and outcomes. Authority is power exercised through normatively accepted roles and institutions (Scott 2003), which structure and influence how actors behave. The use of power can positively contribute to the achievement of organisational objectives and can "enable people to get things done" (Walker and Newcombe 2000: 37). However, power can also be used by an actor to pursue self-interests, which might be at the expense of organisational goals (Walker and Newcombe 2000, Scott 2003). Formal authority, embedded in institutional roles and objects, may only play a small role in determining the power of individuals; instead power is better determined by informal relations (Loosemore 1999). Other views of power highlight the importance of simultaneously considering the relative power and dependencies of actors in exchange relations, where the power of an actor is inversely proportional to the other actor's dependence on them (Emerson 1962, Blau 1964, Pfeffer and Salancik 1978). From this power-dependence perspective, relationships can be characterised by varying degrees of power imbalance and mutual dependency (e.g. Cox *et al.* 2004, Gulati and Sytch 2007, Caniëls and Roeleveld 2009), although this tends to focus on 'the firm' rather than individual interactions. Nevertheless, firm-level interdependencies can affect individual interactions, as shown in Bresnen's (2009) study of partnering relationships where the contractor depended on the client for future work and the client depended on the contractor to ensure the partnering arrangement was successful. These "powerful commercial motives […] helped create the conditions in which interests could be more easily aligned" (Bresnen 2009: 930). Hence project interdependencies may influence individual interactions.

The study of power in construction projects has been piecemeal. The difficulty with developing a sophisticated and holistic understanding of the effects of power in projects is the breadth of conceptualisations and theoretical lenses that can be applied. As a result, existing studies of power cover a wide but fragmented range of approaches, including identifying structural indicators of power such as social network positions (Loosemore 1999) and resource dependencies (Greenwood 2001, Cox *et al.* 2004), 'bases' of power (Walker and Newcomb, 2000), material and embodied registers of power (Sage and Dainty 2012) and positional and relational power (Gluch 2009). Despite their different approaches, these studies indicate that power relations influence how projects are managed and the need to remain open to a range of conceptualisations of power. Nevertheless, boundaries must ultimately be drawn, but these will be inductively informed by findings that emerge from fieldwork.

Collaborative procurement arrangements reduce the problem of post-contract power reversal between client and contractor (Chang and Ive 2007). This is in keeping with ideas from the relational embeddedness and partnering literature and is based on the notion that collaborative procurement incentivises actors to act collaboratively to avoid the losses associated with adversarial behaviour (Granovetter 1985, Uzzi 1997, Bresnen and Marshall 2000c, Nyström 2007). However, some studies indicate that actors use power adversarially in partnering projects, particularly when they are aware of the other actor's dependency upon them in the exchange (Dainty *et al.* 2001, Packham *et al.* 2003, Wood and Ellis 2005, Alderman and Ivory 2007). Whilst understandings of power in partnering projects are limited, what is clear is that power influences interactions and potentially influences partnering relationships in a way that contradicts 'best practice' partnering ideals. This highlights a need to better understand power in emergent practices on partnering projects.

POST-CONTRACT CHANGES

Post-contract changes (PCCs) refer to "an alteration to design, building work, project program or other project aspects caused by modifications to pre-existing conditions assumptions or requirements" (Sun and Meng 2009: 560) which occur during the construction phase. PCCs are common, their causes are often numerous and are a frequent source of conflict (Love 2002, Sun and Meng 2009). Nevertheless, projects with high change costs are still capable of coming in on time and budget (Love 2002), which highlights the importance of how parties manage change. Due to post-contract reversal of power there are opportunities for contractors to act adversarially with respect to PCCs (Winch 1989, Chang and Ive 2007). This is partly counteracted by clients through contracts (Kadefors 2004), but contractual provisions cannot account for all eventualities. Partnering arrangements can facilitate PCC negotiations due to expectations of collaboration and the reward of compromises in the future (Nyström 2007). Relationships based on past experience of working together, "trust, commitment and cooperation" (Love *et al.* 1999: 513) lead to more proactive, joint problem solving of difficult changes. Hence PCCs provide an interesting focus around which to explore how individuals interact and the potential effect of power relations.

INFORMALITY, EMERGENCE AND ETHNOGRAPHY

An alternative approach to the "technical rationalism" of much CM research focuses on informal and emergent processes and highlights the imperative to examine formal and informal discourses and practices (Chan and Räisänen 2009:907). An ethnographic approach is highly suited to gaining an understanding of the everyday experiences and practices of people in construction. As each project is affected by the

social, institutional and political context in which it takes place, practices are said to be embedded and must be understood within this context. Ethnography is "iterative-inductive research; that is to say it evolves in design through the study […] It results in richly written accounts that respect the irreducibility of human experience, acknowledges the role of theory as well as the researcher's own role, and views humans as part object/part subject" (O'Reilly 2009: 3). There are varying extents to which the inductive approach is adopted. It is often the case the ethnographer starts with a problem and some theory to focus the research (Fetterman 1998). Theory must "remain in dialogue" with the fieldwork and the ethnographer must be reflexively aware of their role and theoretical inclinations at all times (Pink *et al.* 2010:649).

Traditionally, ethnographies holistically describe an unknown culture produced following an extended period over one or more years immersed in that social setting. In contrast, contemporary ethnographic approaches are more focused on specific aspects of one's own culture, hence long-term fieldwork is often not necessary (Fetterman 1998, Pink *et al.* 2010) and the researcher can opt to spend weeks and months, rather than years in the field. However, the actual time over which fieldwork should take place is "a period of time which is sufficient for the researcher to appreciate the range of norms, practices, and values, official and unofficial alike, which characterize that research setting" (Watson 2010:207). A number of CM studies have been conducted using varying ethnographic approaches, including Rooke *et al.* (2004), Fletcher and Watson (2007), Baarts (2009), Gluch (2009), Pink *et al.* (2010), Sage and Dainty (2012). However, they are still not widely used in CM research. As such, it is an innovative, highly immersed approach to studying the realities of managing PCCs and interactions in partnering projects.

RESEARCH PROBLEM

From the review of the literature, it can be stated that a better understanding is needed about how individuals interact in partnering projects. Evidence indicates that power relations influence project interactions and have the potential to influence partnering relationships is a way that contradicts the 'best practice' partnering ethos. Actors sometimes use their powerful positions to act adversarially at the expense of others in partnering projects. However, actors are simultaneously influenced by a range of motives, thereby indicating the inadequacy of polarised typologies. Power relations and interactions are highly embedded in the social, political and institutional context in which projects take place, such that practices are localised and emergent.

Therefore, the aim is to adopt an ethnographic approach to explore how individuals interact on projects when managing PCCs and to explore whether, and how, power affects these interactions. There is a clear policy requirement for this research. Partnering is endorsed as a preferred method for public procurement by the UK Government but there are indications of contradictions to best practice guidance with actors using their powerful positions to act adversarially at the expense of others. Such behaviour is unsustainable and does not benefit the industry in the long-term. Therefore, a better understanding of how individuals interact in partnering arrangements and how underlying factors, such as power, help to explain why actors interact in these ways will potentially provide a more meaningful understanding of partnering and insights into how policy guidance can address shortfalls identified in practice. Additionally, fresh insights into power in projects, PCCs and interactions in partnering projects will be gained by using an ethnographic approach.

RESEARCH DESIGN

An ethnographic approach is used to gain a first-hand, context-sensitive account of how individuals interact on projects and how they make sense of the partnering arrangement, with a specific interest in exploring power relations. As the researcher already has experience of PCCs in the construction industry, a traditional ethnographic approach of being immersed in the field for years at a time is not necessary. Instead fieldwork will take place in clusters of weeks or months over a twelve month period, in line with recent ethnographic studies in CM. The focus is on exploring PCCs; however, interactions around PCCs are not typically discrete and are one part of the daily work of project team members. The ad hoc way in which people manage PCCs means that data collection cannot follow a set time schedule. Ethnographic research is exploratory and develops in practice as the fieldwork progresses (Pink *et al.* 2010) and a pre-determined research design is neither possible nor desirable. Hence there is a need for the researcher to be present on a regular basis and get involved in activities that are part of the overall management of the project in order to potentially observe interactions involving PCCs. The research strategy adopted is described as 'ethnographic' due to the sustained periods to be spent in the field, a significant portion of which will involve developing relationships. It is already apparent that this approach produces vast amounts of qualitative data, only a small proportion of which is directly related to the research question, although all of the data contributes to building an holistic picture of the research setting. Additionally, as part of the ethnographic research strategy there is a constant consideration of reflexivity; understanding how the role and stance of the researcher impacts on their interpretation of events (O'Reilly 2009), and acknowledging the changing context of the research setting and the transient nature of the ethnographer's account (Fetterman 1998).

At present, two public sector partnering projects are being studied, although the total number of projects to be studied is uncertain at present. Whilst multi-sited ethnographies are less common, they can be used as a form of collective case study in which to study an issue across a number of cases within a particular field (O'Reilly 2009). Participant observation case studies identify specific cases to address a research question and arguably emphasise more intermittent observation of defined events over multiple cases for comparison. Conversely, the ethnographic approach of the research adopts a more holistic focus with the emphasis on prolonged exposure, building rapports and collecting data on a wide range of project interactions. For the study, the researcher's identity is overt, as a participant-as-observer (Bryman and Bell 2007), with regular interaction with participants in their everyday work. This approach, as opposed to active participation in managing PPCs, is appropriate as it avoids the researcher becoming too closely associated with any one organization on the project. Time is required in order to allow research participants to become familiar with the ethnographer’s presence, so that they become less visible and to build a rapport with the participants (O’Reilly 2009). Observing members of the project team raises difficulties in terms of logistics as individuals often operate from their own company offices. At present the research is focused at the Contractors' site offices as it provides an insight into the project from the Contractor's perspective and is a place where the project team regularly convene for meetings thus providing opportunities for access to other team members to snowball as the research progresses. The data collected is in the form of qualitative notes from discussions with project team members, observations at meetings and document analysis. Data has been gathered by spending as much time as possible at the Contractor's site offices and speaking to members of

the project team about project-specific and non-work matters and also being privy to their conversations within the project team. Ad hoc conversations, triggered by issues from meetings, emails or by the researcher asking open questions, build a picture about how different individuals understand and interact in different situations.

Due to the ongoing nature of the research, discussions focus of one project. The project is a £40million new build hospital procured through a national partnering framework agreement using the NEC3 Option C contract and a design-and-build arrangement. The project is presently 3 months into the 34-month construction period.

PRELIMINARY FINDINGS

There are many PCCs occurring on the project, many of which are client design changes, whilst others are dictated by changing legislation or site conditions. Timescales to agree a PCC from identification to formal instruction varies significantly depending on the change, the information available and how critical it is. The breadth of PCCs presents interesting questions about how different PCCs, involving different actors and information are managed. The procurement of the project on a partnering framework has an influence on some of the project team members. Yet a repeated anecdote is that using a partnering arrangement can only potentially facilitate better project relations and management; ultimately it depends on how people work together, which is influenced by past experience, ways of working and personalities. Project team members recount stories from the pre-construction phase when individuals in the Client team were replaced as they were not considered to be suited to collaborative working. The word 'collaborative' is used by individuals to refer to how openly, honestly and fairly an individual behaves towards others, and how well they share information among the project team. Tensions arise when managing PCCs; this is partly due to the Client’s lack of understanding about the resources used investigating potential PCCs and which PCCs are client additions. Moreover, frequent meetings between the Client and Contractor team encourage open and informal communication, but result in the Client instructing the Contractor to provide proposals for many potential PCCs, the majority of which are rejected by the Client despite the Contractor using extra resources to investigate them.

The contract is heavily relied upon on the project in terms of the procedure to follow when potential PCCs arise and in determining who will pay for the change. Rather than be regarded as ‘contractual’, most of the project team members prefer this way of managing PCCs as it provides a clear audit trail. However, the Contractor PM is concerned that PCCs are starting to be informally requested by the Client Representative, often using piecemeal, unclear and changeable information. It is the Contractor's best interests that the formal contract procedures are followed on this long and complex project as otherwise they are at risk of paying for PCCs that are client changes. The notion that clients use their repeat buying power under framework agreements to influence contractors to absorb extra costs is not obviously apparent on the project. The Client’s power is partly restricted by the contract and the Contractor’s unwillingness to go beyond the contract may be due to their awareness of the accountability required on public sector projects and that ‘deals’ are not expected by the Client. However, there are instances where the Client refuses to use certain contract terms, such as not paying the Contractor for investigating PCCs, and the Contractor reluctantly conforms. There are examples of the Contractor team taking advantage of the Client’s dependency on them in terms of access to market information by overpricing quotes, an example of post-contract power reversal. This

seemingly contradictory behaviour emphasises the complexity of interactions around different PCCs. The contract is a tool to facilitate the management of PCCs on the project, and partly removes the power from individuals to negotiate PCCs. However, some PCCs involving individuals with expert knowledge appear to be less constrained by the contract. Specialist end users are able to use their information asymmetry to negotiate PCCs and challenge contract provisions due to the complexity of their requirements. Similarly, specialist subcontractors, who maintain a large portion of their market, exceed deadlines and provide inadequate information in a way that others cannot. The Contractor is dependent on the specialist subcontractor and is less able to negotiate the PCC. Controlling access to information causes tensions, thus how information is used potentially provides an insight into power relations on projects.

In terms of the researcher's role, there are issues regarding access due to the researcher's presence as an outsider and how access has been gained through the key informant, the Client PM. Many project team members assume that the researcher works for the key informant's company until they are corrected. Association with the Client PM explains why the researcher is frequently asked not to attend Contractor meetings about so-called "internal matters". These access issues might be exacerbated if the researcher attempts, at this early stage, to get closer to other project disciplines.

CONCLUSIONS

The field work is in its early stages as part of the ongoing doctoral research. It is expected that more tangible themes will emerge as it progresses. The number of projects to be studied and the duration of study are to be determined, but will be informed by emergent findings from the field work. At present, an initial period has been undertaken to familiarise the researcher with the research setting and to start building a rapport with participants. The next stage will be, based on the preliminary and ongoing findings, to identify relevant themes and refine the research design. These themes, along with emergent themes, will be explored through the collection and analysis of data throughout the duration of the study.

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IMPACT OF THE PUBLIC PROCUREMENT REFORM ON PUBLIC BUILDING PROJECTS DELIVERY IN NIGERIA

Shwarka S. M[1] and Anigbogu N. A[2]

[1]*Department of Building, Kaduna Polytechnic, Kaduna, Nigeria*

[2]*Department of Building, University of Jos, Jos Nigeria*

Reducing the cost of public projects' delivery is a major challenge of Governments worldwide and increasingly procurement reforms are considered as unique means of achieving lower costs for infrastructure delivery and value for money. Thus the Nigerian Public Procurement Reform is expected to result in significant improvement in public projects' performance which should impact the country's overall economic situation and foster the realisation of the Government developmental target of being among the top twenty economies of the world by the year 2020. This paper analyses the impact of the Public Procurement Reform on public building projects' delivery in Nigeria. The impact of the Public Procurement Reform is hypothesized to depend on crucial factors such as planning practices for public building projects, adoption of appropriate procurement options, contractor selection practices and the enthroning of best ethical standards by public building practitioners. Actual project performance data were compared on public building projects delivered prior and after the commencement the procurement reform. In addition, a sample survey comparing opinions of key practitioners on the impact of the reform on public building projects' delivery was carried out, and the result of the pilot study shows there is no significant difference between the mean response of contractors, consultants and construction professionals in Ministries, Departments and Agencies with regard to the reform's impact on irregularities associated with public building projects delivery in Nigeria. Inadequate project/budgeting plans by the client and the project team identified as the most constraining factors in the attainment of desired impact on public building projects delivery. The outcome of this study would provide empirical ground that assists in decisions on the sustainability of the procurement reform in Nigeria, whose experience might be applicable the rest of the developing world and may provide relevant clues to assist other countries.

Keywords: impact, building performance, procurement reform.

INTRODUCTION

All over the world, public procurement is being subjected to reforming, restructuring or to new rules and regulations in the bid to bring about substantial improvement in governance. According to Hunja (2001), effective and efficient procurement policies are important in assessing the performance of governments. However, Hunja (2001) pointed out that there is no sufficient evidence by which successful procurement reforms can be measured due to lack of analysis and available information on return on investment on procurement reforms which has made the formulation of proposals

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for new multilateral laws in procurement difficult. There is therefore need for research to shed light on the success or otherwise of public procurement reforms in a range of developing countries and to provide case evidence and national experience that will inform reform strategies and international rule making. In the same vein, Evennet and Hoekman (2005) observed that work on the performance of national public procurement systems have not been well documented, in the sense that focus tends to be primarily on legal compliance with required laws and implementation procedures, with little focus on quantifying performance on having applied the processes aimed at enhancing competition, transparency, and combating corruption (Evennet and Hoekman 2005). Evennet and Hoekman (2005) added that much tends to be claimed for the benefits of the procurement reforms, but there is little analysis whether these benefits were actually realized after the reform initiatives occurred.

Few Studies have been made on the Nigerian Public Procurement Reform. While Olatunji (2008) examined the Due Process Policy Model, Ayangede, Wahab and Alake (2009) investigated the Due Process as a procurement method and its legal and institutional framework. Aduda (2007) evaluated the levels of compliance with some of the provisions of the Budget Monitoring and Price Intelligence Unit. This study relates with aforementioned studies because the Due Process Policy and the Budget Monitoring and Price Intelligence Unit were the initial institutional arrangements of the Public Procurement Reform in Nigeria and were based on fundamental principles of the Public Procurement Act, 2007 even before the enactment of the Act. However, this study goes further as a pioneering study to evaluate actual impact of the Public Procurement Reform from the perspective of public building projects delivery.

The set objectives of Nigerian Public Procurement Reform and its provisions/procedures are considered to be sound and capable of achieving desired impact if well implemented (Transparency International 2008). These provisions have been implemented in Federal Ministries, Departments and Agencies procuring building projects in Nigeria for nearly a decade now. This duration is considered long enough for the impact of the reform to appear, and this is considered vital for either justifying or impugning the benefits of the Public Procurement Reform on public building projects delivery. This study therefore is an empirical analysis of real data of a representative sample, of projects performance statistics before and after the introduction of the Public Procurement Reform with the aim of identifying the difference the procurement reform has made.

Condition of Public Building Projects' Delivery in Nigeria Prior to the Procurement Reform

The challenges of the construction industry in Nigeria have not been different from that of many other developing nations. Most of these difficulties relate to lack of fiscal transparency and public accountability, in addition to the inadequacy of resources for providing public infrastructures. For example, in Nigeria, prior to the re-emergence of the democratic governance in 1999, public building projects delivery has been subject to several irregularities which resulted in frequent projects failure. These included poor project planning, insufficient budgeting plans, unnecessary project fragmentation, initial bids inflation and over invoicing, gross change orders during project execution, adoption of inappropriate procurement methods, contract allocation as opposed to competitive tendering, proliferation of incompetent contractors in projects' delivery, poor project documentation and a general lack of transparency in the tendering process and deteriorating ethical standards of public construction

practitioners. According to Ayangade, Wahab and Alake (2009), these anomalies resulted in high project time and cost overruns, job abandonment, improper contract determination, conflicts and litigations, defective job performances and building collapses. Olatunji (2008) stated that contractor selection was not based on value and merits of bid but on tender price and initial lowest bid. The consequence was that Nigeria ranked highest worldwide in the cost of public projects execution (Budget Monitoring and Price Intelligence Unit, 2005). This made the need for the procurement reform in Nigeria to become pertinent.

The continual inadequacy of infrastructural facilities to meet the needs of the Nigerian economy coupled with the poor fiscal realities necessitated the dire need for optimal utilization of scarce resources appropriated for the public building projects delivery. Furthermore, with globalization and advances in information technology, citizens began to demand for greater accountability and efficiency from government and the demands and expectations of the global economy on improving transparency and competition in government procurement added the need to align and harmonize Nigeria's procurement practices with that of the United Nations Commission for International Trade Law (UNCITRAL) model and the World Bank guidelines.

Thus the Public Procurement Reform was introduced to improve service delivery generally in the public sector through focussing on principles and procedures in procurement that would place the country firmly on the path of economic growth. In the public building sector, the reform is expected to promote a sustainable built environment through the application of competition in tendering, effective planning and budgeting for projects and the promotion of global best practices and ethical standards in order to achieve value for money on public building projects.

RESEARCH QUESTIONS

1. How has the Public Procurement reform impacted the factors that were responsible for frequent public building projects failure in Nigeria?
2. How has Public Procurement Reform impacted public building projects performance with regards to projects' completion within specified time and budget?
3. What are the constraints in the attainment of desired impact of the Public Procurement Reform on public building projects delivery?

METHODOLOGY

A sample survey research design that involves the comparison of available data on completed public building projects before and after the introduction of the Public Procurement Reform because the study seeks to establish the counterfactual. This method has been adopted by impact evaluation experts such as Baker (2000) and White (2009) to establish how indicators behave with a program compared with how they would have been without the intervention. The period 1995 to 2002 is used as the pre reform era, while the period 2003 to 2010 is used as the reform era. A total of forty public building projects in the Federal Capital Territory were used in the study. Twenty projects completed before the introduction of the public procurement reform and twenty similar projects completed after the inception of the reform. The purposive sampling method was adopted due to the difficulty in obtaining data on completed projects. Time, cost, and quality are considered crucial parameters to projects' value and as such variables on projects performance. Projects duration and cost performance were used to study the impact of procurement reform. In addition to comparisons of

actual project performance statistics, the study also compares opinions on the impact of the reform on public building projects delivery of key public building practitioners, namely contractors, consultants and construction professionals engaged with fifteen Ministries, Departments and Agencies selected through a simple random sampling in the FCT. The Likert type scale was employed in evaluating responses.

DISCUSSION OF RESULTS

Table1: Performance Data of Public Building Projects Pre Reform Era (1995-2002).

Projects	I.D. in weeks	F.D in weeks	I. Sum in billions Naira	F. Sum in billions Naira	Cost over-run Naira	Delay in weeks	% cost over-run	% time over-run
PFMB 04 Ph.1 Fed.Sec.	130	517	0.84	4.06	3.22	387	298	383
NTA, Area 11, Garki	130	783	0.63	2.99	2.36	653	375	502
Foreign Affairs HQTRS.	130	592	13.18	15.14	1.96	462	14.8	355
Karshi General Hospital	24	36	2.9^{-2}	3.1^{-2}	1.0^{-3}	12	3.62	50
Sch/orphanage, Karu	24	25	1.7^{-2}	1.7^{-2}	0	1	0	4
P.Fencing, Gwagwalada	12	76	1.97^{-3}	2.38^{-3}	4.08^{-4}	64	20.7	53
2No.1BR 3No. 2BR, Kubwa Ph. 1	12	44	3.04^{-3}	3.04^{-3}	0	32	0	267
1 No.1BR, 1No 2BR Life camp	12	51	3.19^{-3}	3.19^{-3}	0	49	0	408
1No 2BR S/D& 1No.3BR Gwagwalada	12	19	4.14^{-3}	4.14^{-3}	0	7	0	58.33
2BR Karshi Hospital	12	15	2.58^{-3}	2.58^{-3}	0	3	0	25
3BR Karshi	12	16	$4.\ 28^{-3}$	$4.\ 28^{-3}$	0	4	0	33.33
1No. 4BR S/D Duplex, Area 11, Garki.	24	111	7.84^{-3}	7.84^{-3}	0	99	0	825
1No 3BR.S/D Apo.	12	72	5.37^{-3}	5.37^{-3}	0	60	0	500
4BRS/D Duplex Gwarinpa Badagry	24	208	$1.5\ 3^{-2}$	2.15^{-2}	6.2^{-3}	184	40.6	1533
3BRS/D Duplex at Gwarimpa Master	24	206	1.22^{-2}	1.71^{-2}	4.91^{-3}	184	40.2	1533
1 Blk of 4units of 3BR duplex, Wuse II (OAU)	12	35	2.96^{-2}	2.96^{-2}	0	23	0	192
Chief's Palace, Abaji	12	77	4.6^{-3}	6.2^{-3}	1.6	65	34.8	542
4No. 2 BR terrace flats at Karu	4	15	3.5^{-4}	3.5^{-4}	0	11	0	275
2BR S/D Kado	18	29	4.85^{-3}	5.11^{-3}	2.6^{-4}	11	5.4	6.11
4No 1BR Security Qtrs. Asokoro	12	104	2.12^{-2}	2.12^{-2}	0	92	0	767

Table 2: Performance Data of Public Building Projects Post Reform Era (2003-2010).

Projects	I.D. in weeks	F.D in weeks	I. Sum in billions Naira	F. Sum in billions Naira	Cost over-run Naira	Delay in weeks	% cost over-run	% time over-run
Completion of Shagari Complex Asokoro								
NASS, Ph.III, Part II	130	520	20.0	22.98	2.98	390	14.9	300
PFMB Plot 4 Phase II at Federal Secretariat	130	425	4.06	6.34	2.28	295	56.20	227
225 bed G. Hospital karu	84	260	1.41	1.95	0.534	166	38	198
6blks of classrooms, JSS Wuse, zone 6	24	78	5.9^{-2}	6.4^{-2}	5.02^{-3}	54	8.52	225
Fencing Orphanage Homes Gwagwalada	12	124	4.11^{-2}	4.11^{-2}	0	112	0	933
13 No. 2BR Shere-Galuyi	12	179	4.30^{-2}	4.30^{-2}	0	169	0	1408
10 No. 2BR Shere Galuyi	12	119	3.25^{-2}	3.25^{-2}	0	107	0	892
9 No. 2BR at Shere Galuyi	12	130	2.89^{-2}	2.89^{-2}	0	118	0	983
8No. 1BR,1 No.3BR Apo	12	121	2.50^{-2}	2.50^{-2}	0	109	0	908
6No.2BR Apo	12	130	2.26^{-2}	2.55^{-2}	2.82^{-3}	118	13	983
4No.1BR, 5No. 2BR and 1No. 3BR, Apo.	12	117	4.13^{-2}	4.14^{-2}	4.44^{-5}	105	0.11	875
1No. 4BR, 2No.3BR, 4No. 2BR 3No.1BR Wasa	12	116	3.36^{-2}	3.36^{-2}	0	104	0	866.67
4No. 1BR, 3No. 3BR 3 No. 3BR Wasa	12	120	3.30^{-2}	3.30^{-2}	0	108	0	900
4 BR duplex Gwarimpa II	24	82	2.39^{-2}	2.39^{-2}	0	58	0	242
4No. 2 BR terrace flats Karu	4	6	3.02^{-3}	3.02^{-3}	0	2	0	50
6No 3BR flats of 2 storey at Wuse Zone 5	24	97	4.27^{-2}	4.49^{-2}	2.25^{-3}	73	5.3	304
Installation of 490 meters Kado Estate	4	16	2.55^{-2}	2.81^{-2}	2.59^{-3}	12	10.2	300
2 No.Rms, old parade ground Area 10 Garki	4	32	2.78^{-3}	2.78^{-3}	0	28	0	700
Police Stn. Kubwa	12	36	1.1^{-2}	1.1^{-2}	0	24	0	50

Table 3 presents the means of data collected on both cost overruns in billions of naira and time overruns in weeks.

Table 3: Group Statistics

	Projects' Performance	N	Mean	Std. Deviation	Std. Error Mean
Cost Overruns	Pre reform	20	4.281	1.0554	2.3600
	Post reform	20	1.480	5.1396	1.1492
Time Overruns	Pre reform	20	89.50	156.755	35.052
	Post reform	20	114.75	86.448	19.330

To establish if the difference in these means are statistically significant at α = 0.05; the Levene's test presented in table 4 is employed. In table 4, the column F shows the value calculated by the ratio of two sample variances, the column Sig. shows the calculated significance or probability P-value used in interpreting the results. Where Sig. value is less than or equal to 0.05, it means that there is no more than a 5%, probability the observations were solely due to chance and the association between the two study durations is considered statistically significant. The column T refers to the t-statistic values and the column Df shows the degrees of freedom.

Table 4: Independent Samples Test

		Lavene's test		t-test for Equality of Means						
		F	Sig.	T	Df	Sig. (2-tailed)	Mean Diff.	Std. Error Diff.	Lower	Upper
Cost Over run	Equal variances assumed	.582	.021	-1.07	38	.29	-2.80	2.63	-8.12	2.51
	Equal variances not assumed			-1.07	27.5	.295	-2.80	2.63	-8.18	2.58
Time Over run	Equal variances assumed	.486	.490	.631	38	.532	25.25	40.03	-55.78	106.28
	Equal variances not assumed			.631	29.6	,533	25.25	40.03	-56.6	107.05

Analysing the cost overruns, from the column sig. in the Levene's test (.021), the probability value is statistically significant (0.021 < 0.05) thus the variances are unequal and the row of data equal variances not assumed is used. The second row of column labelled sig. (2tailed) shows there is no statistically significant difference between the two eras because the significance level is 0.295, (p >0.05), hence there is no statistically significant difference between the means of data on cost overruns in the two eras.

Similarly, to test if there is significant difference in the means of data collected on time overruns at α = 0.05; the column sig. in the Lavene's test in table 4 is 0.490. The probability value is not statistically significant (p >0.05), thus equal variances are

assumed. The column labelled sig. (2 tailed) shows the null hypothesis is also supported, p = *0.532* >0.05). Thus the mean scores on data on time overruns on public building projects in both the pre and post reform era are not statistically significantly different. This finding is not surprising as it is supported by a comparison of opinions of key public building practitioners on the impact of the procurement reform on curbing irregularities in public building projects' delivery. Table 5 presents the mean responses on the reform impact on projects' irregularities. From table 5, it can be seen that there is disagreement that the public procurement reform has had an impact on delayed payments for executed works, frequent fragmentation/phasing of projects, over invoicing/initial bids inflation, gross contract variations/cost overruns and project delays/time overruns. However, it has had an impact on use of incompetent contractors and unprofessional personnel in projects' execution, poor project documentation, and poor works quality performances and the rash/improper abandonments and determination of contracts.

Table 5: Reform's Impact on curbing Irregularities on Public Building Projects Delivery

S/N	Item	$\bar{x}$	Remark
1	Impact on delayed payments for executed works	3.0	Disagree
2	Impact on frequent fragmentation/phasing of projects	3.2	Disagree
3	Impact on use of incompetent contractors and unprofessional personnel in projects' execution	4.0	Agree
4	Impact on poor project documentation	3.5	Agree
5	Impact on over invoicing/initial bids inflation	3.4	Disagree
6	Impact on poor works quality performances	3.8	Agree
7	Impact on gross contract variations/cost overruns	3.2	Disagree
8	Impact on project delays/time overruns	2.7	Disagree
9	Impact on rash/improper abandonments and determination of contracts	3.7	Agree
10	Impact on incessant collapse of public buildings	3.5	Disagree
	Grand Mean	3.4	

Table 6: Analysis of Variance on Irregularities associated with Public Building Projects' Delivery

	Sum of Squares	Df	Mean Square	F	Sig.
Between Groups	1.76	2	.882	.807	.447
Within Groups	488.51	447	1.09		
Total	490.28	449			

From table 6, the Pvalue is 0.447 which is greater than the significance level α 0.05and the calculated F ratio 0.807 is less than the Critical value 3, therefore we accept the Null hypothesis that there is no statistically significant difference in the means of Contractors, Consultants and MDAs in response to the impact of the reform on irregularities in projects' delivery. To further confirm that there is no difference in the means, the Scheffe post hoc test was employed and the analysis is presented in table 7.

Table 7: Scheffe Post Hoc Test of Multiple Comparisons on Irregularities

(I) Target Groups	(J) TargetGroups	Mean Difference	Std, Error	Sig.	Lower Bound	Upper Bound
Contractors	Consultants	.153	.121	.447	-.14	.45
	MDAs'	.080	.121	.803	-.22	.38
Consultants	Contractors	-.153	.121	.447	-.45	.14
	MDAs	-.073	.121	.832	-.37	.22
MDAs'	Contractors	-.080	.121	.803	-.38	.22
	Consultants	.073	.121	.832	-.22	.37

The Scheffe post hoc test of multiple comparisons also showed that there is no significant mean difference at the 0.05 level.

The Study also evaluated why the impact of the public procurement reform has been undermined on public building projects delivery in Nigeria with the aim of suggesting how constraints can be reduced. Table 8 presents the mean opinion on the analysis of responses on constraints in the attainment of desired impact of the public procurement reform.

Table 8 Constraints to PPR's impact

S/N	Items	$\bar{x}$	Remark
1	Weak monitoring/enforcement to ensure compliance by ministries, departments and agencies.	3.6	Agree
2	Inadequate project planning by the project team/insufficient budgeting plans by the Client	4.3	Agree
3	Lack of committed leadership within the procuring entities with political will to support the Reform.	3.9	Agree
4	Resistance to change faulty contractor selection criteria	3.6	Agree
5	General lack of Project Management competencies and a lack of multidisciplinary teams by public building contractors	3.5	Agree
6	Poor ethical practices of public building practitioners	3.8	Agree
7	Lack of prosecution of defaulters that contravene the provisions of the Public Procurement Act.	4.2	Agree
8	Adoption of inappropriate procurement methods	3.1	Disagree
9	Selection of lowest tender	2.9	Disagree
10	Inadequate usages of ICT for project communication, documentation and monitoring, including e-tendering and e-payment payment	3.3	Disagree
	Grand Mean	3.5	

CONCLUSION/RECOMMENDATION

Public Procurement Reforms as pointed earlier are introduced to provide a strong base to improve service delivery and foster economic growth. However, the findings of this Study revealed that the procurement reform has not been efficacious in redressing cost and durations overruns and other irregularities public building projects in Nigeria as there is no statistically significant difference from the situation that existed before the

procurement reform. The implication of this finding is that if focus is not placed on improving procedures that improve performance outcome, the reform would end like other past government policies with limited success. The Study also shows a greater consensus agreement that inadequate project/budgeting plans by the client and the project team is the most constraining factors in the attainment of desired impact on public building projects delivery. This implies that the Ministries Departments and Agencies circumvent provisions of the Procurement Act which relate to proper project planning. Public building procuring entities must improve in identifying procurement needs by competent staff that is capable of making realistic estimates. Contributory factors are the slow decision making process by the client and fiscal constraints attributed to lack of full implementation of the capital component of the budget in the past years. The use of open competitive methods of tendering must be complimented with incentive/disincentive forms of contracts to solve the problem of delays in projects execution. To ensure the sustainability of public procurement reforms, there must be full implementation of provisions of the Public Procurement Act to institute prudence at all levels of government and establishment of a more effective institutional framework for fighting and sanctioning corrupt practices

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THE INFLUENCE OF PROCUREMENT METHODS ON DISPUTE RESOLUTION MECHANISM CHOICE IN CONSTRUCTION

Joseph Mante[1], Issaka Ndekugri, Nii Ankrah and Felix Hammond

School of Technology, University of Wolverhampton, Wulfruna Street, Wolverhampton, WV1 1LY, United Kingdom.

The success of major infrastructure projects is crucial to economic development. Clients' expectations that infrastructure projects will meet their objectives are however confronted by hackneyed construction and engineering challenges relating to cost overruns, delays, issues of quality and disputes. In dealing with major construction disputes, the focus has been on the promotion of the use of alternative resolution mechanisms. The discussions in the literature on the subject have, however, failed to align the procurement method with the parties' selection of dispute resolution mechanism in the event of disputes. The result of the failure has been cost in terms of resources and relationships. An understanding of the link between procurement methods and DRM will avoid situations where cooperating construction entities end up as adversaries mainly as a result of how disputes between them are resolved. This study reports on the preliminary phase of on-going research into the avoidance/ resolution of major infrastructure project disputes. Initial findings, based on a critical review of the literature and an analysis of DRM provisions in standard forms of contract, show that: (i) The standard contracts have virtually the same provisions on dispute resolution regardless of the procurement method: arbitration, adjudication/dispute board ; (ii) whilst there is ample evidence of the impact of choice of procurement method on project success generally, the literature on the relationship between procurement methods and dispute reduction and resolution is fragmented and of limited direct relevance. What research exists on the subject is primarily confined to an examination of the relationship between procurement methods and dispute frequencies. There are, however, indications from the literature of strong connection between choice of procurement methods and DRM. The implications of the initial findings for the design of the rest of the on-going study are examined.

Keywords: construction, dispute resolution mechanisms, procurement methods, project success, collaborative procurement.

INTRODUCTION

The emerging consensus on the relationship between infrastructure development and economic development points to a positive correlation between the two (Calderón and Servén 2010). The expectation that an infrastructure project will meet its objectives is however confronted by clichéd construction and engineering challenges relating to

[1] J.Mante@wlv.ac.uk

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cost overruns, delays, issues of quality and disputes. Reports and research in the field have explored the impact of choice of procurement method on project success (Love *et al.* 1998; Franks1998; Egan 1998; Morledge *et al.* 2006). However, information on the link between procurement methods and dispute reduction and resolution has been fragmented and generally dealt with as an ancillary issue (Critchlow 1998). There is a general lack of alignment of principles underlying DRM selection and procurement objectives and methods of the parties. An understanding of the link between these themes will avert situations where cooperating construction entities end up as adversaries mainly as a result of how disputes between them are resolved. The result of the failure is cost in terms of resources and relationships. In this paper, the relationships between procurement methods and disputes resolution mechanisms are explored with the aim of drawing attention to how decisions on each of the themes taken separately, without regard to the other, could result in less than satisfactory outcomes. Various standard form contracts are analysed to determine the extent to which parties' selection of DRM is influenced by the procurement methods they use.

As an initial step in an on-going study, a critical review of the literature is indispensable, hence the approach for this preliminary study. The paper begins with a brief outline of the existing procurement methods for construction and engineering works. This is followed by an examination of the impact of the various methods on disputes. Then there is a discussion on the relationship between procurement methods and DRM. The types of contracts used under the various procurement methods are briefly examined to assess the extent to which the link between procurement methods and DRM is reflected in construction agreements in practice. The implication of the findings from the literature on the rest of the research design is then discussed.

OUTLINE OF ENGINEERING AND CONSTRUCTION PROCUREMENT METHODS

Successful acquisition of a major infrastructure project, building or engineering, requires prior thorough preparation. Apart from the development of the project concept, the initial preparation will include the selection of appropriate organisation(s) or individuals for the procurement of the project. Procurement, in this context, has been defined as the process of acquiring new services or products and includes contract method, contract documentation and contractor selection (Bower, 2003). Love *et al.* (1998) regard procurement as an organisational system that identifies relationships and assigns responsibilities among key players in the construction process.

Various authors have provided their respective classifications of the available procurement methods. Masterman (2002) identifies three categories of procurement systems in respect of building projects; the separated and cooperative procurement systems, the integrated procurement systems and the management-orientated procurement systems. Each system has its variants. Negotiated contracts, two-stage tendering, continuity contracts, serial contracts and the cost-reimbursable contracts are variants under the separated and cooperative procurement category (Traditional Methods). Alternatives of the integrated system (Design and Build) include Package deals, design and construct and turnkey. The main methods under the management-orientated systems are management contracting, Design and Manage and Construction management. Franks (1998) identifies the designer-led competitive tender system (the traditional system), the designer-led construction managed for a fee (management contracting and construction management), Package deals (package deal turnkey;

design and build; design, build, finance and operate/private finance initiative) and Partnering as the main procurement routes for buildings. Morledge *et al.* (2006:108) have classified what they referred to as "commonly adopted basic procurement frameworks" into design-bid-build (traditional system), measurement, construction management, management contracting, and design and manage and design and build. Whilst most of the classifications outlined above relates to buildings, they are equally applicable to other construction and engineering works as well (Bower, 2003).

From the various classifications provided above, the following procurement methods can be identified: (i) the traditional methods; (ii) the integrated approaches; (iii) the management–orientated methods; and the collaborative/ relationship-based procurement methods (partnering, project alliancing and Private Financing Initiatives / Private-Public Partnerships). It is noted that there are divergent views on whether or not partnering is a procurement method. However, in this work, it has been treated under the collaborative methods due to its focus on enhancing team work and how that influences DRM selection. Each of the procurement methods outlined has its advantages and disadvantages in relation to project delivery generally and dispute occurrence and selection of resolution mechanisms in particular. As explained in the next section, evidence from the available literature points to a relationship between the use of particular procurement methods and dispute frequencies.

PROCUREMENT METHODS AND DISPUTE OCCURRENCE

Previous research on causes of conflicts and disputes in the construction industry are varied, and the findings well rehearsed (Fenn *et al.* 1998; Kumaraswamy 1998; Love *et al.* 2010). Several factors have been identified by the literature on construction as causes of disputes including failure to meet the clients' primary objectives in relation to cost, time and quality. However, project disputes are, to some extent, the consequence of how projects are procured. Conlin *et al.* (1996) have found that there is a correlation between the types of procurement method used and the types and frequencies of disputes. Studying procurement methods in use by private , public and local authority clients in the UK, the authors found that projects which utilized the traditional procurement method experienced higher conflicts in budget and payment issues, performance issues, delay and time related matters and in negligence (Conlin *et al.* 1996).

Reasons for the higher number of disputes found in projects where the traditional procurement method is used are traceable to the key features of the procurement method. These include fragmentation (Latham 1994), price competition (Bourn 2001), poor communication, and the sequential process which results in delays (Morledge *et al.* 2006). The issue of fragmentation associated with the traditional procurement method is not limited to the construction process. There is also fragmentation of the client-project team relationship. Designers and contractors are employed separately both in time and space. The relationship between them is often based on suspicion (Ndekugri and Turner 1994). Each entity - client, design consultant or contractor - promotes its interest without much regard for the interest of the others in the transaction. The results are poor communication, confrontation and adversarialism (Latham 1994; Masterman 2002). Masterman (2002) opines, that designs, under the traditional method, are hardly explicit enough to provide accurate bills of quantities, hence the inevitability of excessive variations, a well-known cause of construction disputes (Semple *et al.* 1994; Bourn 2001). A survey conducted in Malaysia, involving one hundred and fifty construction practitioners, on the relationship between

procurement methods and disputes also revealed that dispute frequencies are higher in traditionally procured projects than in projects where other methods have been used (Yusof *et al.* 2011).

Research on the effect of the use of other procurement methods such as design and build has pointed to reduction in disputes. Ndekugri & Turner (1994) reported a survey of contractors, designers and building clients on design and build issues. One of the findings indicated that the use of design and build procurement method leads to a reduction in disputes. The authors reported that the few disputes encountered by design and build projects related to abortive work, inaccuracies in client's brief, conflict between the brief and the contractor's proposals and valuation of variations. Conlin *et al.* (1996) also found that design and build disputes were few as compared to disputes arising from projects where traditional procurement methods have been used. Design and build disputes were primarily quality related.

As is the case with traditional procurement methods, the review received by design and build as a procurement method in relation to disputes stems from its characteristics. Ndekugri and Turner (1994) set out to test what, at the time, was regarded merely as a popular belief; that is, the fact that design and build carried less risk of arbitration and litigation because the contractor is responsible for all matters of design and construction, including issues of functionality and fitness for purpose. Seventy-nine percent (79%) of contractors, eighty-nine percent (89%) of clients and eighty-six percent (86%) of architects, agreed to the assertion that the very characteristics of design and build procurement reduces risks of disputes, subject to conditions such as clarity of client's brief and the contractor's proposals and avoidance of variation. The philosophy underpinning this procurement method promotes integration of processes and project team members. Though the client/supplier relationship still remains, the single point responsibility arrangement between the client and the contractor reduces the contending interests to just two; that of the client and the contractor.

Procurement methods and procedures which emphasize collaboration not just within the project team but also between the client and the project team exhibit even more awareness of the correlation between such methods and disputes. Some definitions of partnering, for example, view the process as a useful mechanism for dispute avoidance and resolution. Cowan, one of the key progenitors and promoters of partnering, defines partnering as a process which enhances cooperation in contract management with the view to reduce stress, litigation and cost (Cowan 1991; Cowan *et al.* 1992; Li *et al.* 2000; Crowley and Karim 1995). Under partnering, adversarial and confrontational relationships give way to collaboration and cooperation not just among project team members but also between client and the team (Bower 2003; Stehbens *et al.* 1999). Communication is enhanced, goals and interests are shared (Morledge *et al.* 2006). The change in attitudes and the emphasis on trust and good faith in partnering arrangements are the drivers in its dispute prevention scheme. It is the case that every partnership arrangement will often include dispute escalation provisions which determine how disputes are to be resolved promptly and speedily (Seddon 1999). Beyond this, most partnering arrangements will include other alternative DRM such as mediation and conciliation (Critchlow 1998).

Recent assessment of partnering as a method aimed at construction dispute reduction and resolution has questioned its viability as a mechanism for dealing with disputes (Hinchey 2012). Project alliancing and integrated project delivery systems (used in the

USA) have been found to be more effective in dispute reduction and resolution. Hinchey (2012) argues that this is as a result of the fact that these procurement strategies seek to align the objectives and interests of project parties in an enforceable contractual arrangement and also result in the project owner bearing virtually all risks on the project. The collaborative procurement method adopted for the Heathrow Terminal 5 Project and the consequent drastic reduction in disputes still remains an example of how choice of a procurement method can impact dispute reduction and resolution (Deakin and Koukiadaki 2008).

RELATIONSHIP BETWEEN PROCUREMENT METHODS AND SELECTION OF DRM

The selection of dispute resolution mechanism is a discretionary act by parties to a contract. It is therefore difficult to state with certainty what considerations may inform the choice of a particular mechanism over others. However, it is also the case that procurement method has a bearing on what dispute resolution mechanism will attract the most attention of parties to a construction project. By examining the procurement method employed on a project and the kind of relationships that the method engenders or envisages among participants, one can get a sense of the kinds of DRM the parties ought to incorporate into the agreement or activate when there is a dispute. As shown by Figure 1 below, the procurement methods exist on a continuum ranging from those with most fragmented relationships, goals and interests (the Traditional Methods -TM) to those which are based on collaborative relationships in terms of collective promotion and safeguarding of the objectives and interests of all parties and shared goals (the Collaborative Methods -CM). In between are the Management Methods (MM) where a third party or parties hold fragmented relations together and the Integrated Methods (IM) where though client and team are separated, members of the latter are integrated with shared goals and objectives.

Fragmented relationships, separate goals and interests and competition breed confrontation and adversarialism. Each party is likely to insist on its rights and exploit the weaknesses of the other as much as possible. Parties involved in projects where such conditions exist are likely to seek right-based DRM at the earliest opportunity. On the other hand, where the parties to a project have shared goals, interests, objectives, risks and rewards, the relationship becomes one of interdependence and the intermeshing of interests is often of an intensity sufficient to make the parties willing to collaborate to resolve disputes (Fuller, 1971). The kind of relationship that exists between parties to a dispute and the extent to which parties' objectives and interests concur should, therefore, be key determinants of the kind of dispute resolution mechanism which the parties use.

Figure 1 illustrates the connection between the various procurement methods and the likely DRM to be employed. Projects executed under the traditional procurement methods naturally, will employ adversarial mechanisms such as litigation, arbitration and mediation as the means of resolving disputes even at the very inception of the disputes. This is due to the competitive, fragmented and confrontational relationships that the method promotes. Alternatively, the shared goals, interdependence and collaboration which undergird the collaborative methods should necessarily signify a propensity to negotiate solutions for emerging disputes. As discussed below, the linkage between procurement methods and DRM is not often reflected, in reality, in the contract types.

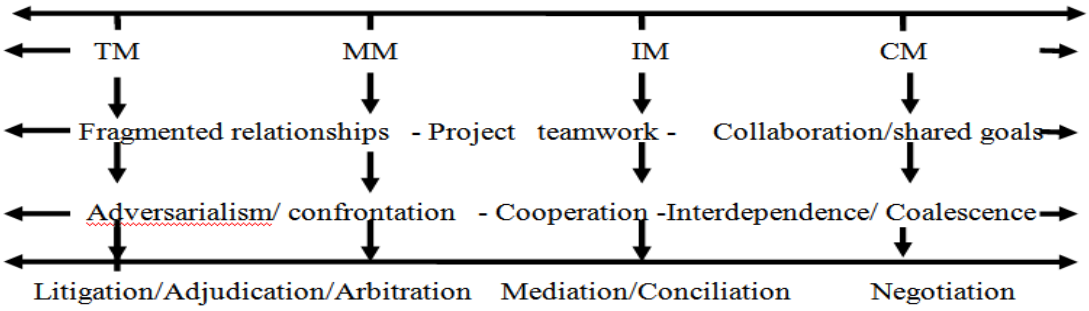

Figure 1: Procurement Methods and DRM: A Conceptual Model of their relationships

Keys: TM-Traditional Methods; MM-Management Methods; IM-Integrated Methods; and CM- Collaborative Methods.

PROCUREMENT METHODS, CONTRACT TYPES AND DRM

The use of standard forms, with necessary modifications to suit specific projects, is the norm in the construction and engineering industry. Apart from regulating key issues affecting the project such as responsibility of the parties, costs of project, time, quality, risk distribution, performance etc., the standard forms also provide information on how disputes are to be resolved. Traditional procurement contracts often contain resolution mechanisms which emphasize right-based adversarial approaches. Almost all the traditional procurement contracts in the UK provide for adjudication, arbitration and litigation as the primary resolution mechanisms. JCT Standard Building Contract, 2005, GC/Works/1 With Quantities (1998) and the NEC Engineering and Construction Contract Third Edition, for example, provide for adjudication, arbitration and litigation as the DRM available to parties.

Two main reasons may account for this. The first is the widespread adversarial culture which still prevails in the industry in spite of the several efforts to reform. The second reason is the intervention by the Housing Grants, Construction and Regeneration Act, 1996 (HGCR Act) as amended by Part 8 of the Local Democracy, Economic Development and Construction Act 2009 (LDEDC Act). Deriving from the recommendations contained in the Latham Report, 1994, the HGCR Act and the LDEDC Act require all construction contracts under their scope to include provisions on parties' right to adjudication, failing which such statutory rights shall be implied. These statutory interventions have made adjudication the most used dispute resolution mechanism in the UK today. Contracts such as JCT Major Project Construction Contract, 2005 Edition and the ICE Conditions of Contract Measurement version Seventh Edition (1999) which may be used for projects which are traditionally procured, recommend conciliation and mediation in addition to adjudication, arbitration and litigation because they are also suitable for use in transactions procured through methods other than the traditional methods (Clamp *et al.* 2007).

The design and build and the management contracts are equally dominated by adjudication, arbitration and litigation as the main DRM, with a few others such as the ICE Design and Construct Conditions of Contract Second Edition (2001) including conciliation and mediation as options. The choice of adversarial mechanisms to resolve disputes in integrated or management-orientated procurement contracts is not surprising for two reasons; firstly, these procurement methods have evolved within an overwhelmingly adversarial culture; and secondly, the procurement methods do not focus on building cooperation and trust or advocating cultural changes as does partnering or alliancing, for example.

Some standard forms on partnering, unlike those related to the traditional, integrated and management procurement methods emphasize a clear preference for non-adversarial methods of dispute resolution. The ACA Standard Form of Contract for Project Partnering PPC2000 is one such example. This standard form is the first to merge conventional contracts and the partnering agreement (which, on its own, is non-binding); it is unlike the NEC3 Partnering Option X12 which keeps the Partnering arrangements as an optional document which may be incorporated into the main NEC3 Contract (Clamp *et al.* 2007). The PPC 2000 provides a problem-solving hierarchy which starts with the Client's representative and "escalates" rapidly to the Core Partnering Group, a conciliator or a mediator or any other form of alternative dispute resolution mechanism agreed by the parties if the problem remains unresolved. The parties' rights to adjudication under the HGCR Act and LDEDC Act are preserved. In extreme situations where problems remain unresolved after all the above options, the parties may consider arbitration and litigation as the final means of determining the dispute. The use of the multi-tiered dispute resolution mechanism ensures that relationship – based approaches to resolving disputes are exhausted prior to the use of any adversarial mechanism. The use of an adversarial resolution method may invariably be linked to a deterioration of relationship between the partners.

It has been said that the main focus of partnering is not dispute reduction or resolution (Barlow *et al.* 1997; Critchlow 1998). However, it is logical to posit that the use of non-adversarial mechanisms to resolve dispute is a natural consequence of a collaborative and interdependent relationship such of the nature of partnering. As the adversarial and confrontational relationships and culture give way to a more cooperative and collaborative culture, so will the quest to settle disputes by adversarial means within the construction industry reduce.

Although the literature gives an indication of a strong link between procurement methods and DRM, the standard contracts (which reflect current practice), on the whole, have virtually the same provisions on dispute resolution regardless of the procurement method: arbitration and adjudication/dispute board. They do not reflect the wide range of ADR methods available. However, nothing stops the parties from incorporating or using mediation or other ADR techniques not mentioned in the Standard form contracts. Indeed, one would expect parties to collaboratively procured projects to do this. Consequently, the matters that will be investigated in the study include the extent of use of ADR methods and reasons for non-use. The foregoing finding and the issues raised have implications for the design of the research as next discussed.

RESEARCH DESIGN

The qualitative research approach is best suited for this kind of research for several reasons. Firstly, the subject-matter of the research- dispute resolution- is a social phenomenon which occurs in a real world setting. Secondly, the views of participants in construction projects are crucial to our understanding of the extent of use of ADR methods and barriers to their use. Thirdly, the appropriate instruments required in studying complex human interactions such as those exhibited during project delivery and selection of DRM must be those which offer some flexibility in terms of administration on the field. This statement accords with the social constructivists or the interpretivist view of research (Berger and Luckmann 1967; Lincoln and Guba 2000). Most of the major treatises on research design, such as the Handbook of Qualitative Research (Denzin and Lincoln 2005), point towards a qualitative research

approach being most appropriate for research with the types of features outlined above.

Finally, the very questions that this enquiry is to explore are the types best suited for qualitative research. Questions to be examined at the next stage of the research include; (i) how often do parties attempt resolution with methods other than the contractual ones? (ii) what are the barriers to the use of suitable DRM not stipulated in the contract and how can these obstacles be countered? (iii) What impact do these choices have on dispute resolution and relationships between the parties? These questions seek, among other things, an in-depth understanding of the extent to which parties use DRMs other than those agreed at the contract formation stage and what impact such choices have on the relationships of the parties. Although qualitative research offers various approaches for data collection and analysis such as ethnography, phenomenology, grounded theory (Corbin *et al.* 2008), the biographical method and narrative research (Creswell 2009) a qualitative case study seems the most appropriate for the questions outlined above (Yin 2009; Stake in Denzin& Lincoln 1998; Flick2006) . Yin argues that case study research is useful where the aim of the research, among other things, is to explain, explore, or describe an intervention in its natural setting. He states further that in making a choice between case study and other social science strategies, consideration should be given to the research questions to be investigated and the type of study envisaged. If the enquiry is about "how" and "why" some social phenomenon works, and extensive and in-depth study envisaged, then case study will be a good choice of strategy. This type of study raises a number of challenges; sample or case(s) selection, the theoretical implications of a context-based study, issues of verification and generalizability (Eckstein 1975; Achen & Snidal 1989;(Flyvbjerg 2006; Gerring 2007; Collier and Mahoney 1996; Stake 1995; Seawright and Gerring 2008; Yin 2009). It is expected that this research will examine these challenges and their impact on the plausibility of the research design envisaged.

CONCLUSION

The literature reviewed confirms the impact of procurement methods on dispute frequency and the selection of DRM. Some key conclusions deducible from the above discussions are as follows. Firstly, every construction project has the potential to encounter disputes regardless of the procurement method used. Secondly, mechanisms outlined to deal with such disputes are often not selected with the principles undergirding the relationship created by the procurement method in mind. Indeed, an analysis of standard form contract provisions on dispute resolution reveals that arbitration, adjudication/dispute board - essentially binding ADR methods- are the main DRMs often outlined regardless of the procurement method used. Paying attention to the link between procurement methods and DRM will see parties making use not only of the binding DRMs but also the non-binding types. Parties to projects, particularly those which are collaboratively procured, have no reason not to consider the use of other DRMs not incorporated into their contracts. The literature is however silent on the extent to which parties are utilising these non-binding DRMs and the reason why these DRMs may not be enjoying similar patronage as the others such as adjudication and dispute boards. In order to explore these issues comprehensively, a qualitative research approach is adopted. The choice of this approach for the rest of the research stems from the contemporary character of the subject matter, the fact that it is based in a natural setting and the kind of questions to be investigated. A qualitative case study is thus the appropriate method of enquiry going forward

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PROJECT MANAGEMENT

ATTAINING ZERO DEFECTS WITHIN BUILDING SCHOOLS FOR THE FUTURE: A REALISTIC TARGET OR A SISYPHEAN TASK?

Chris Boothman[1] Anthony Higham[2] and Ben Horsfall[1]

[1] *Faculty of Advanced Engineering and Sciences; University of Bolton, Deane Road, Bolton.*

[2] *Department of the Built Environment; Sheffield Hallam University, Howard Street, Sheffield.*

Until its demise in July 2010 The Building Schools for the Future (BSF) programme represented the biggest single UK government investment in school buildings for more than 50 years. One of the key goals of the investment programme was the desire to ensure that pupils learn in High Quantity 21st-century facilities that are designed or redesigned to allow for educational transformation in historically underperforming schools who's pupils where often enshroud in depravation and social exclusion. This represents a major challenge to those involved in the delivery of the new or refurbished schools. The paper explores the extent to which schools completed under the umbrella of BSF lived up to the government's ideology of 'value for money' a key parameter of which is the delivery of high quality buildings. Drawing on an embedded case study methodology based around one local authority which completed nine secondary schools under the BSF funding model between 2006 and 2010. The findings portray the many challenges faced by constructors in the pursuit of zero defect construction. Critical to this, the authors argue, is the approach used by stakeholders to define and measure the presence of a 'defect'. Analysis of quantitative defect data reported in the paper suggests a large number of those defects identified related to mere cosmetic imperfections caused by inter alia the client team moving the school into the new building rather than serious defects caused by poor workmanship on behalf of the constructor. Findings from the research raise important questions about the use of 'defects' as a performance measurement for quality within the construction sector.

Keywords: building defects, quality, total quality management.

INTRODUCTION

In 2003 the Government launched the Building Schools for the future (BSF) programme with the aim of renewing all 3,500 English secondary schools over a fifteen year period with an initial estimated public spend of £52 to £55 billion (National Audit Office 2009) subject to future public spending decisions. The initial plan was to rebuild half the schools, structurally remodel 35% and refurbish the

[1] J.C.Boothman@bolton.ac.uk

[2] A.P.Higham@shu.ac.uk

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balance. The scheme's key aspiration was to ensure that pupils learn in High Quantity 21st-century facilities. That are designed or redesigned to allow for ‘educational transformation’ in historically underperforming schools, where pupils are often enshroud in depravation and social exclusion. The first schools BSF contract commenced in 2005; however in July 2010 the BSF programme which represented the biggest single UK government investment in school buildings for more than 50 years met its demise as austerity measures were introduced. Shortly followed by the James review in April 2011 which recommended that schools be constructed to "standardised drawings" which incorporate the latest thinking on educational requirements implemented by the new Education Funding Agency which still aims to deliver high quality state of the art educational facilities. This study seeks to explore the extent to which schools completed under the umbrella of BSF lived up to the government's ideology of 'value for money' a key parameter of which is the delivery of high quality buildings. The paper concludes by proposing further research into how stakeholders define quality.

THE LITERATURE

Theory of Quality

Following world War II and his ground-breaking work in Japan Deming (1986) in his seminal text “out of a crisis” produced a fourteen point plan which is considered to be a “complete philosophy of management’, which can be applied to small or large organisations in the public, private or service sectors” (Institute for Manufacturing 2009). Deming (1986) suggested that quality can only be defined in terms of customer satisfaction, management is key and quality can be achieved through continuous improvement. Deming differed from Juran (1989) who placed great importance and responsibility on statistical process control with ‘quality through continuous improvement’. Deming (1986) also believed that management is responsible for 94% of quality issues. Deming had a major influence in changing the way Japan controlled quality and stated to Japans chief executives; “improving quality will reduce expenses while increasing productivity and market share” (Deming, 1986).

Prior to the introduction of quality assurance, quality was predominantly measured by the finished product. Other than Deming there have been only a few quality champions who have advanced the theory. Juran (1989) albeit not the first master of quality but is believed to be of significant importance, looked further into quality linking it to value and the end user. Juran further defined quality as the ‘fitness for use’ and suggested that this could be linked to value management where unnecessary costs and products are removed. Juran’s theory brought the development of the quality trilogy: quality planning, quality control and quality improvement as a result of Deming's work and further development of Pareto’s principle; that 80% of the problem is caused by 20% of the causes. It is widely acknowledged and understood that the main aim for quality management is to provide customer satisfaction for all stakeholders. Harris and McCaffer (2006) suggest that this can only be achieved if all stakeholders directly contribute to achieve the objectives.

Quality management could be defined as “the culture of an organisation committed to customer satisfaction through continuous improvement” (CIOB 2011). Quality management should have the same principles for all industries, although quality management evidently is more successful in the car industry than in other industries such as construction, which can be attributed to the early implementation of Deming’s methods.

Deflects as a Proxy for Quality in Construction

The International Council for Research and Innovation in Building and Construction´s (CIB) group W86 (Building Pathology) define a 'defect' as 'a situation where one or more elements don't perform its intended function and an anomaly is referred to as an indication of a possible defect' (CIB 1993). A definition fully supported by one seminal quality theorist. Juran (1989) attests that quality is another term for fitness for purpose. Yet can quality really be measured in such a simplistic manner. When this definition was tested in the courts, the limitations of its suitability became quickly apparent. For example in Yarmouth v France (1887) and later in Tate v Latham (1897) the court held something not fit for purpose was defective. As a result of these cases, it quickly becomes apparent, that if a wall was constructed in concrete blocks rather than facing bricks yet is fit for purpose and therefore high quality. Although the architect may still declare it as defective, given the incorrect materials were used.

The international standard for Quality Systems (ISO9001) published by the International Organisation for Standards has widened Juran's initial definition of quality, suggesting the term quality is to be regarded as the delivery of a product at a set standard. This would appear to suggest that high quality would be indicative of a high level of attainment against that standard. It would be therefore plausible to argue that a defect is a measure of deficiency when it is compared, all be it in a subjective manner, against a predetermined minimum standard. In the case of construction, this would be the specification documents forming part of the contact. A definition which appears to align with the interpretation many of the construction standard forms of contact have implemented. For example, in clause 2.38, of the JCT Design and Build standard form, a defect is expressly defined as "materials or workmanship not in accordance with this agreement". Whereas the New Engineering Contract (NEC3) defines a defect as "part of the works which is not in accordance with the works information or a part of the works designed by the contractor which is not in accordance with the applicable law or contractor's design which the project manager has accepted".

As such defect can be accepted as a measure of underperformance against a standard allowing it to be adopted as a proxy for quality in construction. Consequently, high quality translates into a low number of defects and vice versa -quality is therefore reciprocal to the amount of defects

Latham (1994) and Egan's (1998) seminal reviews of the 1990s collectively challenged the UK construction to have a greater focus on the quality of the assets it deliveries. The authors collectively suggested improvements in quality would foster improvements in the levels of client satisfaction achieved. Key strategies in the attainment of this ambitious target included Latham's (1994) assertion that existing tendering procedures required significant transformation throughout the supply chain and Egan's (1998: 22) call for continuous quality improvements through the targeted reduction and eventual eradication of primary building defects within five years.

Whilst Egan does not purport the adoption of the 'defect' as a singular measure of quality, it is nonetheless important to establish the suitability of a 'defect' as an indicator for quality within construction projects. Wolstenholme (2010) acknowledges in his review of progress since the Egan report, on behalf of Constructing Excellence, that industry has achieved its 20% year on year target for the reduction in the number of recorded defects since Egan first set the target in 1998. A critical part of the sectors continued attainment of this target must be a commitment to the identification of the

principle causes of construction defects. Yet as Auchterlounie (2009) opines defects have continued to plague construction projects across the full spectrum of projects raising important questions as to the underlying causes of defects. Atkinson (1999) suggests there is a wide spread believe within the construction industry that defects are merely the result of both human error and a general lack of work ethic leading to poor workmanship standards. Yet countering this view, Atkinson (1999) also opined that these are often quite complex, with different active and latent errors interacting which eventually lead to human error and the occurrence of a visible defect (Douglas and Ransom, 2007) either way it is clearly in the interests of the construction industry to identify and combat the root causes of defects.

Josephson and Hammarlund (1999) attempted to identify these underlying causes in their four-year research study based on the detailed observation of seven Swedish construction projects over a four to six month period. Identified that defects could not be attributed to either a single stakeholder or phase in the project but to the overall motivation of the project organisational team, suggesting improvements in the motivation of the construction team would lead to a reduced occurrence of construction defects. Love *et al.* (1999) used a system dynamics framework to evaluate two Australian projects, the first a residential tower block and the second an Industrial warehouse facility, from commencement of the construction phase, to the end of the defects liability period. The researcher concluded that a paradigm shift in project management strategy was needed to reduce the occurrence of defects. At the centre of their calls for improvement, was the implementation of a collective, joined up approach to the management of the project with a single point of information and responsibility. Kim *et al.* (2008) concluded a ten-project study, consisting of 700 apartments in multi-storey buildings, and they suggested an Information Communication Technology (ICT) solution for managing defects in large construction projects. They tested and suggested real-time data collection and processing of defects, and the study reported significant efficiency improvements. Hassan *et al.* (2011) reviewed the occurrence of defects across four design and build hospital projects constructed for the Malaysian department of Health. From their quantitative analysis of secondary defect data together with stakeholder interviews, the researcher's analysis of 1343 and 5483 defects per hospital reaffirmed the earlier findings relating to the breakdown in the management of the project. The researchers suggested the management of quality on the project should be a continuous process, overseen by the employment of an independent third party organisation. Yet such approaches are already utilised in the UK construction industry but do not appear to have led to a reduction in the occurrence of construction defects.

The research reviewed so far appears to advocate a relatively project focused approach to the causation of defects, yet another body of evidence has argued the need for a more long term strategy for the reduction in construction defects, based around the theory of organisational learning. Schön, the leading organisational learning theorist argued that people and organizations should be flexible and incorporate their life experiences and lessons learned throughout their life through a process of double–loop learning, where the organization adjusts its operations to both keep pace with changing market conditions but also to create new and better ways of achieving business goals (Fulmer 1994). A number of researchers have argued, such an approach would allow organisations to proactively reduce and eventually eliminate defects and improve the quality of their projects (Love *et al.* 2000).

In later research, Love *et al.* (2002) examined how the extent to which change management or the potential lack of change management processes within the project management system affected the overall quality levels attained. The research again adopted a case study approach, with data collected through both observation and stakeholder interviews. The research identified that change occurrences had a significant impact on the management of the project, inevitably leading to an increase in the number of observable defects. As a result, the researchers concluded that the reduction in defect occurrences required the project manager to learn from and develop mechanisms to proactively anticipate project change, and on occurrence deal with the effects of those changes.

Yet as Lundkvist *et al.* (2010) quantitative survey of forty-one Swedish project and site managers suggested Love *et al.*'s (2000) calls for the adoption of organisational learning strategies as a part of enhanced quality management have been largely ignored. The survey revealed that although the majority of respondents understood the benefits associated with the detailed analysis of defect data from past projects, in practice very few tried to use it for experience feedback and continuous improvement. The majority did little more than correct the defects. Although evidence from two of the UKs largest contactors Laing O'Rourke (2009) and Bovis Lend Lease (2010) appears to suggest this lack of reflection or organisational learning, could be a symptom of the construction teams eagerness to move to the next challenge. A problem which Peach (2010) opines must be addressed if overall quality is to improve and the industry is to close in on achieving zero defects.

If Auchterlounie (2009) is to be believed, the finding of these studies have thus far failed to identify the principle route causes of construction defects raising the question, is zero defects truly a Sisyphean task. Deming (1986), the world authority on quality, appears to suggest this to be the case, arguing efforts to remove all defects would be an excessive waste of time and money. Instead Deming asserted that the client and manufacturer should establish an acceptable level of defects for the project prior to commencement. Looking to the literature, Aagaard *et al.* (2010) have developed a theoretical framework for the identification of the optimal level of defects based around economic theory of optimisation. The model suggests it is possible to identify an acceptable number of defects based on the economic cost associated with defects. Fundamentally the model suggests the decision to attempt to deliver a zero defect building is principally economic. The fewer defects the client is willing to accept, the more the project will cost, whereas the more defects the client accepts the less the project will cost. Yet the complexity of construction procurement would appear to suggest that the model is overly simplistic, especially given the excessive use of price based competition (Wolstenholme 2010). In reality, the cost of defects are borne by the contractor, who has little prospect of transferring these back to the client in the form of additional transaction costs. Bovis Lend Lease (2010) suggests, defects can be up to 1.7% of the projects total value. On an £80million project, this would translate to an additional expense of £1.4million wasted on the correction of poor workmanship. However, Fagbenle's (2010) recent large scale quantitative survey of over eight hundred Nigerian construction firms suggests these costs and the total number of defects could be reduced significantly if contractors proactively managed their supply chain. Analysis of the data from the questionnaire revealed a strong positive correlation between time and quality performance of labour only subcontractors. Suggesting labour only subcontractors compromised on quality to complete the work in the quickest time possible.

The literature reveals that although defects are costing contractors nearly 2% of the project value to put right (Bovis lend lease 2010). Significant progress has not been made against Egan's fourteen year old target of delivering defect free construction. The literature evidences that whilst defects are the result of human error, a highly complex interrelated set of factors lay behind this. Yet the major contactors in the sector appear dismissive of the academic models developed. Suggesting instead that the pivotal reason for the number of defects recorded at handover is simply the low priority construction management professionals assign to the rectification of sub-standard work immediately prior to the critical hand over stage of the project. Yet this hypothesis appears to be untested in the literature. This paper is drawn from a larger PhD study which is aiming to develop a theoretical framework to allow major contractors to monitor defects as an indictor of performance.

RESEARCH APPROACH

Yin (2008) defines case study research as “an empirical inquiry that: investigates a contemporary phenomenon within its real life context, especially when the boundaries between phenomenon and context are not clearly evident”. Yin identifies several points within this definition, which typify case study research. First, the case study is involved with empirical inquiry and therefore relies on the collection of evidence on what is going on. The case study focuses on a phenomenon in context, typically in situations where the boundary between the phenomenon and its context is not clear. It is useful to this study when a how or why question is being asked about a contemporary set of events over which the investigator has little or no control (Yin, 2008). In the case of research into defects, earlier researchers appear to have favoured the single case study as a tool for the collection of empirical data.

In his seminal work on case studies Yin (2008) asserts the use of a single case study is justifiable in any one of the following five situations (a) the case is critical, testing a well formed theory; (b) the case is extreme or unique; (c) the case is representative or typical; (d) the case is revelatory or of finally (e) the case is longitudinal. As all BSF programmes and centrally funded and controlled the researchers feel the programme evaluation is typical of projects completed under this funding model. The adoption of a single study design also allows the researcher to undertake a more detailed scrutiny of the organisation thus strengthening the research whilst improving the studies validity (Proverbs and Gameson 2008).

Data Collection

The paper reports the initial exploratory phase of the case study research, based on analysis of defect data from the case study programme is reported. Identification of both the levels of defect occurrence and any specific trends with the identification of defects is an important stage in determining how BSF project stakeholders interpret quality and how this interpretation evolved through the three phases of the project. As the case study projects selected were constructed over three phases, between 2006 and 2010. The researchers have dismissed the use of primary data collection. This called for a research design making use of existing data held by both the client's professional team and the main contractor. The use of secondary data analysis is supported by Gilbert (2008:287) who argues the use of document analysis as an appropriate data collection approach when the researcher wishes to start with a generic question, or a statement from which the main research will evolve. Whilst Proverbs and Gameson (2008) opine that, the use of document analysis is wholly appropriate, if used as part of a fully triangulated research design.

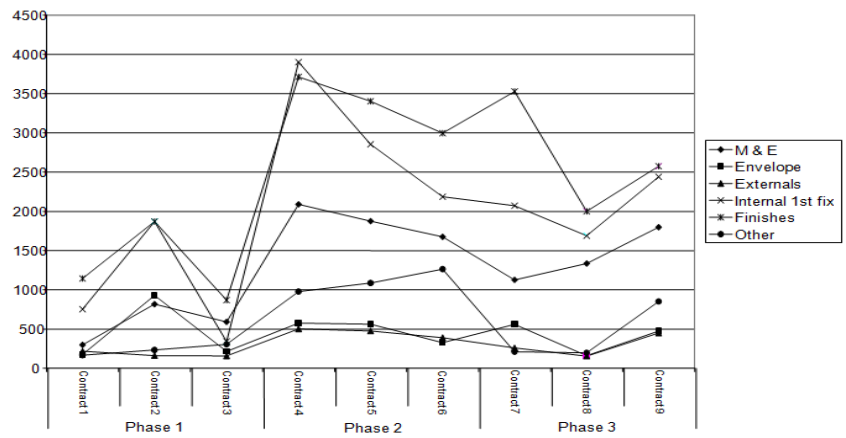
DEFECT DATA ANALYSIS

The first round of results has been analysed using descriptive statistical techniques in order to determine:

- Defect occurrence trends across the full programme to establish if organisational learning is taking place;
- To establish defects occurrence patterns across works packages for the three phases;
- To appraise how defects are managed between key milestones in the contract.

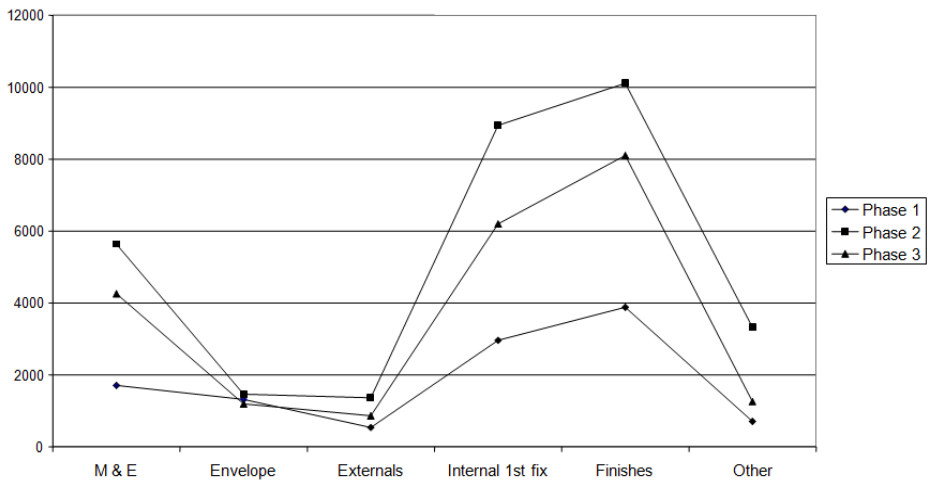
Figure one illustrates a positive trend in the number of defects recorded across the three phases consisting of nine projects. The figure shows a significant fluctuation after phase one which albeit recovered within the final phase but did not return to the previous lows seen in phase one.

Figure1: Defect occurrence across the programme



Further analysis of the data in figure one and figure two illustrate both the external works and the main structural envelope delivered a constant level of quality across all nine projects.

Figure2: Defect Occurrence Patterns

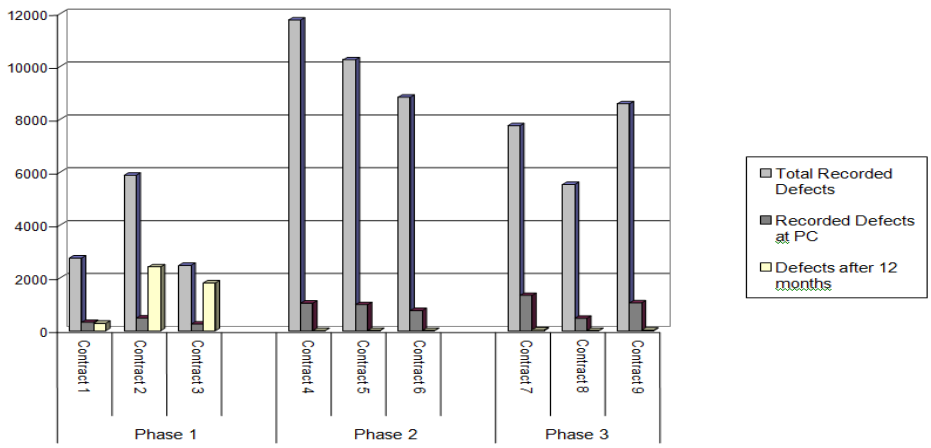


This is suggestive of the implementation of effective management systems, workmanship control and quality standards. However mechanical and electrical, the internal first fix and finishes all recorded significant fluctuations in quality both

between phases and within the phases. Leading researchers to hypothesise that the significant fluctuations may be triggered by inter alia (i) lack of specialists knowledge within the management team; (ii) the operatives consider that unseen work albeit needs to be functional does not need to be aesthetically pleasing and finally (iii) finishes are generally more scrutinised and prone to damage thus leading to stakeholders perception that there is a increase in the number of defects recorded.

Figure three illustrates the number of defects identified at three key stages within the project life cycle. The data suggests albeit the clients feel that construction quality is poor typically they are unaware of the contracts commitment to quality control. This can clearly be seen in figure three where column one records the total number of defects observed by the main contractors site management team upon completion of the various packages. The second column records the number of latent defects observed by the designer at practical completion where a marked improvement in quality can be observed. The data in figure three further demonstrates an improvement in achieved quality at phase one with a complete eradication of latent defects in the subsequent phases.

Figure3: How defects are managed



DISCUSSION OF RESULTS

Through the evaluation of defect data collected from nine case study projects, completed over a four year period by the same project team revealed an unexpected positive trend in the number of defects identified. Over the three phases of the programme the number of defects recorded at both pre completion and practical completion stages increased significantly from phase one to two. The CIOB (2011) assert that one of the key facets of quality management is to strive for continuous improvement. For this to be attained on the BSF project analysed the number of defects should reduce. Potential reasons for the none achievement have been identified in the work of Love *et al.* (2000) and Lundkvist *et al.* (2010) who have both assert the construction team should learn from their past experiences, build on them and subsequently reduce the number of defects identified. Yet the data appears to suggest that a limited amount of organisational learning had taken place which is evident through the fall of the number of latent defects recorded.

More extensive observation of the data suggested that only certain works packages followed this trend. Typically the packages recording the higher levels of defects were the specialist mechanical and electrical or packages where quality was deemed less important. This would appear to align with Labbad (2010) who suggests the

importance of quality is not understood by the operatives completing the work. However if this was the case we would have expected to see similar levels of defects across all works packages within all nine contracts. This may add weight to Douglas and Ransom's (2007) suggestion that the cause of defects is often quite complex with various active and latent errors interacting which eventually lead to human error and a visible defect. A further contributory factors maybe the lack of experience of the site management team such as the work of Farrell and Gale (1999) evidences the career path of the construction manager which shows younger inexperienced staff often supervise smaller or less important work. Although it may also simply be that some aspects of the work are subject to more scrutiny than other by the various stakeholders.

CONCLUSIONS

This paper raises a number of important questions about the use of 'defects' as a performance measurement for quality within the construction sector. The literature identified that poor management practices together with a disregard towards organisational learning has resulted in the adoption of a weak approach to the management of quality within the construction sector. The literature further identifies a number of contributory factors including (i) the lack of personal ownership of quality (ii) procurement driven by price not the wider parameters of value and (iii) the construction teams eagerness to move on to the next project. This collectively prevents the sector attaining the levels of quality Egan (1998) observed in other industries.

The initial baseline analysis of defects appears to support the initial view developed from the literature review. The research identified that the number of recorded defects has not reduced over the three phases. This suggests organisational learning is not taking place within the team. Secondly, the defect data appears to suggest that that certain works packages appear to be more prone to the occurrence of defects than others. Yet these packages appear to exhibit two common traits. Either they were highly complex in nature, for example the M&E package or where more visible at building handover for example floor finishes. A number of possible explanations for this exist within the literature. These include inter alia: the assigning of these packages to the less experienced members of the supervisory team or simply the desire to leave site for the next challenge.

The next phase of the PhD research is to undertake exploratory interviews with project stakeholders to establish if the initial observations are valid.

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CURRENT PRACTICE OF VARIATION ORDER MANAGEMENT IN THE SAUDI CONSTRUCTION INDUSTRY

Jawad Alsuliman[1], Graeme Bowles[2] and Zhen Chen[3]

Institute for Building and Urban Design, School of the Built Environment, Heriot-Watt University, Edinburgh, EH14 4AS, UK

The complexity of construction projects means that it is unusual to deliver a project without any change during its project lifecycle. Liability to change is an attribute that generally characterises almost all projects. It is assumed that the use of a change management system in construction projects would assist the management of variation orders effectively. Variation order management is not fully understood nor well applied in the Saudi construction industry. In order to better understand the current practice of variation order management at the design stage of public sector construction projects in Saudi Arabia, this paper reports the results of an exploratory study that used a series of interviews with public sector clients and consultants in 2011. Findings indicate that there are currently no formalised approaches to the management of variation orders at the design stage. In addition, there is a general lack of knowledge about managing variation orders. The paper concludes that there is not only a need to apply an appropriate variation order management system to Saudi public sector construction projects at the design stage, but it also presents participants' suggestions of the most appropriate ways of doing so.

Keywords: design stage, public sector, Saudi Arabia, variation orders.

INTRODUCTION

The construction industry has been described as complicated and uncertain in nature, as each construction project has its own unique circumstances and conditions. The complexity of construction projects means that it is hardly possible to deliver a project without any change in its lifecycle, that is, every construction project is unique in many respects, but liability to change is an attribute that generally characterises almost all projects. This has led Revay (2002) to claim that change is 'a fact of life' for a construction project. Baxendale and Schofield (1986) define variation orders as any change that can occur to the basis that is different from the agreed and signed contract. Following the same line of thought, Ssegawa *et al.* (2002) explain that sources that

[1] ja169@hw.ac.uk

[2] g.bowles@hw.ac.uk

[3] zhen.chen@hw.ac.uk

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might trigger change in a construction project can be as simple as a change of mind on the part of the clients, their consultant or unforeseen problems raised by the main contractor or sub-contractors.

This paper intends to investigate the current practice of managing variation orders in Saudi public construction projects, at the design stage, by conducting a series of exploratory interviews among some public sector clients and consulting firms. The paper also presents some suggestions of practical ways of applying an appropriate variation order management system to Saudi public sector construction projects at the design stage.

LITERATURE REVIEW

Variation orders at the design stage

It is well established in research into variation orders that the design stage is totally unlike the construction stage and, therefore, they are two separate functions. As a result of this separation, it is very unlikely that a project can be delivered without any variation orders during both the design stage and the construction stage (Ssegawa *et al.* 2002) and it is not an uncommon situation (Construction Industry Institute, 1990; Ibbs *et al.* 2001). In fact, Revay (2002) has been argued that there will certainly be variation orders in each single construction project in most, if not all, of their lifecycle of design, time, cost and quality. Ssegawa *et al.* (2002) further explain that the complex nature of construction projects suggests that, in order to finish a construction project, changes to plans or the construction process itself must be expected.

Therefore, the construction industry is subject to poor performance due to design and construction quality that may cause the occurrence of variation orders, which leads to time delays and cost overruns. Design changes are natural results of the design process. The complexity arises in multi-disciplinary design situations because changes made in one discipline commonly influence design descriptions in the other disciplines involved (Zaneldin, 2000). In fact, research indicates that the design stage is often distinguished by the high likelihood of changes in variation orders. This has been documented in more ways than one. Some examples are:

- Variation orders are easier to manage at the earlier phases, such as the design phase, simply because these variations do not require any rework or demolition (Arain and Pheng, 2007).
- During the early stage of design, variations can be conducted at minimum cost and have the greatest potential for maximum saving (Zaneldin, 2000).
- Motawa (2004) suggests that efforts should be focused to trim down the amount of variation orders at the design stage.
- Clough and Sears (1994) claim that any major variations or additions in the design phase may increase the project total cost.
- Variation orders at the design stage always lead to poor performance, whether they are owner-initiated or consultant-initiated (Oladapo, 2007).
- Clients who spend more time and money at the design stage reduce variation orders (Ndihokubwayo, 2008).
- Langford *et al.* (1986) states that the design team initiates 72% of the variation orders (cited in Akinsola, 1997).
- Oladapo (2007) emphasises that clients and consultants initiate the majority of the variation orders.

- The earlier that variation orders are managed, the greater time value will be recognised (Bearup, 1995).

Management of variation orders

Due to the inevitability of variation orders, as well as their potential impact on the planning, design, progress and completion of any given construction project, it is not uncommon for the literature to devote considerable time and effort to the experimentation and theorisation of how such orders can best be managed. In this respect, Arain (2008) asserts: "The issue of managing variations has received much attention in the literature. Despite many articles and much discussion in practice and in the academic literature, the issue of learning from past projects in making timely and more informed decisions for the effective management of variation orders has not been explored much in the literature".

In fact, several strategies have been acknowledged as useful in managing variation orders. According to Charoenngam *et al.* (2003), among the various strategies used to manage variations is that of involving the creation of good communication and cooperation among project team members. Charoenngam *et al.* (2003) further explain that, in making information accessible to all stakeholders, it is important to establish such communication and cooperation and that is why the authors advise making good use of the Internet technology as the communication media, where accessibility to timely and accurate information is not bound to time and place. While Jacob (1978, pp. 64–65) noted that "lax attitudes and unfamiliarity with proper change order procedures have led to serious financial loss and insolvency", Chan and Yeong (1995) assert that good contract documentation and good communication and cooperation between building team members are major elements that can make the task of managing change orders easier. As for good documentation, explains Chan and Yeong (1995), it is generally facilitated by designing an effective change order system, which should be geared towards understanding the change order process or "workflow", which can be collected from the standard forms of contracts. With regards to good communication, however, it might be facilitated by providing information in a well-timed manner.

Motawa (2004) emphasises that, in order to improve the project change management, it is essential to adopt a change process model. For Motawa (2004), variation models can be adopted to facilitate the process of variations that have occurred or are about to occur. Ibbs *et al.* (2001) further state that identifying variation orders prior to their occurrence can assist the project team in managing variations better and earlier. Hence, if the project team established a knowledge-base of similar past projects, they would be capable of planning efficiently before conducting a project and during the design and construction stages, in orders to minimise variation orders and avoid their negative impact (Arain and Pheng, 2007). Similarly, Ibbs *et al.* (2001) suggest that having a systematic approach to managing change orders effectively in construction projects would minimise cost overruns and time delays. In a similar manner, Krone (1991) suggests a variation order process in which efficient administrative processing is promoted.

Following a similar line of thought, several research projects have been carried out into modelling change processes in the construction industry that attempt to identify the factors that affect the success of the change lifecycle, such as those by Motawa *et al.* (2007) ND Arain and Pheng (2007), amongst others.

Design performance in the Saudi construction industry

The Saudi construction industry is often seen as one of the largest construction industries in the Middle East. Furthermore, the construction industry is the second largest industry in Saudi Arabia (National Commercial Bank, 2010). In their article Arain *et al.* (2006) explain that the inconsistencies between design and construction have a negative impact on the performance of construction projects in Saudi Arabia. They also state that a number of factors are responsible. Some of these include: (a) the involvement of the designer as a consultant, (b) communication gaps occurring between the contractor and the designer, (c) insufficient details in the work drawings and (d) lack of coordination between the parties. In addition, Arain *et al.* (2006) also identified the lack of qualified personnel in the design firms, the designers' lack of knowledge of available materials and equipment and the use of incomplete shop drawings and specifications. Following the same line of thought in another study, Arain *et al.* (2007) state that inexperienced clients have led to the adoption of inadequate designs, resulting in many changes to drawings, specifications and contract terms and, therefore, to failure in project performance.

Similarly, a study conducted by Al-Dubaisi (2000) states that variation orders are the major cause of failure in construction project performance in Saudi Arabia. To this researcher, this failure occurs because the variation orders lead to cost and time overruns. Also, the results of the study indicate that cost overruns because of variation orders were in the magnitude of 6% to 10% of the original contract value. Time overruns due to variation orders were reported as being less than 10% of the original contract period. The study also concludes that the clients initiate most changes during the design phase. Furthermore, design errors are considered as the most significant cause of variation orders in large building projects in the Saudi construction industry. Mutauwaa (1988) explains that inadequacies in the design and construction stages, financial abilities and the behaviour of the construction parties were the most common causes of variation orders in the Saudi construction industry.

The quality management in the design and construction stages is a key factor in achieving a successful project. In this respect, Al-Abdulrazzak (1993) asserts that quality management practices in the design phase, such as drawing checks and the provision of clear, concise and uniform plans and specifications, have a significant impact on project performance. Further explanation by Bubshait *et al.* (1999) indicate that the aspects influencing quality activities in design firms are: (a) the major need for development in the quality of working relationships and (b) the need to overcome design errors that affect project performance, specifically staff training and performance quality audit. In the same way, Al-Musallami (1992) reports that clients are dissatisfied because of the high percentage of variation orders due to design errors, especially those that have a significant impact on project performance. Moreover, a study conducted by Assaf and Al-Hejji (2006) identified the failure in construction projects in Saudi Arabia. Their results indicate that several factors relating to design affect project performance. To Assaf and Al-Hejji (2006), these factors include: "mistakes and discrepancies in design documents; delays in producing design documents; unclear and inadequate details in drawings; the complexity of project design; insufficient data collection and surveying before beginning the design; misunderstanding of the client's requirements by the design engineer; inadequate design-team experience; and the non-use of advanced engineering design software".

Performance of Saudi public construction projects

Generally speaking, the Saudi construction industry is considered the same as any other construction industry in the world. According to Falqi (2004), the Saudi construction industry suffers from poor performance and faces some difficult challenges. In this respect, several local studies have proven that there is considerable poor performance in Saudi construction projects. A survey conducted by Al-sultan (1987) to examine the time performance in different types of construction projects in Saudi Arabia stated that 70% of construction projects experienced time overruns. Similarly, Alkhalil and Alghafly (1999) carried out a preliminary survey to evaluate the time performance in Water and Sewage Authority construction projects and found that 45, out of a total of 76, construction projects were delayed. Moreover, Alkhalil and Alghafly (1999) asserted that changes in the 76 projects evaluated were one of the major causes of delay. In the same way, Assaf and Al-Hejji (2005) conducted a survey to identify the causes of delay in large construction projects in Saudi Arabia. Surprisingly, all three parties involved in this survey state that variation orders are the most common cause of delay in the Saudi construction sector.

On the other hand, literature indicates that there are limited publications related to Saudi construction project performance, specifically with regard to variation orders. The public sector in Saudi Arabia is the major source of construction projects. Statistically speaking, the Saudi government has been the major client for the construction industry, accounting for approximately 67% of industry volume (Alsaqer, 2001). Government construction projects include a variety of projects, such as residential houses, highways, government office buildings, schools, hospitals, airports, utility projects, cultural and recreational facilities, power plants, etc.

RESEARCH METHODS

The lack of knowledge about the management of variation orders in Saudi Arabia and the limited published work in relation to the same topic in the Saudi construction industry has led this researcher to implement a qualitative approach. Semi-structured interviews were adopted as the main research technique. To Bryman and Bell (2003), the interview approach is the most commonly used research technique in qualitative approaches as this particular technique provides a flexible method that can be adopted to collect significant ideas and comprehensive opinions to enrich the research. A series of exploratory interviews was carried out with public sector clients and consulting firms in the Saudi construction industry. The general aim of the interviews was to better understand the current practice in relation to variation order management at the design stage. The interviews also aimed to identify whether or not there has been some sort of criteria for managing variation orders in the research context. In addition, the interviews intended to explore the existing/non-existing models or frameworks or IT-based software to manage variation orders and to confirm whether or not the research context is in need of a variation order management system. The semi-structured format of the interviews allowed a good opportunity to qualitatively make additional observations that would assist the subsequent development of the research.

Design of the exploratory interviews

An interview guide was designed in order to develop the interview questions. The guide was divided into four sections: interview topic, questions, objectives of the questions and response analysis. These four sections of the interview guide ensured

that (a) valid questions were asked and (b) how the questions would be evaluated and analysed. It was crucial in designing the interview guide to ensure that the sequence of the interview questions follows an order to facilitate moving between questions. The semi-structured interview consists of fourteen questions and these were divided into three main parts: (a) personal background, (b) management of variation orders in Saudi Arabia and (c) existing of models/frameworks or IT-based software to manage variation orders in Saudi Arabia.

Sample and data collection

The sample of the study consisted of members of the public sector clients and engineering firms involved in the Saudi construction industry. The rationale behind the sample selection was based on the possibility of (a) examining different perspectives, (b) issues and experiences and (c) gaining valuable diverse data to better understand the current practice of variation order management at the design stage. The public sector clients were the Saudi Ministries that have construction management departments. The selected participants amongst the public sector clients were project managers or client representatives for construction projects. The consultants were merely the certified consulting engineering firms from the Ministry of Municipal and Rural Affairs in Saudi Arabia. The selected participants from the consulting firms were design and/or project managers. The sample comprised 23 respondents in total, 7 from different public sectors and 16 from different consulting firms in Saudi Arabia. The interviews were performed through recorded phone calls during the last quarter of 2011. The total time spent on interviews is 710 minutes, with an average duration of 31 minutes for each interview and the spoken language was Arabic. The recordings were transcribed as Microsoft Word documents. The collected data from the semi-structured interviews were analysed manually and systematically as described by Ritchie *et al.* (2003). The analysis steps of the interviews consist of 9 major steps that derived to the key findings and problem confirmation. These steps are recording and transcribing, data familiarisation, theme and concept identifications, indexing the concepts, synthesis, categorisation, constructing thematic matrices, findings and problem confirmation.

FINDINGS AND DISCUSSION

The major findings of this study indicated that there is currently no formalised approach employed to manage variation orders at the design phase in the Saudi public construction projects. However, the conceptual framework of common practice has currently based itself on the responses, which can be divided into four main stages: identifying and evaluating variation orders, estimation and approval, implementation and documentation. In order to facilitate the research findings, a thematic matrix was constructed with extreme care with regards to the amount and content of the collected data. The constructed thematic matrix consists of two main topics, each of which consists of sub-topics that present key findings. The weightings of the key findings are measured based on how many respondents stated the finding. Table 1 shows a summary of the constructed thematic matrix and the frequency of the key findings by the study respondents.

Table 1: Shows the constructed thematic matrix

Topics	Sub-topics	Key findings						
Current practice of variation order management at the design stage in Saudi public construction projects.	Impact of variation orders.	Delay at design stage (14)*	Cost overruns (9)	Quality defects (8)	Disputes and conflicts (7)	Design errors (8)	Design productivity (7)	Design effectiveness (6)
	How variation orders are managed.	Straightforward process (13)	Identify variation (10)	Evaluate variation (8)	Estimate cost and time (12)	Documentation (7)		
	Problems associated with current variation order management.	Poor change management (15)	Poor co-ordination and communication (12)	Lack of written contracts (10)	Change in one discipline affects others (9)	Late design changes (8)	Bureaucracy of public clients (11)	Shortage of training courses for engineers (8)
Existing models/ frameworks to manage variation orders in Saudi public construction projects.	Using models/ frameworks to manage variation orders.	Currently no existing approach (18)	No idea about how these work (12)					
	Causes of not using models/ frameworks.	Lack of awareness (10)	Lack of knowledge (9)	Assuming that it is complex (8)	Lack of sufficient contracts (7)	Lack of experience with change management (8)	Assuming that it is costly (9)	Not enough details are produced in the design(9)
	The need for variation order management systems.	Significant need (17)	Analysing variation order comprehensively (13)	Leading for effective design (12)	Better understanding of variation orders (14)	Assists with better management (14)	Avoiding unforeseen design errors (11)	

* The frequency of the key finding by the respondents

It can be seen, from the analysis of the exploratory interviews, that the tasks of the parties involved in construction projects at the design stage in Saudi Arabia are not yet clearly identified and understood with regards to variation order management. This issue could be attributed to the fact that there are currently no formalised approaches to manage variation orders during the design process. This conforms to the results obtained by Almazyad (2009), who carried out a study in which he states that the tasks and activities of construction projects in Saudi Arabia are not yet well explained and identified among the project parties. Moreover, it can be clearly seen from the interviewees in the public sectors that the scope of any construction project is not clear enough for the public clients, notably with regard to project variations. Here, the considerable lack of knowledge in relation to change management practices can be clearly noticed. This finding adds weight to Al-sudairy's (2001) argument, which states that the system of change management is new in the Saudi construction sector and is not yet well established.

Analysis of the data also revealed a significant lack of knowledge and experience with the management of change orders in Saudi construction projects, which led to several problems that could easily be associated with variation orders. Such a result agrees with Alkhalil and Alghafly (1999), who claim that changes are one of the major causes of delay in the Saudi construction industry. Similarly, the survey conducted by Al-sultan (1989) identified that there is no systematic engineering approach, or at least no formal procedure followed by the public sectors in Saudi Arabia, in order to set the contract duration for the public construction projects. Hence, participants in the current study, both public clients and consultants, strongly suggested a need for adopting a change order management system at the design stage to assist them in overcoming problems and managing changes effectively. Additionally, participants suggested some further issues must be taken into consideration before applying a change management system in the Saudi construction industry. These suggestions are, for instance, providing workshops and training courses to the project parties to understand how these systems work, having full awareness of the variation order process, paying more attention to contract terms and improving the communication and co-operation between project teams.

CONCLUSIONS

This paper investigated the current practice of variation order management in Saudi public construction projects at the design stage by carrying out exploratory interviews among public sector clients and consulting firms. The results of the exploratory interviews indicated that there are currently no formalised approaches to the management of variation orders at the design stage. The paper concludes that there is a need to apply an appropriate variation order management system to Saudi public sector construction projects. In addition, this paper presents some of the participants' suggestions.

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RE- CONCEPTUALISING AGILE FOR LEAN CONSTRUCTION: THE CASE FOR "AGILEAN" PROJECT MANAGEMENT

S. Tugra Demir[1], David J. Bryde, Damian J. Fearon and Edward G. Ochieng

School of the Built Environment, Peter Jost Enterprise Centre, Liverpool John Moores University, Byrom Street, Liverpool, L3 3 AF, United Kingdom

To address limitations of Lean in construction, new paradigms linked to Agile management methods are receiving increased attention. Agile approaches to management in manufacturing and information technology [IT] developed independently and with different objectives. However in applying Agile to construction, theorists have not made a distinction between the two paradigms. Hence the aim of this research is to analyse the appropriateness of Agile manufacturing and Agile IT to construction. A review of the extant literature on both is undertaken and from this it is concluded that Agile IT is more suitable to construction project management [PM] than Agile manufacturing. Then interviews were undertaken with Agile experts and project managers to assess how Agile IT could be applied. The results of the interviews suggest that concepts from Agile IT need to be integrated with those of Lean to be effective in the construction environment, i.e. Agile needs to be re-conceptualised for Lean construction. This paper presents a potentially unifying framework, called "AgiLean PM", which illustrates how waste elimination, through Lean, and the ability to react to change, through Agile, is achieved at the operational level; with PM methods providing the necessary strategic oversight.

Keywords: agile, agilean, leagile, lean, project management.

INTRODUCTION

Over the past two decades there has been a great deal of attention paid by theorists to developing Lean construction. However theoretical advances have not been reflected by widespread adoption of Lean in practice (Demir *et al.* 2012). Indeed the industry is still struggling to implement the complex combination of Lean thinking, principles and tools too much of construction-related activity (ibid.). This failure to gain traction may well be related to the roots of the theoretical developments, as Lean construction is clearly derived from Lean production.

To address some of the limitations of Lean in construction new paradigms linked to Agile management methods are receiving more and more attention in the sector. The origins of these methods are in manufacturing and in IT; although they developed

[1] S.T.Demir@2009.ljmu.ac.uk

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independently of each other and with different objectives. In applying Agile to construction, theorists and practitioners have not made a distinction between these completely different modern paradigms (Owen and Koskela, 2006a, Owen and Koskela, 2006b; Owen *et al.* 2006; Ribeiro and Fernandes, 2010). Indeed they have often been mixed together and used at the same time (ibid.). This results in a farrago of management methods which makes it difficult to assess the appropriateness of Agile to construction. It also inhibits the establishment of a solid theoretical foundation for Agile construction.

Hence this paper seeks to explore the appropriateness of Agile manufacturing and Agile IT approaches for construction. This is facilitated through a comprehensive literature review with the conclusion being that Agile IT is more applicable. The research focuses on exploring Agile IT through conducting interviews with Agile professionals and construction project managers. Clear potential advantages, limits and barriers for Agile IT in construction are identified. The authors conclude that Agile approaches in general are most useful when combined with elements of Lean. The combination of waste elimination, through Lean, and the ability to react to change at the operative level, through Agile, when underpinned with universal project management [PM] methods at the strategic level, is a potentially unifying framework. As such a new approach, called AgiLean PM is introduced in this paper. AgiLean PM is a wider research project conducted in the BEST Research Institute at Liverpool John Moores University. This paper summarises one part of it. The paper is structured as follows: first the appropriateness of Agile IT and Agile manufacturing are analysed; second, the research method is explained; then the results of the collected data are shown, followed by the discussion of the findings; finally, conclusions are drawn.

LITERATURE REVIEW

Agile in Manufacturing

Agile in manufacturing was initiated through market research, where the Iacocca Institute (1992) established that the future markets for manufacturing required a production system which is not only able to produce the right volume but also to supply the right variety into its market niches (Booth, 1996). The United States [US] saw the possibility "[...] to regain the leadership it lost in the 1970s and '80s" in manufacturing (Iacocca Institute, 1992, p. 1), i.e. to develop a paradigm which was able to compete with Lean (Booth, 1996). The concept of Lean works well where demand is relatively stable, predictable and where the variety of production goods is low (Christopher and Towill, 2001). Therefore the implementation of Lean requires a stable platform, in which it is possible to maximise efficiency (Andersson *et al.* 2006). Highly dynamic conditions or a highly dynamic environment, as the demand driven future markets represent, cannot be dealt by Lean, "[...] as there is no room for flexibility due to the focus on perfection [...]" (Andersson *et al.* 2006, p. 289). Contrariwise, Agile is focused on producing goods where the demand is volatile, less predictable and the customer requirement for variety is high (Christopher and Towill, 2001). Hence Lean can be seen as a contrasting paradigm to Agile. The aim of Agile manufacturing is to combine the enterprise, people, and technology into an integrated and coordinated whole, which will result in agility (Kidd, 1994). This agility enables the reaction to demands in the market through the ability to use and exploit cooperate knowledge (ibid.). The concepts of Agile manufacturing are, according to the Iacocca Institute (1992), based on core competence management, capability for reconfiguration, knowledge-driven enterprise and virtual enterprise. An organisation is

Agile when it covers all the conceptual elements, but the crucial enabler is the concept of the virtual enterprise. Hence it is built around the synthesis of a number of enterprises, each have some core competencies. It uses each co-operators knowledge and resources in order to fill the newly occurred need in the market, through changing and adopting the required business strategy (Kidd, 1994). This creates a virtual enterprise which is formed only for this particular demand in the market, which is Agile as the virtual enterprise can be formed and changed rapidly. For example, the virtual enterprise can have the design competency of one company, the manufacturing competency of another, with the distribution and logistics competency of third, creating a new innovative product, produced and brought to the market as efficiently and effectively as possible (ibid.). Therefore Agile manufacturing can be also called Agile enterprise (Ross, 1994), because it is more related to business strategy.

Agile in IT

Agile IT developments can be related to the understanding that different types of projects exist, each with different characteristics (Wysocki, 2006), namely: projects which are linear (defined goal and solution), iterative (defined solution but no defined goal), incremental (defined goal but no defined solution) and adaptive (no clear goal and solution). Agile methods focus on iterative and incremental solutions (ibid.; Fernandez and Fernandez, 2008). The attention of the Agile IT PM community arose through a misinterpretation of the waterfall model (Larman and Basili, 2003; Owen and Koskela, 2006a), which was developed by Royce (1970). The IT PM practitioners see the waterfall model as a static linear system, where each phase has to be completed sequentially, resulting in a slow and monolithic PM system (Aoyama, 1998) which allows no feedback (Wysocki, 2006) and assumes that all project requirements can be determined at the initiation phase (Highsmith and Cockburn, 2001).

Working in a dynamic project environment results in changing project requirements over the project life-cycle, hence there is a need of flexibility when undertaking a project (Chin, 2004). Out of that need the IT practitioners developed different PM methods, which are able to deal with changing project requirements and were applied in practice centuries ago (Larman and Basili, 2003). The formalisation of those practices took place under the framework of a movement called 'Agile Software Development Alliance' (Agile Alliance, 2001). This movement produced a manifesto with the following values (Agile Alliance, 2001): individuals and interactions over processes and tools; working software over comprehensive documentation; customer collaboration over contract negotiation; responding to change over following a plan. Based on these values twelve principles were identified. The Agile values do not specify a method; rather they provide a guiding statement, to help people gain knowledge about agility and to see if one is following an Agile methodology or not (Hunt, 2006). As such Agile is an umbrella term used to describe a number of different PM methodologies, for instance eXtreme Programming, Adaptive Software Development, Crystal and Scrum (Boehm, 2005). Those methods have quite similar practices such as daily meetings, backlogs, user stories, and iteration planning (Weyrauch, 2006), which reflect the Agile principles and therefore the Agile values. If an organisation wants to implement Agile, then all the practices of the method have to be in place, otherwise it will result in project failure (Coffin, 2006).

Agile PM involves planning, design and documentation only as much as is required (Karlesky and Voord, 2008). The focus is on delivering working features to a paying

customer as soon as possible (ibid). This is facilitated through designing and planning modular elements of the overall task rather than the whole as monolithic (Aoyama, 1998). So to conclude, traditional PM methods focus on developing a project plan and sticking to that plan, which improves coordination but reduces variability (Lindstrom and Jeffries, 2004). Agile methods assume that variability cannot be reduced, therefore the aim is not to minimise or eliminate change; rather it is about managing and allowing change in a systematic way (Highsmith and Cockburn, 2001).

Why Agile IT instead of Agile manufacturing for construction?

The applicability of Agile concepts to construction have been analysed by Owen and Koskela (2006a), Owen and Koskela (2006b) and Owen *et al.* (2006), with the conclusion being that it is more applicable to the design phase than to the execution phase. Ribeiro and Fernandes (2010) argue on the other hand that Agile methods show high potential for managing the whole project, when applied by medium and small sized companies. However, these studies did not make a formal distinction between Agile manufacturing and Agile IT, as the conclusions drawn consider concepts of both paradigms. A comparison of Agile IT and Manufacturing based on a synthesis of the salient literature on the topic is provided in Table 1 below.

Table 1: Comparison between Agile Manufacturing and Agile IT

Comparing Criteria	Agile Manufacturing	Agile IT
Origin	Business Management	Software development
Reason for development	Solution for demand driven production markets in the future	Solution for iterative and incremental projects
Contrasting paradigm	Lean Production	Universal Project Management Methodologies and waterfall model
Acting Industry	Production	IT Project Management
Environment	Static (Plant) and dynamic (Business)	Dynamic
Series	Several times (same products)	Once (unique projects)
Good at	Getting into new market segments, delivering the right volume and the right variety	Uncertainty and change management in projects, achieving high degree of customer satisfaction

As shown in the Environment criterion in Table 1, both paradigms have different elements but the core concept is the same, namely that static project planning, where the requirements need to be determined in advance, cannot cope with dynamic project environments which are characterised by uncertainty and change. The concept of Agile manufacturing is related to strategic entrepreneurial issues, as it is also called Agile enterprise (Ross, 1994). Therefore Agile manufacturing might be used for construction business strategy research. However, the need of construction is not in finding new methods for business management, nor in managing technical challenges (Ritz, 1994; Dubois and Gadde, 2002).

The increase in the level of the complexity of construction processes (Gidado, 1996) has resulted in the need of new management paradigms. This can be reflected through the report of the Construction Task Force (1998), which concluded that the construction industry is performing poorer in comparison with other industries.

Therefore there is a need for management practices which will improve performance at the operative level when executing a project (Pan *et al.* 2007). Agile manufacturing cannot fulfil this need, as there are no exact definitions, methods and techniques developed (Kettunen, 2009) and because it is more about a certain vision (Zhang, 2011; Kidd, 1994). Furthermore Agile manufacturing is more appropriate for setting up a business strategy to penetrate new market segmentations.

Agile IT on the other hand provides new solutions with a high degree of customer satisfaction through an iterative project planning (Wysocki, 2006), which leads to project success. It fits with a project-based environment like construction, as the products of construction can be defined as "a temporary endeavour undertaken to create a unique product, service, or result" (Project Management Institute, 2008, p. 5). The aim of the Agile IT movement is the development of new practices, which are able to deal with iterative and incremental projects (Wysocki, 2006). Agile has a clear theoretical basement and is used widely in IT practice; and involves clear values and principles. Therefore being Agile is defined by adhering to the values expressed in the Agile manifesto (Adolph, 2006). So, considering that the IT environment is project-based in a similar fashion to construction and Agile developments are presenting practices which do improve performance leads to the conclusion that Agile IT is more appropriate for construction PM than Agile manufacturing.

METHOD

The wider research project aims to develop a new method for the management of construction projects, which will focus, on the one hand, on the elimination of waste through aiming for perfection in the internal processes, whilst on the other, focusing on being flexible and reacting to changes in the project circumstances. As part of the project, a detailed understanding of the salient concepts of Agile manufacturing and Agile IT is required. However, both management paradigms are completely different from each other, even though they have the same nomenclature. Hence the research seeks to identify in the first instance on which of these two paradigms to focus. This identification has been facilitated through reviewing the trends in current literature, with the conclusion that Agile IT is more appropriate for the aim of this research. Therefore the research project explores the potential of Agile IT rather than Agile manufacturing. In order to get a deeper understanding of practice, semi structured interviews were conducted with 4 Agile Practitioners [APs] and 5 PM Practitioners [PMPs]. The APs were software developers/experts working in IT and the PMPs were working as Client representatives in construction. When collecting the data, the aim was to get a deeper understanding of the applicability of Agile IT to construction projects. The interviews with the APs and the PMPs focused on the definitions, potential benefit, impact, environment, limits and barriers of Agile IT approaches to construction. The interviews were recorded, transcribed and then analysed in relation to each of these three sub-topics.

FINDINGS

A typical definition was articulated by AP 4, who described Agile PM as "a model to proceed, in which one is planning not so much the aim but more the way through rhythmic meetings". This results in, according to AP 1, that "one is only doing management per demand and not more". Agile was further described by AP 2 as a more action-oriented approach to the management of the project. This was confirmed by AP 4 who argued that Agile methodologies focus on the planning and implementation of small manageable tasks rather than big aims and objectives; thus

making the scope more tangible for the project team. All the APs stated that the main benefit of Agile lies in its ability to react to change in a systematic and structured way. Furthermore it creates, according to AP 3, more efficiency in PM, as needless activities will be rejected. In terms of impact, the APs shared the common experience of consistently receiving high customer satisfaction when they applied Agile to a project. AP 1 related that satisfaction to the "short cycles, where parts are delivered and feedback is received". AP 2 explained that the customers are highly satisfied "because they can see how it grows, they see where it grows and they can influence it". All the APs concluded that Agile paradigms are best in dynamic project environments. This was articulated by AP 4 as follows: "If my environment is dynamic or if it becomes more and more dynamic Agile gets more and more important. Then where my environment is static, it might be that it harms". In terms of limits, even though some PMPs stated that they are working already with Agile, a common view was the undesirability of change to key stakeholders. PMP 3 stated that:

"Changes are not welcome at each stage of the project, because it is difficult to explain to the clients, landlords or decision makers that they have to decide today for actions which will occur after three quarters of a year. The building structure has to be calculated from top to down, but I am building from down to top. Therefore the structural engineer needs to know the loads of the top today".

AP 2 explained further that it limits Agile methods, "if the task is getting too big", i.e. if there are too many project team members, because it makes it too complex to practice. All the APs agreed that the greatest barrier to the implementation of Agile methods is the attitude of the Client. AP 2 explained this as it being difficult to tell to the Client that "we do not have any planning, we just do it".

DISCUSSION

Previous research has tried to simultaneously draw from both Agile manufacturing and Agile IT paradigms. However a review of this research suggests an Agile PM originating in Agile IT as most appropriate for construction PM. The findings lend weight to this conclusion, indicating that the use of Agile IT methods has potential advantages to construction, such as the ability to adapt to changing customer requirements. However, the findings also show that there are potential limitations, which are related to the nature of construction, in particular construction's complexities in terms of planning and executing the work. Given that all the Agile IT values, principles and hence practices of Agile need to be in place if success is to be achieved (Coffin, 2006) suggests clear limiting factors to its implementation in construction. The literature review and interview data show that those limiting factors can be generally related to the different typology of a construction project. Even a small construction project requires a large number of contributors, with a high variety of workmanship and experts (Walker, 2007). Considering that Agile professionals do not recommend using Agile practices for project teams where more than 50 people are involved (Chin, 2004) creates a barrier for implementation even before those practices have been introduced. The high separation between design and execution (Ankrah *et al.* 2005) makes the ability to react to change more difficult. But the high separation is required because a construction project is designed from the top, as the loads of the facility have to be determined at the beginning; even though it is erected from bottom to top later. This is in contrast with the plan-as-you-go principle of Agile - which limits the flexibility over the whole project view. Furthermore, this creates a barrier for the "welcome change" attitude of Agile IT practices to construction, because in the

execution phase particularly, the impacts and consequences of those changes are high. Another major difference between IT and construction projects is that the implementation of IT projects is built upon scenario-building and testing (Wysocki, 2006), i.e. a program code can be tested and afterwards improvements can be made. This action is clearly not applicable to construction PM, because if something is designed and erected, the last possible solution would be to demolish and rebuilding it; although the rise of Building Information Modelling (BIM) may mitigate for this factor in the future.

The key success factor of Agile Software PM methods lies in the feedback loop (Wysocki, 2006). The feedback loop allows the reaction to change and uncertainty, as well as delivering high customer satisfaction, i.e. allows agility. During the design phase of a construction project, there is a high demand for communication and getting feedback by all the parties involved. There is more room for accepting change in the design phase than in the execution. Therefore many organisations have formal and informal approaches for gaining feedback in the design rather than the execution phase (Kartam, 1998); so there is a good fit with Agile IT practices and design (Owen and Koskela, 2006b). But managing the design is not managing the whole project, as it is just one out of several project phases. Therefore Agile PM concepts may not be suitable for all types of project. It is the project type and type of organisational stakeholders which determines whether Agile concepts should be used or not (Dyba and Dingsoyr, 2008).

So considering that Agile IT "[…] is not an all-or-nothing methodology" (Chin, 2004, p. 13) leads to the conclusion that one should combine classical PM and Agile PM concepts to fulfil the project requirements as best as possible (Chin, 2004). An effective construction PM plan needs to be focused on value for the client and be performance driven (i.e. focused on effective and efficient processes) (Winch, 2006). Given that the core strength of Lean management lies in efficiency as well as effectiveness (Naim and Barlow, 2003) and the strength of Agile lies in customer satisfaction (ibid.), suggests that a good PM plan should allow the implementation of both Lean and Agile at the same time. This has been considered by Naim and Barlow (2003) who developed the "Leagile" supply chain for construction. As such, Leagile combines both paradigms, through using the decoupling point model, where a switch from one paradigm into the other takes place. The focus of the Leagile supply chain is mainly on the execution phase, where the material supply is managed with Agile and the execution on site with Lean principles, which results in a non-holistic view on a construction project.

However, viewing a construction project holistically, fluctuating demands create changes in the project; hence creating different tasks and situations. So just as the requirements of the project can change over the project life cycle (Gidado, 1996; Dubois and Gadde, 2002), the PM Plan must be iterative (Project Management Institute, 2008). If there is a task or situation which does not enable a clear decoupling from one paradigm into the other then Leagile becomes limited in use. This is the rationale for the development of a new approach labelled by the authors as – "AgiLean". Instead of combining Lean and Agile sequentially, AgiLean merges them together. The aim of AgiLean is to make Lean more flexible, irregular and rapid, using Agile IT concepts to agitate Lean practices. "AgiLean PM" has two different levels, namely strategic and operative. On the strategic level it is underpinned with universal PM methodologies i.e. from the Project Management Institute (PMI) or Association of Project Management (APM). On the operative level it allows 1) Lean

and Agile working sequentially i.e. Leagile; 2) in combination i.e. AgiLean; or 3) completely independently of each other.

CONCLUSION

The aim of Agile IT is in improving the performance at the project level. Agile manufacturing has the aim of improving performance at the business strategy level. The concepts of Agile manufacturing are not new to the construction industry, as the future markets of manufacturing are clearly reflecting what the construction industry has been facing for many years. However, in terms of moving the Agile research agenda forward in relation to construction PM the focus would more usefully be on adapting Agile IT rather than Agile manufacturing. Nonetheless the different typologies between an IT project and a construction project show clear limitations and barriers for its implementation. Construction projects don't generally have the same amount of flexibility as IT projects, though there are specific project phases where this flexibility might be possible. Therefore Agile can potentially be implemented for managing particular phases, work packages or situations, but not for managing the whole project. A similar perspective can be derived for Lean construction, which is clearly focused on managing particular project phases separately. Lean does not take a holistic view of a project, as is taken with universal PM methodologies. Therefore a new unifying strategic framework is required. The focus of AgiLean PM is particularly on highly dynamic projects, where the dynamism is characterised by uncertainty and the uncertainty causes changes. This characteristic can occur on several different types of construction projects, where besides the functionality, aesthetics have also to be considered.

AgiLean PM allows the elimination of waste, is able to react to change and focuses on the whole project lifecycle. Such an approach could be the best way of dealing with complex construction projects to achieve maximum performance. AgiLean PM builds on the strengths and addresses the weaknessess of Lean and Agile through a process of synthesization. It benefits from being underpinned by universal strategic PM approaches which will eliminate waste. Perfection is pursued through the adaption of Lean principles and being capable of dealing with uncertainty through the adoption of Agile principles. The AgiLean PM framework is still a work in progress, which covers the development of values and principles. Once the detailed AgiLean PM framework is established, the development of AgiLean tools or the agitation of Lean practices will be a fruitful field for further study. To conclude, managing construction projects under the umbrella of AgiLean PM is a potential response to dealing with the increasingly complex nature of construction projects.

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HOUSE BUILDING SERVICE QUALITY AND BUYER EXPECTATIONS

James Sommerville, Nigel Craig and Nicola Callaghan

School of the Engineering and Built Environment, Glasgow Caledonian University, UK

Increasingly, house builders are being challenged to provide services which align with the thoughts and views of potential home buyers in terms of construction and customer service as well as overall satisfaction; which can only be obtained when post-purchase perceptions meet or exceed pre-purchase expectations. The expectation of receiving "good" service from house builders relies on overly used marketing terms such as "customer care" and "customer focus": both of these terms are aimed at increasing sales and competition within the marketplace, and yet tied to customer satisfaction. It is, however, unclear whether or not house buyers and builders agree on the types and quality of homes which should be constructed with current research suggesting that failings may result from seemingly under-performance in the service delivery process. The findings from questionnaires undertaken describe the agreement between the types of homes being constructed by house builders and the types of homes expected by home buyers in relation to the Code for Sustainable Homes.

Keywords: construction, service quality, house builders, home buyers.

INTRODUCTION

The selection and purchase of a new home is likely to be the single, largest capital investment a person undertakes in their lifetime; and next to marriage and divorce, it is considered to be one of the most stressful events in life (Michaels, 2001). To ensure an easy transaction, it is imperative that house builders maintain high levels of customer satisfaction though the development of strategic management systems. However, retaining satisfied customers is challenging due to changing shifts in the economy and markets (McCabe, 2010). As a result, construction companies are faced with short and long term customer satisfaction problems. Unfortunately, there is little evidence to suggest that house builders are actively conducting consumer research to establish consumer needs and preferences. Instead, the house building industry is still considered to be producer driven, with little account being taken of the consumers needs (Ball, 1996). Home buyer satisfaction together with service quality is the result of home builders providing services that are perceived as meeting or exceeding buyer expectations. As market pressures increase and home buyers become well-versed, house builders are realising the need to reform their business strategy to remain competitive (Kerber, 2000 cited by Nahmens and Ikuma, 2009). As a result, house builders need to identify and understand buyer needs in order to continuously improve service output and strategically manage their business performance to increase profits and market share whilst reducing costs.

Sommerville, J; Craig, N and Callaghan, N (2012) House building service quality and buyer expectations *In*: Smith, S.D (Ed) *Procs 28th Annual ARCOM Conference*, 3-5 September 2012, Edinburgh, UK, Association of Researchers in Construction Management, 1025-1034.

This research aims to discover whether or not a gap exists between house builders and home buyers expectations in relation to the Code for Sustainable Homes (CSH). Additionally, the research aims to determine whether or not house builders believe that they are building "remarkable" homes; the effect of Zero Carbon (Zc) initiatives and whether or not they believe that new home buyers want Zc homes. The results also hope to connect house building to the management of customer satisfaction to determine whether or not house builder and buyers are aligned in their views of the CSH.

LITERATURE REVIEW

The term service quality has a variety of academic definitions however, Parasuraman *et al.* (1985) states that the measure of service quality is the gap between the consumer's expectation level and actual experience encountered, which in this instance, extends to opinions formed before, during and after construction. Although the majority of organisations are keen to provide product and service quality, many fall short simply because they do not have an accurate understanding of what customers expect from them (Zeithaml *et al.* 1990). According to Goodier and Pan (2010) house builders should aim to identify their customer base and be able to track them in order to predict future organisational requirements, a view shared by the National Association of Home Builders (NAHB, 2003) who claim that sustaining home buyer satisfaction will positively impact referral rates and company reputation. Jahn (1996), however, argues that many house builders remain unconvinced about good customer service transpiring as increased profits. As a result, it is suggested that the initial planning stage should be undertaken in a more holistic way to ensure long term sustainability and positive service delivery. However, the concept of consumer satisfaction is burdened with difficulty due to subjective perceptions of potential buyers (Auchterlounie and Hinks, 2001).

As the housing market contributes approximately 27% of the overall CO_2 omissions associated with energy use in the UK (Edwards and Turrent, 2000), the UK Government has introduced a series of directives, strategies and targets aimed at addressing this problem. Near the top of the agenda, is the task of achieving Zc housing by 2016, significantly reducing greenhouse emissions by 2050 and preventing further decline of the world's finite resources (This Common Inheritance, 1990). Although both Government and public recognition towards sustainable development is increasing, a significant impact can only be made if society is willing to adapt and change (Sustainable Build, 2010). This increased requirement for sustainable construction and innovation, combined with the irreversible change of the world's climate, atmosphere and eco-system has highlighted an urgency for the introduction of new "green" properties within the housing market (Sustainable Construction, 2001). However, as the supply of such homes is driven by associated demand, the process of solving many of the sustainability issues is predominantly dependant on consumer perception and acceptance of such homes. It is suggested that both house builders and home buyers have very little influence and involvement of Government decisions and are therefore looking for a mass market proposition. This is emphasised by Arnsteins (1969) "ladder of participation" which shows the current level of consumer power. Figure 1 shows the importance of a co-ordinated approach where consumers, house builders and the UK Government, must form a strong relationship in order to conjure change.

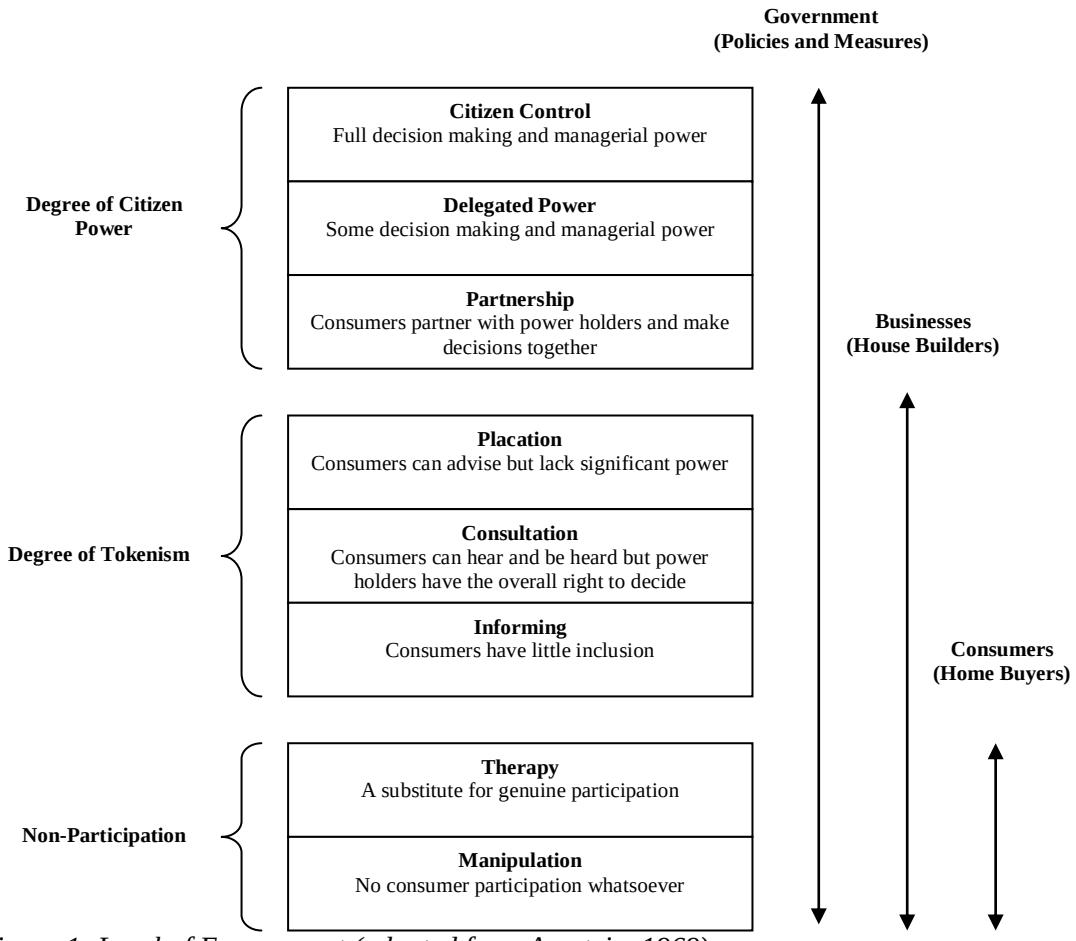

Figure 1: Level of Engagement (adapted from Arnstein, 1969)

The CSH was introduced in 2008 with the aim of becoming the solitary criterion used to design, construct and purchase sustainable homes whilst eradicating unsustainable building practices (Communities and Local Government, 2010). The code itself comprises of six key levels, each with a corresponding energy performance percentage. The success of the code primarily depends on the associated level of consumer acceptance, which must align with the thoughts, attitudes, values and wants of potential home buyers, particularly when faced with a variety of factors that have the ability to influence consumer decisions (Wright, 2006). However, it is suggested that consumers have very little knowledge of the code and its purpose, as there have been relatively few studies conducted to identify the discrepancy between house buyer's expectations and house builder's perceptions (Leishman *et al.* 2004).

In addition to the CSH, the UK Government has created a policy which aims to encourage house builder's to produce a mix of housing of differing price, style and segregation in order to achieve more balanced and diverse communities. However, research by Rowlands *et al.* (2006) states that the "framework on which this is based is rigid whilst at the same time vague in its prescriptions of what constitutes mix". Although it is suggested that a continuum of different opinions shared by house builders exists, it is recommended that a successful mix should; ensure good quality *design* throughout and be effectively *managed* to ensure a pleasant environment in which to live.

Very often house builders pre-select the types of homes available to consumers, known as the "choice editing option", which is regarded beneficial to house buyers who may otherwise choose a home which is unsustainable in its design. This is

highlighted by Purvis (2006) who suggests that such editing ultimately brings an end to unethical options as consumers will select sustainable homes by default rather than making a conscious decision. This will lead to reduction of the variety of homes available to consumers by allowing house builders to sell what they want rather than fulfilling consumer requirements (Saha and Darnton, 2005). In reality, however, each consumer should be treated as an individual rather than adopting a "one size fits all" policy. For example, Japanese house builders offer a wide range of house design allowing a great deal of consumer input, where is it suggested that such high levels of personal involvement is likely to have a positive affect on the overall level of satisfaction (Bartlett *et al.* 2002). Similarly, a survey undertaken previously by Barlow and Gann (1999) states that the majority of house buyers would like greater control over the initial design of their homes and at the very least, should have the opportunity to consider alternatives that would be more suitable to their lives.

METHODOLOGY

The philosophical assumptions associated with both quantitative and qualitative research paradigms have been well outlined by many authors; it is possible to combine both methods for use within a single study. As a result, two forms of triangulation were used in this study as a powerful tool to strengthen the research design (Patton, 1990). Firstly, data triangulation involved collecting views and opinions from a range of different participants with different career choices and aspirations. A methodological triangulation approach was then used to combine both quantitative and qualitative data collection methods (Banister *et al.* 1994). The data collection was therefore undertaken in several key stages as shown in table 1;

Table 1: Triangulation Methods

Type of Respondent (Data)	Method	Technique	Analysis
Non-Construction Students	Cluster Sampling	Face to face questionnaires	Minitab
Construction Students	Cluster Sampling	Face to face questionnaires	Minitab
"Average" (General Public) Consumers	Simple Random Sampling	Face to face questionnaires	Minitab
House Builders	Target Population	Email	Nvivo

Both young construction and non-construction professionals were selected using a cluster sampling technique in order to provide a basis for comparison.

The "average consumers", on the other hand, were selected using a simple random sampling technique, which provided access to consumers of differing backgrounds and cultures including those with differing values and opinions. Respondents stating that they worked within the construction industry were excluded from the survey to avoid any biased results. As no prior arrangements were required, this process was fast and efficient. Furthermore, participants were not given the opportunity to investigate areas of uncertainty and consider their responses. Instead, they were asked to answer each question based on their genuine level of knowledge.

During the second stage of the research, house builders were targeted using online databases. Sixteen major house building organisations constructing the majority of new homes within the UK were asked to participate in the study, where a 31%

response rate was achieved. Each organisation received an email with a link to an online questionnaire to be completed. In order to identify a common theme among all participants each respondent was asked the same questions. A variety of open-ended questions allowed each respondent to expand their response, as and when they wished to do so and the questions asked were kept relatively simple and straightforward, allowing effective communication.

The quantitative data collected was analysed using Minitab statistical software. Additionally, a key word in context (KWIC) technique was used to compare and contrast the qualitative data using NVIVO software. All of the data was analysed without preconceptions in order to allow the emerging themes to present themselves (Strauss and Corbin, 1990). Additionally, all of the research methods were conducted without bias or any preconceived ideas of the possible outcomes.

RESULTS

The paper reports a small aspect of a survey which sought simple data on the awareness of the CSH, where an analysis of the results has been obtained from the stated questionnaires in order to determine;

- Whether or not a gap exists between house builders and home buyers expectations in relation to the CSH.
- Whether or not house builders believe that they are building "remarkable" homes; the effect of Zc initiatives and whether or not they believe new home buyers want Zc homes.

Although the following results are subject to some sample limitations, particularly in relation to the number of house building respondents which make generalisation difficult, the results aim to provide an understanding of general tends which require further investigation.

Section one of the questionnaire (shown in table 2 and figure 2) asked the respondents to consider their current knowledge of the CSH. The results obtained show that the majority of consumers questioned (88%) had never heard of the code. Furthermore, there is a difference between the "type of respondent" and the level of knowledge of the CSH they possess. For example, as expected, house builders were the most knowledgeable group (80%), followed by young construction professional's (29%). Additionally, the Construction Managers were more knowledgeable than the Quantity Surveying respondents. Unfortunately, none of the "average" consumers and only 2% of the young non-construction professionals had heard of the CSH. Additionally, figure 2 introduces a gender analysis of the responses which shows that 24% of males and 3% of females questioned were aware of the CSH.

Table 2: Respondent Breakdown

Have you heard of the Code for Sustainable Homes?							
	Construction Professionals (31)		**Non-Construction Professionals (58)**		**"Average" Consumers (22)**	**House Builders (5)**	**Total**
	Quantity Surveyors (28)	Construction Managers (3)	Marketers (20)	Food Bio-Science (38)			
Yes	7	2	0	1	0	4	**14**
No	21	1	20	37	22	1	**102**

If everything were left to chance;

H_0: the type of respondent is not associated with the level of knowledge of the CSH.

As the *p*-value = 1.72 (is greater than the universal benchmark of $p = 0.05$) the null hypotheses can be accepted, as there is no statistical difference between the type of respondent and their associated level of awareness of the CSH.

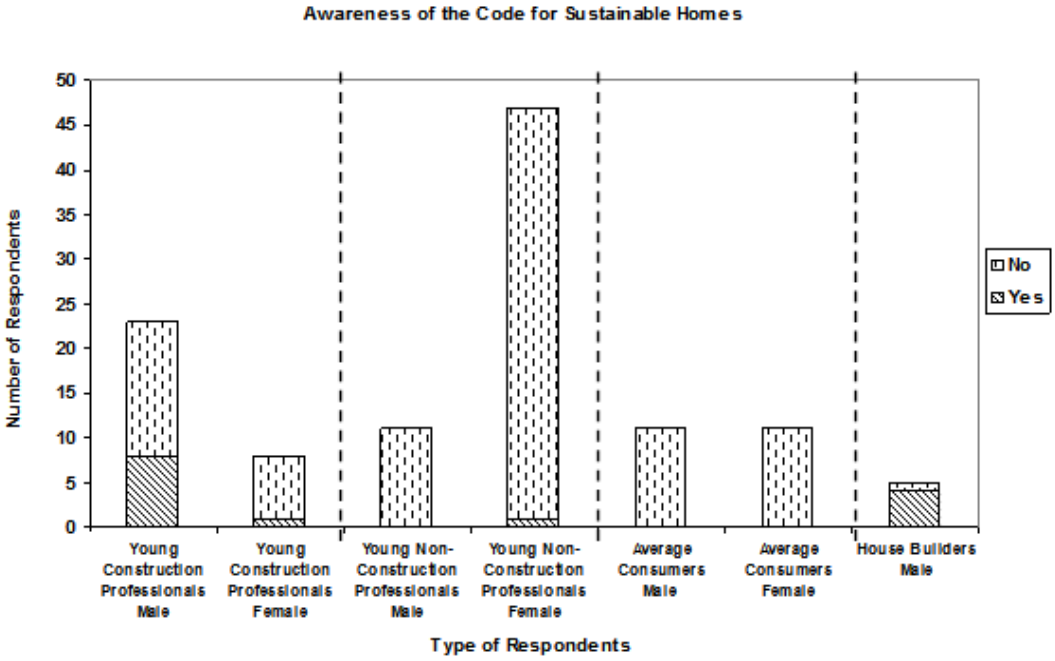

Figure 2: Awareness of the Code for Sustainable Homes

All of the young construction professionals who had heard of the CSH provided the following responses of what they thought the code actually meant (shown in table 3). 72% of these respondents mentioned the words "sustainable/sustainability" within their comments.

The second stage of results section reviewed the answers provided by house builders regarding the quality of the homes that they build; the effect of Zc initiatives and whether or not they believe new home buyers want Zc homes.

When the house builders were asked about whether or not they thought that the homes they construct were "remarkable", 100% agreed that the calibre of homes currently on the market are not "remarkable". Reasons for this response included; homes being built as "basic, standard construction". Homes were also classified as "not unique" and "lacking personality". Furthermore, one respondent suggested that "housing, whilst good, hasn't the budget to break any ground in sustainability terms". House builders where asked this question as many claim to use lower energy costs, improved efficiency, insulation and air quality as marketing incentives for new homes; whilst not fully understanding and engaging with the CSH concept.

In addition, 60% of house builders agreed that Zc initiatives do not affect the types of homes that their organisation constructs and that 60% also believe that new home buyers do not want Zc homes (shown in figure 3).

Table 3: Comments provided from young construction professionals about levels within the CSH

Respondent	Comments provided about levels within the CSH
1	Did not know what each of the levels meant but suggested that "level six is an unachievable target".
2	"The code one only meets basic sustainability requirements, gradually increasing to code six which is the most advanced".
3	Had a general idea of the CSH, suggesting that the codes were associated with "CO2 emission reduction, including sustainable building products used in construction". However, they thought codes 4, 5 and 6 were related to "client and end users education of sustainability".
4	The code is "a target set by the Government for all new builds to be zero carbon by 2016".
5	Aware that the code ranges "from very unsustainable to very sustainable" but though that code one was the "most efficient home" and code six was related to the "least efficient home".
6	Classified code one as "not sustainable at all", code two as "the minimum sustainable level required by house builders", code three as homes having a "good incorporation of sustainable products" and code 4 as having "high incorporation of sustainable products". Code 5 "the majority of products/goods in the home we sustainable and code 6 "all products used to construct and incorporated are sustainable".
7	Did not know what each of the levels meant but suggested that the code was "a range of sustainability measures for new homes".

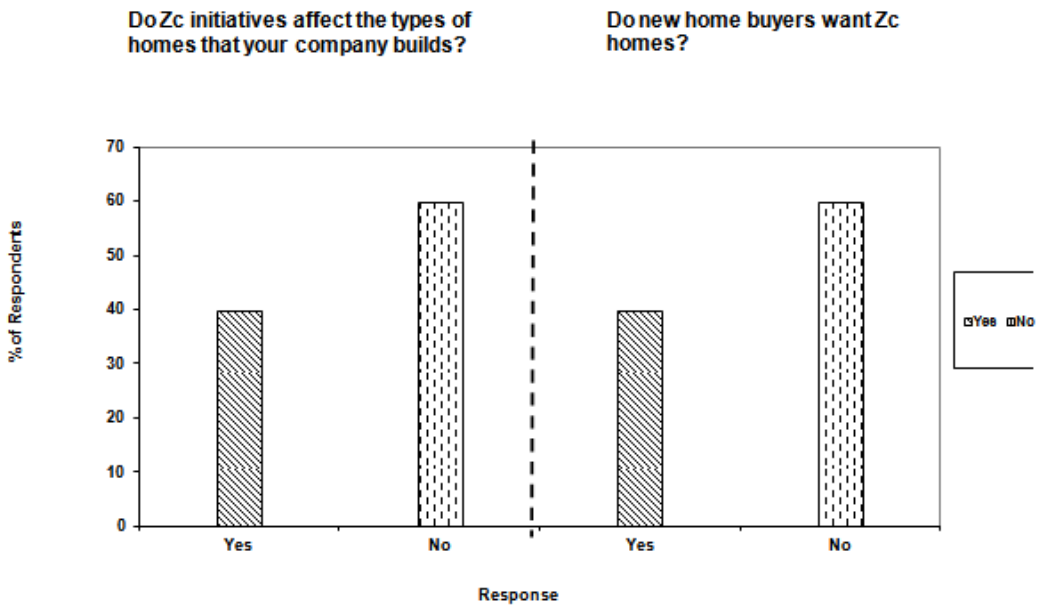

Figure 3: Responses from house builders regarding Zc initiatives and whether or not home buyers want Zc homes

CONCLUSIONS

The first section of the paper set out to discover whether or not a gap exists between house builders and home buyers expectations in relation to the CSH. The findings from the questionnaires undertaken suggest that there is currently no gap between the types of homes being constructed by house builders and the types of homes expected by home buyers as neither the consumers nor house builders hold the CSH in high regard.

Alarmingly, very few construction, non-construction and "average" respondents had heard of the CSH which may be the result of limited media coverage. Although the majority of house builders were aware of the CSH, which is likely to be the result of close interaction with the UK Government and industry bodies seeking to deliver new housing targets, none were able to provide a detailed breakdown of each individual level of the code. As a result, the findings from this research imply that consumers have very little knowledge of the CSH and do not consider it when making decisions on purchase intents and that house builders lack the detailed knowledge expected and are working a level behind where they should currently be operating.

The second section of the paper set out to determine whether or not house builders believe that they are building "remarkable" homes; the effect of Zc initiatives and whether or not they believe new home buyers want Zc homes. Unfortunately all of the house builders questioned agreed that the quality of homes currently on the market are not "remarkable"; implying that house builders are happy constructing homes which are simple and "standard" in design and reluctant to construct energy efficient homes which are unique and technically challenging. Interestingly, the house builders who believed that Zc initiatives do not affect the types of homes that their organisation currently construct also believed that new home buyers do not want Zc homes, suggesting that a correlation exists between consumer expectations and the types of homes actually being constructed by house builders. Additionally, this suggests that a number of house builders have yet to recognise the pivotal importance of sustainability issues to their business operations and have yet to respond in a positive manner. It is not clear, however, whether attitudes are beginning to change as tighter targets are enforced.

However, a gap does exist between where the industry is now and where it needs to be by 2016, suggesting that some Governments targets are perhaps challenging or unrealistic. The critical question is whether the vision conceptualised by companies at a strategic level is being driven down effectively into day to day operations and delivering good Zc performance. It seems, however, that the responsibility ultimately resides with home buyers who are satisfied with the current standards of new homes being delivered in the UK and who accept products with lower than anticipated quality and sustainable requirements. As a result, it is suggested that house builders will continue to produce homes which simply meet consumer needs and as such, will struggle to achieve the Government's aim of achieving Zc homes by 2016.

Although the results obtained can only be used as an indication of general trends due to the restricted sample size, in the future, the research intends to revisit the issue of consumer awareness of the CSH in a more thorough and comprehensive survey whist extending into areas relating to customer satisfaction in relation to both the build experience and personal experience received.

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AN INVESTIGATION OF THE FACTORS INFLUENCING THE SUCCESS OF CONSTRUCTION PLANNING FOR THE 2012 OLYMPIC STADIUM: AN ETHNOGRAPHIC STUDY

Ashokkumar Subbiah[1]

Birmingham School of the Built Environment, Birmingham City University, Birmingham B4 7XG, UK

Adherence to the planned duration is one of the main criteria when judging whether a construction project is a failure or not. In addition, construction planning is said to be successful if the project completes within the planned duration; or if it identifies an issue well in advance, thereby alerting the project management team to solve the issue before it causes any impact on the completion date. This research investigates the factors that influenced the success of construction planning of 2012 London Olympic Stadium. An approach of participant observation was adopted which is informed by the principles of ethnography: one that reports the participants' view of their world rather than imposing an artificial theoretical framework upon it. As a senior planning engineer working professionally on the Olympic Stadium from pre-construction until final completion, key human-relations factors were observed and identified that had an impact on the management and execution of the construction planning. The success factors were identified and relate to, for example: the effectiveness of preconstruction planning; the inclination of top organisation hierarchy towards construction planning; the inter relationship between the project participants; the influence of the client and contract; and the efficiency of planning team. It was found that a 'shadow culture' exists between the project participants which, it is argued, is only observable from the perspective of an embedded participant observer. This shadow culture acts to enable the management of the planning process and its efficacy relates to the 'quality' of human inter-relationships in the planning team and amongst immediate stakeholders. The research concludes by questioning the myth amongst project participants that construction planning is a mechanistic process that has to be conducted solely by the planning team.

Keywords: construction planning, inter relationship, participant observant, shadow process.

INTRODUCTION

Whilst there is an extensive literature that identifies construction planning as one of the major factors influencing the success of a construction project, there is scant examination of the factors that influence the success of construction project planning. This paper investigates the factors that influence the success of construction planning and the significance of the shadow culture among project participants to meet the planning requirements. A leading civil engineering contractor, Sir Robert McAlpine (SRM) was appointed as the design and build contractor for the construction of the 2012 Olympic Stadium under Engineering and Construction Contract (ECC), which is a part of the New Engineering Contract (NEC) family. This contract was signed

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between the Olympic Delivery Authority (ODA) and SRM in 2008. CLM (a joint venture of CH2M Hill, Laing O Rourke and Mace) the ODA delivery partner, was solely responsible for monitoring the works executed by SRM. NEC3 Engineering and Construction Contract, Option C: Target Contract with Activity Schedule was used for the appointment of the contractor for engineering and construction work, including any level of design responsibility. The top level hierarchy of SRM is occupied by the project director succeeded by the project manager. They are primarily responsible for the delivery of this project and they manage the various teams under them for the successful completion of the project. Bowles (1991) uses the conceptual framework of "shadow organisation" to investigate the underlying factors which act as a shadow for the effective functioning of the process. This paper researches the effectiveness of the planning process in terms of how it meets the requirements of the project participants and explores the significance of shadow organisation for the success of construction planning process. Although the research focuses on one landmark construction project, the 2012 UK Olympic Stadium, it can be related to the project management of a wide variety of other large projects.

BACKGROUND

Construction planning is a key determinant of success for a project and the sequence of steps undertaken in planning can be identified (Syal *et al.* 1992; Hamilton and Gibson 1996). Mawdesley *et al.* (1997) argue that planning is a general term used to encompass programming, scheduling and organising. Programming is seen as a constituent part of planning (Mawdesley *et al.* 1997; Cooke and Williams, 2004; Griffith and Watson, 2004). According to Gidado (2004), construction planning is aimed at making effective use of space, people, materials, plant, information, access, energy, time and money in order to achieve the set project objectives. It is made up of four main parts, namely programming and scheduling, method statements, organisational systems and site set up. The project plan, often referred to as a programme, is prepared in close coordination with the project team. Programmes - good programmes - can be difficult and time-consuming to produce (Joselin 2004); however, they are also essential for the proper management of the contract. Dvir *et al.* (2003) identify pre-construction planning as a crucial factor in the successful delivery of the project. Winch (2002) proposed that overall project programme methodology is often effectively formed during the tender or pre-construction period and quickly becomes enshrined within the master construction programme; therefore subsequent programmes developed to actually manage the project are constrained by the decisions often made in haste during this stage. However, Miyagawa (1997) considers that it is essential to create pre-construction and project master plans that are feasible, as their overall reliability and achievability is deemed a prerequisite for later success during the construction phase.

Cooke and Williams (2004) state that the programme is an important document for administering the contract and its role is to monitor progress and to make sure that it is maintained as the most recent one. Bar charts have been used extensively for planning and monitoring construction projects (Lowsley and Linnett 2006). The construction plan is prepared by the planner and there are three types of planner, grouped by the role of their organisation, namely the client organisation, the architects or designers and the contractors (Harris and McCaffer, 2006). Laufer and Tucker (1988) state that specialist planners have the time to do the work and better strategic decision-making skills, but they may have incomplete practical knowledge, limited detailed information available and also lack final decision-making authority. Conversely, construction

managers may have improved practical knowledge and possess decision-making authority but lack the time to plan. Construction planning, be it master planning, stage planning or short-term planning, relates to site activities involving people who normally, with the exception of short-term planning, do not participate in this process (Cooke and Williams, 2004). Construction planning must be carried out by competent people who are experienced in field work (Clough *et al.* 2000). There are two types of construction planning; strategic planning and operational planning (Harris and McCaffer, 2006). Strategic planning results in a broad outline of an integrated programme, which consists of design, procurement and construction activities, and is logically linked to forecast the critical path. This program is submitted for acceptance to the client, and is later used for scheduling and tracking the project.

Adeli and Karim (2001) define scheduling as a process of creating and maintaining a plan of work that documents the sequence and timetable of execution; therefore considering only the time attribute of the project and not the cost. There is a substantial literature that examines the planning process. Over twenty years ago, Laufer and Tucker (1987) critically examined the US construction planning process and found an over-emphasis on critical path methods; a lack of construction experience amongst planners; poor information gathering; and an overemphasis on control at the expense of action-orientation. Subsequent work by Laufer *et al.* (1994) found that the planning process lacked a clear system, and is often conducted by a planning 'specialist' who often does not have the necessary practical experience. Furthermore, they argue that collaboration involving line managers, designers, and planners is essential for effective planning. Laufer (1992) claims that construction managers often consider the delegation of construction planning authority to planner as threat to their position and treat such plans as irrelevant forecasts.

Johansen (1996) agreed, finding that construction managers often ignore the formal project master programme and instead adopt their own flexible approach to planning. Ballard and Howell (1998) emphasize that construction planners should only be responsible for "quality assignments" where tasks are sufficiently well defined to be co-ordinated with other work, for example in an attempt to improve the quality of production. Winter and Johnson (2000) also shared the view that most contractors' programmes do not have the necessary links, are not resource-driven and, on the whole, are not prepared to reflect what will actually happen on site, but are designed to win the job for the contractor. Faniran *et al.* (1999) found that poor performance was the result of both too little and too much planning, where uncertainty and over-control were evident within the plan. Johansen and Porter (2003) highlighted the need for improved sub-contractor planning competence, their increased input and closer involvement in the planning process and the availability and distribution of accurate subcontract trade performance output and resource data.

All these factors have a cultural context, but such studies are most often presented in a rationalistic framework of the work process. This research adopts a methodology that seeks to present the findings and analysis in manner that moves away from the rationalist approach towards a more 'fuzzy' interpretive approach; one that is better equipped to encompass the subtleties and even paradoxes observed in real practice. Jha and Iyer (2007) concluded that commitment, coordination and competence are the key factors for the success of a project and these need to be managed efficiently to achieve better overall performance. This research will apply some of the principles of shadow organisation to investigate the organisational structure and relationships in construction planning. The notion of the shadow organisation dates back to work by

Bowles (1993) which suggests that the overt work processes are often shadowed by unseen processes that make organisation function. These shadow processes are rarely evident by observers who are outside the organisation; yet such processes are often vital for the effective functioning of the organisation.

RESEARCH METHOD

Research on the factors that influence construction planning is still in its early stages. Eisenhardt (1989) suggests that prior to entering the field, researchers are well advised to begin by gaining some theoretical background on the phenomenon they wish to study: defining a set of research questions that they would like to address, and identifying constructs that they intend to investigate. According to the seminal work of Homans (1949), there are neither good nor bad methods, but only methods that are more or less effective under particular circumstances in reaching objectives on the way to a distant goal. These options range from qualitative investigations to quantitative analysis, from modelling to simulations designed to describe scenarios and test hypotheses. Qualitative research is appropriate for this type of research which examines the cultural dimension, with its informal and unstructured linkages and process of organisation (Lincoln and Guba, 1985). A qualitative, participant approach also recognises the call for a closer link between research and practice. Seymour and Rooke (1995), for example, argue that a researcher needs to access the 'situated knowledge' of people in practice in order to be able to identify the reasons underlying any problem or success. This method involves the researcher "getting to know" the people being studied by entering their world and participating - either openly or secretly - in that world.

Scott (1965) states that the researcher conducting an exploratory or a descriptive study is more likely to engage in sustained interactions with his subjects. In this research, the objective is to investigate the factors that influence the development and management of the construction planning. In order to answer these exploratory and descriptive questions, it was appropriate to perform qualitative field research. Some of the advantages of qualitative research are greater awareness of the perspectives of programme participants, understanding the significant developments in a programme (process) as it evolves, awareness of time and history, ability to "find out what's happening" more realistically, and alertness to unanticipated and unplanned events (Weiss 1998). Having chosen a qualitative approach, the next task was to choose a methodology from the several options available to qualitative researchers. Leonard-Barton (1990) suggests that the advantage of using one method outweighs the disadvantages of other methods. Being employed by Sir Robert McAlpine as a full-time planning engineer on site for the construction of 2012 Main Olympic Stadium, the researcher decided to choose participant observation as the research method as it would blend in with the role of a full-time employee. Participant observation is a deeply qualitative approach to management research and has much in common with approaches in sociology such as ethnography and action research (Carr and Kemmis 1986).

Dewalt and Dewalt (2002) add that participant observation improves the context-relatedness and overall quality of data collection and interpretation, and can lead to the development of new and insightful research questions. Yet some criticise the participant observer approach, suggesting that it produces erroneous material because of the inevitable bias of the researcher's personal interest in a particular setting or person's behaviour. To respond to this, this research will not seek to be neutral as in a

scientific experiment, but will involve the researcher's views and analysis in an open, balanced approach to neutrality. DeMunck and Sobo (1998) claim that there are problems when researchers select people or settings that are similar to themselves, and simply find what they had hoped to discover in the first place. As the researcher is also part of the setting being studied, it is a component of the methodology that prior thoughts and experiences are not excluded from the analysis, but used as a useful tool in the interpretation of what is going on. Barnard (2006), views as an advantage to have pre-understanding of the setting and not a disadvantage. Several theoretical and practical issues addressed by Van de Ven and Huber (1990) were considered while selecting a project to investigate the factors that influence the process of the project planning. These include the time commitment of the researcher, choices about data collection and the degree of involvement in the project. Having considered these objectives, the 2012 Olympic Stadium was chosen as a case study for this research. Major factors influencing selection of this project for this ethnographic case study included its status as a major landmark project in the global construction arena, involvement of large number of project personnel in organizational hierarchy, the type of contract, the reputation of the main contractor and client, and the facts that the project was then at its early stages and being embedded in this project would prove advantageous in collection and analysis of data.

It has to be agreed with the view of Hammersley and Atkinson (1995) that the problem of obtaining access to the necessary data looms large in ethnography and is often at its most acute in initial negotiations to enter a setting and during the 'first days in the field'; though the problem persists, to one degree or another, throughout the data collection process. It should be noted that access to information and official permission for choosing such a landmark project for research would be virtually impossible if the researcher had not been a full-time employee of this project. As Hammersley and Atkinson (1995) point out, in using this participant observant approach the researcher is himself the research tool *par excellence.* Several key writers have emphasised the need to build relationships during the initial stages of field research (Gardner and Whyte, 1946). In the initial days of this project, the focus of the research was to build relationships with project personnel rather than moving directly to interviews. This research was conducted in an ethical manner by consulting with the project personnel regarding the purpose of observing and the documentation of their activities. Interviewees invited to participate in this research were informed about the purposes of the research and given the opportunity to decline to take part. Another ethical responsibility was to preserve the anonymity of the participants in field notes and in the final write-up. Identities have been described such that stadium team members will not be able to identify the individual participants.

RESULTS

Being embedded as a participant observant for more than 4 years, it was helpful to identify the factors that influenced the success of planning process of the 2012 Olympic Stadium project. A further investigation of the identified factors and semi structured interviews with the project participants was efficient to categorise the key factors. They are pre-construction planning; SRM management team and organisational structure; system of planning; coordination and communication among project team; contract and procurement type; and contribution of client. These factors are discussed below.

Pre-construction planning:

The pre-construction planning commenced almost a year ahead of actual construction. Productivity during the pre-construction stage was exemplary due to the fact that the project participants (which include the client, main contractor SRM, Designers) were all based at one location. The main intention of placing the entire team in the same location is to initiate and drive the design and procurement process. The procurement of the major packages such as piling, substructure and superstructure concrete and structural steel, precast terrace units etc was completed during this pre-construction phase. A senior Quantity Surveyor commented that 'It is very rare to find a whole team organised so early during the preconstruction stage to strategically work out the design, procurement and logistics processes. This pre-construction period also helped to develop the organisation structure of the project team. The pre-construction period was very helpful for the main contractor, SRM to educate their project personnel about the requirements of the contract and the client well ahead before commencement of the actual construction. Due to the effective pre construction planning, the commencement of the actual construction was one month in ahead of what had been planned during by SRM.

SRM Management Team and Organisation Structure:

The involvement and dedication of the SRM management team played a major role for the successful development and management of the construction project plan. The regional management team emphasises effective planning on all construction projects undertaken by SRM irrespective of the requirement of the client and type of contract. A high level summary programme was prepared by the planning team for the project director every month to be presented at the regional board meeting. The regional director made weekly visits to the construction site office and reviewed the detailed project plan with the planning manager and project manager. The organisational structure developed for this landmark project was well resourced with respect to adequate project personnel who had good experience in their allocated designation. SRM had their best and sufficient project personnel allocated for every role of the project. An Engineer commented that 'the responsibilities I have on this project is very less compared to my previous projects with SRM and it is mainly because of the sufficient resources allocated to this project'. The regional management team's direct involvement in the project plan and organisational structure development motivated and demanded that the project planning team achieve the objectives set by the client and the contract.

System of Managing Construction Planning by the Planning Team

Programmes are the best way to develop and manage the construction planning of any major project. The major strategy implemented in 2012 Olympic Stadium project, to make the construction planning successful was to produce the Programme for Acceptance (PFA) and Progress Reports (PR) on a monthly basis. According to the contractual requirements, the main contractor Sir Robert McAlpine Ltd (SRM) submits a programme for acceptance (PFA) in the first week of every month. The Client (CLM) reviews the programme and communicates to SRM within the next 14 days about the outcome of the programme through project manager's instruction (PMI). If the programme had been accepted, SRM record the actual progress in that programme and measures it against the planned progress in PFA. This is then submitted to the client as progress report (PR) towards the last week of every month.

If the programme had been rejected then SRM record the actual progress in the previous accepted programme and submits it to CLM. SRM submitted the first PFA in April 2008 and was accepted by CLM. The last PFA was submitted in March 2011. There had been several programmes which had been rejected by CLM and SRM had to make the required modifications to get it accepted. There had been several programmes rejected by CLM along with an explanation for the rejection during the initial months when programmes were submitted by SRM for acceptance. An informal communication between the Planning Managers of SRM and CLM with an objective to get the programme accepted before formal submission was a key shadow process identified in this research. This shadow process helped to get the programmes submitted by SRM to be accepted by the CLM. The Planning Manager stated 'objective of a PFA is to demonstrate to CLM that the programme is practicable and therefore, that we are spending the Clients money properly. Process/obligations not fully understood or adhered to initially by either SRM or CLM, but for most of the time they were followed as closely as reasonably practicable'. All the Planners involved in the project agreed with the Planning Manager view that PFA cannot be prepared just by the planning team. It must have significant input from construction, design and commercial management staff.

Coordination and Communication among Project Team:

It is a well known fact among construction industry professionals, that the coordination between the project manager, planning manager and site team should be excellent for the successful development and management of the project plan. This research identified the shadow process that made the communication and coordination among the project personnel effective and thereby played a key factor for the successful development and monitoring of the construction planning. The coordination between the planning manager and project manager, planner and subcontractor had shadow process embedded in it to develop and manage the construction project plan. The shadow process was identified from the pre-construction stage up to the final completion. The ability of the planning team to develop, coordinate, communicate and monitor the construction project plan to satisfy their own requirement along with the needs of the SRM management, client and sub contractors was one the major driving factor for the success of the planning process.

Contract and Procurement Type

The NEC contract and the procurement type were major factors that influenced the success of the construction planning. The level of information required to be presented on a construction planning is very high and this requirement pushed the planning team to develop a detailed integrated program to accommodate the NEC contract requirements. NEC form does not make provision for a traditional baseline other than the current Accepted Programme. It's emphasis was to looking forwards at what needs to be done to achieve the objectives, (with the effects of all the updates) rather than assessing what we have done compared with what we should have done against a programme developed a relatively long time ago. Also to satisfy the requirements of the NEC contract on programming, a significant amount of effort from designers, commercial team, construction team and sub contractors were required. The procurement type for this project was Design and Build, and this allowed the main contractor SRM to drive the design process to the required standards during the preconstruction phase. SRM dictated the designers the sequence of the design deliverables to accommodate the construction program. For example, the designers

were prepared to develop and deliver the drawings of the south stand of stadium ahead of the west stand as per the contract programme. During the pre-construction period, the main contractor realised that the design information of the west stand was of higher priority and instructed the designers to release the details of west stand ahead of the south stand. It was design and build procurement type which allowed the main contractor, SRM to communicate and coordinate effectively with the design team.

Contribution of Client

The involvement of the client on the planning process was a major factor for the success of planning process. The contract placed a set for requirements on the main contractor's planning team and the client played a significant role by making sure that the objectives set by the contract was achieved. The correspondence between the client and main contractor were formally communicated as 'project manager's instruction' and was recorded. The program for acceptance and progress reports submitted by the main contractor planning team was reviewed and the outcome of the decision was formally communicated within the specified time limit. Though some of the reports which were produced to the client on a monthly basis were time- and effort–consuming, and proved to be of lesser significance from the main contractor's perspective, it has to be acknowledged that the client's requirements pushed the main contractor to develop a fully integrated programme as per the contractual requirements.

CONCLUSION

The aim of this research was to investigate the factors that influence the success of construction planning of 2012 London Olympic Stadium. The participant observation method was adopted from pre-construction until final completion, to understand the process of construction planning and the challenges associated with it. The preconstruction planning proved to be every helpful to progress well in advance with the design and procurement phase before the commencement of the actual construction. The key factor which helped SRM during the preconstruction planning was the formation of a project team during the preconstruction stage and the same team was maintained till the completion of the project. The top management of the main contractor were very committed and focussed in planning process. Training was given to project personnel to extend their full cooperation towards planning process. Engineers were trained to become managers and educated them that planning is a process which will be successful only when it is supported by the whole project team.

The planning requirements of the client helped the main contractor to successfully manage the planning process. Though some of the planning reports which the main contractor produced for the client were of lesser importance from the perspective of the main contractor, it drives the main contractor to develop and manage a strong planning process in order to deliver the reports to client. The procurement type and the contract played a significant role for the performance of the planning process. The preconstruction planning of the stadium was very effective with respect to design delivery since SRM was the design and build contractor and instructed the design team to produce information based on their requirements. This research revealed that planning is a systematic process and requires key human-relations factors to have an impact on the management and execution of the construction planning. The research revealed that shadow culture acts to enable the management of the planning process and its efficacy relates to the 'quality' of human inter-relationships in the planning team and amongst immediate stakeholders. The research concludes by questioning the

myth amongst project participants that construction planning is a mechanistic process that has to be conducted solely by the planning team. It is evident form this research that there is not going to be a single programme which could foresee and address the entire list of challenges to be encountered before the construction phase. The initial programme which is being developed with the best available information should be continuously monitored and developed further to reflect any additional information from design team or any change in the planned sequence due to the challenges faced by the construction team. The process of planning was made successful by SRM in the 2012 Olympic Stadium due to the contributions of the factors discussed in this paper and could be related to major construction projects across the globe. The outcome of the research will benefit the planning professionals, the client and the contractors.

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A GENETIC ALGORITHM FOR RESOURCE LEVELING OF CONSTRUCTION PROJECTS

Mahdi Abbasi Iranagh[1] and Rifat Sonmez[2]

Dept. of Civil Engrg, Middle East Technical University, Ankara, 06800, Turkey

Critical path method (CPM) is commonly used in scheduling of construction projects. However, CPM only considers the precedence relations between the activities and does not consider resource optimization during scheduling of projects. Optimal allocation of resources can be achieved by resource levelling. Resource levelling is crucial for effective use of construction resources particularly to minimize the project costs. However, commercial scheduling software has very limited capabilities for solving the resource levelling problem. In this study a genetic algorithm (GA) is developed for the resource levelling problem. The performance of GA is compared with the performance of Microsoft Project 2010 for several sample projects. The comparisons indicate that the GA outperforms resource levelling heuristic of Microsoft Project 2010 significantly. Furthermore, exact solutions were obtained for the sample problems using linear-integer programming technique. Exact solutions reveal that the algorithm is capable of achieving adequate solutions. Hence, the GA provides a powerful alternative for the resource levelling problem.

Keywords: project management, resource levelling, genetic algorithms, optimization

INTRODUCTION

Critical path method (CPM) is commonly used for scheduling of construction projects. However, CPM is not capable of minimizing undesirable fluctuations in resource utilization profile (Hegazy 1999; El-Rayes and Jun 2009). Inefficient planning of resource utilization profile may result in idle workforce, or may present the need to hire and release the workers in short periods which can make attracting and keeping qualified workforce difficult (El-Rayes and Jun 2009; Harris 1978). Therefore, resource levelling problem (RLP) is crucial in project scheduling for achieving optimal allocation of resources.

There are several exact and heuristic methods in literature which have been proposed for solving the RLP. Exact methods based on linear-integer programming technique have been proposed initially by Easa (1989). Exact methods such as linear-integer programming can be implemented to solve small problems but, exact methods have

[1] mahdi.iranagh@metu.edu.tr

[2] rsonmez@metu.edu.tr

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several limitations due to complexity of the RLP. Hence, numerous researches have focused on heuristic methods. Initial heuristic methods implemented the priority-based procedures for the RLP (Burgess and Killebrew 1962; Harris 1990; Martinez and Ioannou 1993). The developments in meta-heuristic algorithms in recent years enabled powerful alternatives for the RLP. Genetic algorithms (GAs) (El-Rayes and Jun 2009; Hegazy 1999; Leu *et al.* 2000; Zheng *et al.* 2003), simulated annealing (Son and Skibniewski 1999), ant colony algorithms (Xiong and Kuang 2006; Geng *et al.* 2010) and particle swarm algorithms (Qi *et al.* 2007; Pang *et al.* 2008; Guo *et al.* 2009) are among the meta-heuristics implemented for the RLP. Majority of the existing research have focused on solving very small networks and did not evaluate the performance of commercial software (such as; Microsoft Project, Primavera etc.) for the RLP. The main objective of this paper is to develop an efficient GA for RLP. The GA will be used to minimize the absolute deviation between the resource requirement and the average resource consumption.

PROBLEM FORMULATION

The purpose of general RLP is to minimize the undesired fluctuations in the resource utilization profile with respect to an objective function while satisfying the precedence relations and without changing the CPM project duration. In other words, the objective of RLP is to schedule the non-critical activities in such a way that the fluctuations in the resource utilization profile are minimized, precedence relations are satisfied, and the project duration is not changed.

Numerous resource levelling metrics have been proposed to measure the fluctuations in the resource utilization profile. Sum of squares of daily resource requirements, and the absolute deviation between the resource requirement and the average resource consumption (AbsDev) are the two metrics that are commonly used for solving RLP. The AbsDev metric is considered in this research, because, it is used by of Microsoft Project' s heuristic to solve RLP and it can also be formulated easily by linear-integer programming. The objective of AbsDev is to minimize the deviation between the resource requirements and a desirable constant resource rate. The mathematical formulation of the objective function for the AbsDev is as follows:

(1)
$$AbsDev = \sum_{m=1}^{n} \left| U - R_m \right|$$

and,

(2)
$$U = \frac{\sum_{x=1}^{y} DM_x \times DU_x}{n}$$

Where, “n” is the project duration and “Rm” is the requirement of all activities at the day m. In addition to these, “U” represents uniform resource level, “y” is the number of activities, “DMx” is the total demand of activity x and DUx is the duration of activity x. In this paper the average resource consumption is used to determine the uniform resource level U, as shown in Eq. (2).

GENETIC ALGORITHMS

Genetic search algorithms are population based search strategies inspired by the principles of natural selection. In GAs, first a population of chromosomes is generated for natural selection. Each chromosome represents a set of numerical data, a

possible solution to the optimization problem. These chromosomes are composed of genes. By manipulating the genes, new chromosomes are created. These manipulations occur through by mating the two parent chromosomes using a crossover operation (Figure 1), or by altering a gene slightly using a mutation operator (Figure 2). During each generation a fitness function is used to determine the performance of the chromosomes. The driving force in GAs is the selection of chromosomes based on the fitness function (Blum and Roli 2008). The fitter chromosome is assigned a higher chance of survival hence; in general the fittest individuals are passed to the next generations. Eventually after several generations, the population is expected to converge to the optimal solution.

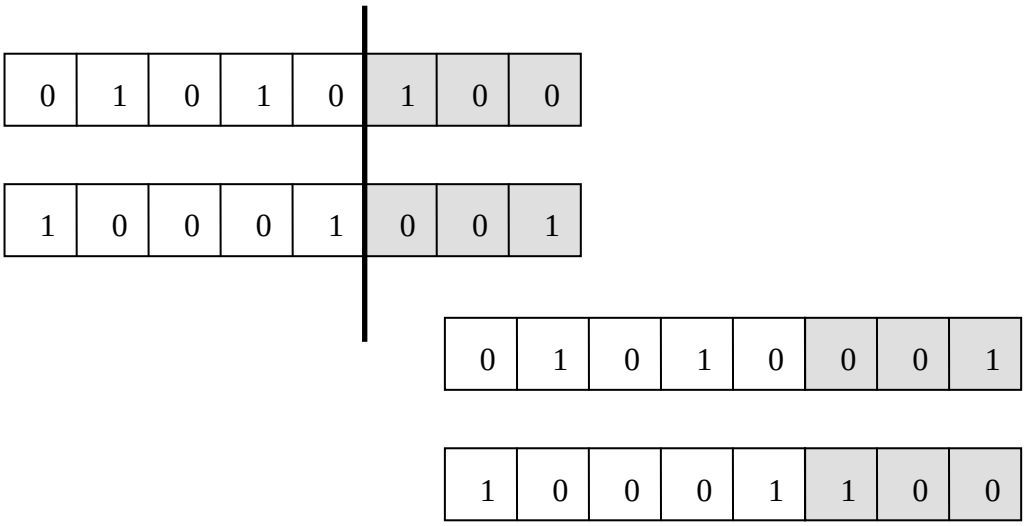

Figure 1. Crossover Operator

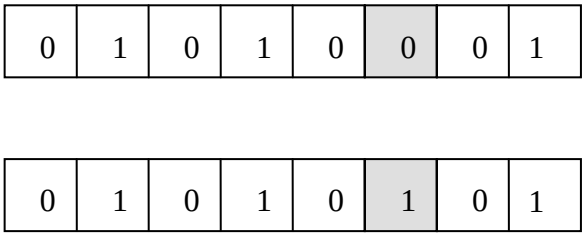

Figure 2. Mutation operator

GAs in recent years have been a very popular tool for solving optimization problems that are similar to RLP. Although a GA does not always guarantee to find the optimal solution, it is a powerful technique to search and find optimal or near optimal solutions in a reasonable period of time. The computational procedure of GA developed in this study includes the following 3 steps:

1) CPM scheduling

The CPM method is used in this step to define the critical path, to calculate the project duration and to determine the activity start and finish dates, and floats. The procedure for this step is performed as follows:

- The data required for scheduling including each activity's ID number, duration, successors and daily resource demand are inputted.

- The early start time (ES) and early finish time (EF) are determined using forward-pass, then, the late finish time (LF) and late start time (LS) and the total float (TF) for each activity are calculated using backward-pass.

2) Generation of Initial population

At this step a pre-determined number of chromosomes (Nc), is generated as the initial solution population according to the following procedure:

- Nc numbers of chromosomes are generated randomly. Each chromosome is formed of genes that represent a start time selection for the non-critical activities.
- The objective function values of the initial population are determined using equations (1) and (2).

3) Implementation of genetic operators

In order to create the next generation populations, genetic operators such as crossover and mutation are implemented at this stage as follows:

- According to a predefined crossover probability (Pc), some chromosomes from the previous solution generation are selected randomly. Then they are used to generate the new chromosomes by implementing the one-point uniform crossover operator.
- The chromosomes that will be selected for the next generation are determined by the elitist roulette-wheel selection. In this technique the chromosome with the best objective function value is first selected for the next generation. The remaining chromosomes are selected based on a probability determined according to the value of their objective function. In this selection method the chromosomes with a better objective function value have better chance to survive.
- The mutation operator is implemented next according to the predetermined mutation probability (Pm). A number of chromosomes are selected at this step according to the Pm rate and the mutation operator is performed to obtain the new chromosomes.

Steps 2 and 3 are repeated until a predefined number of solutions (Ns) are reached. In the final stage, the last generation's best solution is considered as the solution of the problem.

TEST PROBLEMS

16 problem instances related to RLP were selected from the literature to test and compare performances of the GA and Microsoft Project 2010. All of the problems included a single resource. The sources and number of activities of the test problems are shown in Table 1. The activity numbers in the table does not include the start and finish dummy activities.

Table 1: Sources of the selected problems

No	Number of activities	Source
1	20	El-Rayes and Jun (2009)
2	15	Stevens (1990)
3	19	Stevens (1990)
4	11	Harris (1990)
5	13	Leu *et al.* (2000)
6	13	Son and Skibniewski (1999)
7	11	Son and Skibniewski (1999)
8	7	Mutlu (Generated II) (2010)
9	13	Mutlu (Generated V) (2010)
10	14	Mutlu (Generated VI) (2010)
11	14	Mubarak (2004)
12	11	Mubarak (2004)
13	8	Mubarak (2004)
14	15	Hinze (2004)
15	10	Demeulemeester and Herroelen (2002)
16	5	Easa (1989)

COMPUTATIONAL RESULTS AND COMPARISONS

The proposed GA was developed on a 64 bit platform using C# programming language. All of the instances were tested in a personal computer with a processor speed of 2.67 GHz. The GA was able achieve solution for each of the problem instances within a processing time of 5 seconds.

The optimal solutions for the problem instances were obtained by using the linear-integer programming technique (Easa 1989). The percent deviations from the optimal solution for Microsoft Project 2010 and GA are shown in Table 2. The proposed GA was able to determine the optimal solution for 8 of the 16 instances (50 %), and it had an average percent deviation value (from the optimal solution) of 4%. Whereas, Microsoft Project was able to determine the optimal solution for only two of 16 instances (12.5 %), and it had average percent deviation value of 44 %. The results demonstrate that the proposed GA was able to achieve reasonably adequate results and outperforms the levelling heuristic of Microsoft Project significantly. Hence the results of Microsoft Project are far away from the optimal even for very small networks including only 10 activities.

Table 2: Percent deviations from the optimal solution

No	MICROSOFT PROJECT 2010	GA
1	31%	2%
2	66%	6%
3	51%	5%
4	88%	0%
5	75%	6%
6	86%	19%
7	74%	0%
8	0%	0%
9	37%	0%
10	40%	0%
11	8%	3%
12	7%	3%
13	4%	0%
14	64%	0%
15	80%	20%
16	0%	0%
Average Dev.	44%	4%

CONCLUSIONS

A GA was developed to minimize the undesired fluctuations in the resource utilization profile of construction projects. Comparisons of the proposed GA with Microsoft Project indicated that the GA outperforms Microsoft Project's heuristic significantly for the RLP. In order to evaluate the GA's performance, exact solutions were obtained for the sample problems using linear-integer programming technique. Exact solutions revealed that the algorithm is capable of achieving adequate solutions. The results demonstrated the limitations of Microsoft Project and the need for better heuristics to solve RLPs in construction projects. The results also revealed that the GA is a good alternative for solving the RLPs. Hence, GA provides a powerful alternative for minimizing the undesirable fluctuations in resource utilization profile to achieve efficient and optimal construction project schedules.

Although the proposed GA yielded reasonably adequate results, it may require some improvements to solve large networks with multiple resources. Hybrid using of GA with other meta-heuristic algorithms may provide a potential for further improvement to achieve an algorithm that can efficiently solve the RLPs for large size construction projects.

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ADAPTION OF STRUCTURED ANALYSIS DESIGN TECHNIQUES METHODOLOGY FOR CONSTRUCTION PROJECT PLANNING

George Agyekum-Mensah[1], Andrew Knight and Christine Pasquire

School of Architecture, Design and the Built Environment, Nottingham Trent University, Burton Street, NG1 4BU, UK

The construction industry has been heavily criticised by researchers and governmental organisations for its performance especially excessive delay. Ballard and Howell (2003) indicated that only about 50% of the tasks on weekly work plans are completed by the end of the plan week. This is a result of a lack of either effective project planning or effective production control. It therefore seems the traditional approach of planning is insufficient to meet the current demand and complexity of construction projects. This paper proposes to critically evaluate the adaptation of Structured Analysis Design Techniques (SADT) methodology as a tool for project planning. SADT which was further developed into IDEF (**I**ntegrated **Def**inition) techniques claims to be a complete methodology to provide the means of understanding complex production systems and aid the implementation of change. The use of this methodology has led to process improvement. The research uses a literature review followed by interviews with academics and practitioners to investigate their knowledge and understanding of SADT (IDEF0). The results of the interviews indicated that SADT (IDEF0) methodology is seldom known and used in the construction industry. However, this study indicates that SADT methodology appears to be an effective project planning tool. This study contributes to the limited project planning techniques in construction industry by exploring the possible adaption of SADT.

Keywords: planning, project control, project management.

INTRODUCTION

Project Management (PM) is claimed to have a very long history; however, its current form was adopted into the construction industry around four to five decades ago (CIOB 2002). This current form is through the publication of Body of Knowledge (BoK) in PM which mainly includes Project Management Institute (PMI), Association for Project Management (APM), Chartered Institute of Builders (CIOB) Code of PM, International Project Management Association (IPMA), Japanese Project Management Forum, and Australian Institution of Project Management (Maylor, 2010; Cleland and Gareis 2006). PM has truly become "boundary-less"—cutting across disciplines,

[1] george.mensah@ntu.ac.uk

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functions, organisations, and countries (Cleland and Gareis 2006). The evolution of PM has been closely associated to the development of systems engineering in the US Defence and aerospace industry (Morris 1994, Kenley 2004). The US Defence, before the late 1960s, developed tools such as: Work Breakdown Structure (WBS), Critical Path Method (CPM) (similar to PERT), Network Diagram, and Gantt chart (originally developed in 1917 by Henry Gantt) as the main PM tools which are referred to as the conventional techniques (Mubarak 2005).

Morris (1994) argues that PM, despite its fairly long development and techniques of planning currently available to the general practitioner, is often insufficient to the overall task of managing a project successfully. Koskela (1992) also argued that poor planning occurs because traditional planning techniques fail to support work flow of teams or materials which leads to suboptimal flows. Sweis *et al.* (2008) argue that, despite the current advantage of technology and understanding of PM techniques, construction projects still experience delays.

In the late 1980s, the US Air-force introduced a programme for Integrated Computer Aided Manufacturing (ICAM). The ICAM programme identified the need for better analysis and communication techniques for people involved in improving productivity. As a result, a series of techniques known as IDEF techniques were developed including IDEF0 which was adapted from SADT (IDEF0 1993). Prior literature claims great benefits in performance and productivity have been realised by the use of IDEF0 methodology (Later, SADT and IDEF0 are used interchangeably) in many industries. However, despite IDEF0 aiding better comprehension of engineering systems as they becomes more complex (IDEF0, 1993) it is little known and seldom used in construction. The question is asked whether IDEF0 can be adapted to enhance construction project management as a tool. Therefore, this study critically reviews IDEF0 model as a planning tool in the construction industry.

RESEARCH METHODOLOGY

This study is based on a comprehensive literature review of construction PM, focusing on planning and control, and SADT (studies on IDEF0). The research identified the delays and the causes, as the slogan “time is money” is globally acknowledged.

A qualitative approach was chosen because the research aim was to assess the understanding and knowledge of SADT/IDEF0 application. The use of a qualitative approach aids in focusing on perspective and expert experiences. (Bryman and Bell 2011). A personal (face to face) semi structured interview was utilised. Owing to the qualitative nature of the research carefully selected people were chosen to be interviewed. A total of thirty interviews were carried out comprising fifteen academics and fifteen practitioners in the field of construction. These groups were chosen so that both ends of the industry were covered. The interviewees were senior members of prominent companies and academia in the UK with significant experience. During the interview, the participants were asked about their knowledge and understanding of the SADT/IDEF0 model. The interviews were carried out to a point that desired data saturation was achieved.

CONSTRUCTION PROJECTS

According to Agyekum-Mensah (2012), “a construction project is the production of unique artefacts, normally using multiple disciplines, generally relating to Architectural, Engineering and Building; examples include civil engineering and building works such as roads, bridges, dams, railways and building works (new,

refurbishment and conversion)". Atkinson (1999) ascertained construction projects are continuously described as failing. Despite the advanced technology and project management techniques available to the practitioners, construction projects experience delays (Sweis *et al.* 2008). Sambasivan and Soo (2007) describe the delays in construction projects as a universal problem. This has led to many empirical studies on delays in both developed and developing economies (See table 1). Conclusions from many studies cite the fragmented nature of construction projects, lack of communication, management and financial problems as principal causes.

Hamzah *et al.* (2011) conclude that, the improvement of delay is not only limited to the consideration of technical factors, but also to issues of PM. Sambasivan and Soo (2007) concluded improper planning is the most likely cause of delay followed by poor site management. According to Sweis *et al.* (2008), responses from both consultants and owners ranked poor planning as the main cause of delay. Jongeling and Olofsson (2007) claim that only 15-20% of the time of a Swedish construction worker is spent on direct work due to lack of planning. The importance of planning is highlighted by Ballard and Howell (1998) who indicated that when planning reliability is above 50%, this will save 30% of labour consequently reducing project cost. Despite all the advances in PM theory and practice, construction project success is still below 40% (Hartman and Ashrafi 2004).

Table 1: Construction Delays observed in Literature

Authors	Delay observed	Country of study
Conlin & Retik (1997)	Overrun on 52% of projects	UK
Zwikael *et al.* (2005)	Overrun on 5% of projects	Japan
	Overrun on 30% of projects	Israel
Assaf *et al.* (2006)	30% completed on schedule (70% overrun)	Saudi Arabia
Ballard & Howell (1998, 2003)	Between 35 – 60% of weekly work regularly completed as planned	UK, USA
Odeh & Battaineh (2002)	Roads – actual to planned 160.5%	Jordan
	Building – actual to planned 120.3%	
Al-Momani (2000)	Public Project 81.5%	
Frimpong *et al.* (2003)	Groundwater construction 75%	Ghana
Aibinu & Jagboro (2002)	Building project 92.64%	Nigeria
Odeyinka and Yusif (1997)	Overrun 75% (every 7 out of 10)	
Mansfield *et al.* (1994)	Overrun as high as 342%	

CONSTRUCTION PLANNING

Planning and scheduling are often interchangeable; however, scheduling is one part of planning. Planning seeks to answer what, how, where, whom and when questions, schedule answers when. In fact the schedule is simply the itinerary (Mubarak 2005). Planning serves as a foundation for several related functions such as cost estimating, scheduling, project control, quality control, safety management. Ardit (1985) ranked planning on top of the list on potential for headquarters productivity of construction companies. Project Planning is an integral part of organisation strategic thinking and strategic management (Shenhar *et al.* 2001). Raymond and Bergeron (2008) argued that improvement in effectiveness and efficiency in managerial tasks are observed as a

result of better planning. Planning is vital to the role of a project manager yet there are increasing concerns over the failure of construction planning to achieve its goals (Laufer and Tucker, 1987).

Luiz and Hijazi (1993) discusses the network scheduling techniques used in the construction industry namely CPM, PERT, decision critical path method (DCPM) and the graphical evaluation and review technique (GERT). These conventional techniques have been criticised as ineffective by construction management researchers. There are two main disadvantages of using CPM and PERT in the construction industry. One is the emphasis on finding an optimal solution based on the shortest project duration, which involves minimising resources or cost. The other is the limited emphasis placed on input modelling (Lutz and Hijazi 1993). Birrell (1980) discussed extensively the limitations of CPM in his study, *Construction Planning – beyond critical path (CPM).* Laufer and Tucker (1987) established that only 15% of CPM/PERT users deem these techniques as very successful.

Another planning tool available to the construction industry is the line of balance (LoB) technique. The line of balance concept comprises a graphical plot representing cumulative production versus time. Arditi and Albulak (1986), refer to the Line of Balance technique as a "linear scheduling method" since it is used for repetitive project. Arditi and Albulak (1986) argue that the origins are not clear; however, Arditi *et al.* (2001) suggested that this technique was developed by US Navy in the early 1950s during the Second World War for programming and controlling repetitive and non-repetitive projects. Arditi *et al.* (2001) argue that LoB technique was not fully developed and implemented by construction industry due to the immense popularity of network technique including CPM/PERT. Regardless, it has been applied to repetitive construction projects (Arditi and Albulak 1986), resource scheduling and highway pavement construction (Arditi *et al.* 2001). The contention is that the underlying theory of LoB is that the production rate of an activity is uniform. This is contradictory to general construction activities.

A radical investigation of construction problems from a theoretical stance concludes that the theory for construction project management as practice is obsolete and consequently, proposes TFV theory (Koskela 1992). Koskela later identified seven flow preconditions for the execution of construction task. Koskela and Howell (2002) argue that the conventional planning techniques fail to support flow of work and material since these techniques are based on conventional theory. Conversely, the Last Planner System® (LPS) was thus introduced by Ballard (1998) to bridge the gap in flow, planning and control. However, LPS is based on the limited application of methods such as CPM (Kenley 2004). Kenley (2004) argues that CPM, PERT and WBS are the mainstream planning tools due to the availability of relatively cheap and extremely powerful schedule software. Laitinen (1999) argues that the solution to problems in planning goes beyond the use of IT tools alone. Kenley (2004) claims lean construction proposes change in the traditional approach to construction management and demands a new approach to production planning but still depends on the conventional methodology of scheduling. It was further claimed that little effort has been put forward by researchers in solving the problem of physically creating flow. Existing techniques such as LPS emulate flow through management control systems which has resulted in the well-developed but proprietary LPS technique. Kenley (2004) suggests that it is the time to focus more effort on changing the way work is planned and managed in construction. In response to this, methodologies used

by the US Defence, the original reference point for PM is revisited and IDEF0 is reviewed.

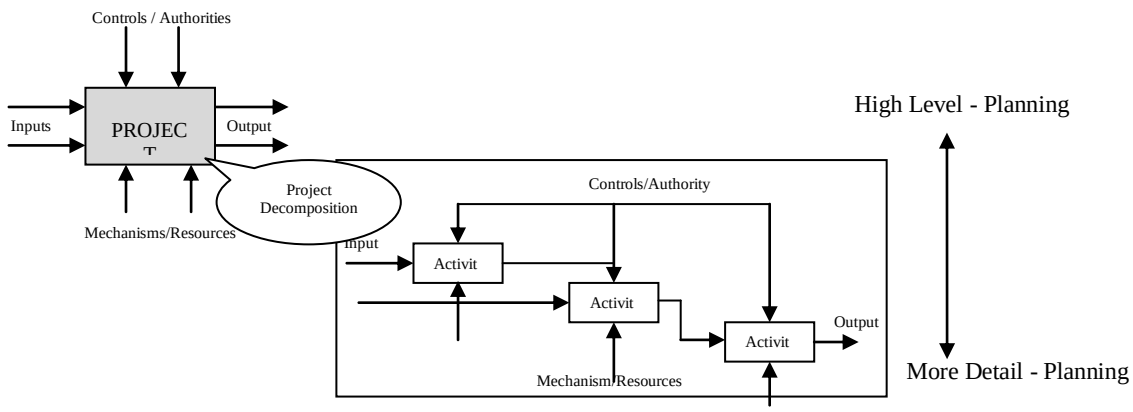
STRUCTURED ANALYSIS DESIGN TECHNIQUE (SADT)

Background

SADT was originally developed by Douglas T. Ross in the 1970s. Douglas was the chairman of SoftTech and head of Computer Applications Group at Massachusetts Institute of Technology (MIT). Due to his background in Mathematics, Electrical Engineering and Computer Science, his interest was in the software development process including methodology, theory, and tool development (Ross 1985). He is also renowned for the introduction of the Computer Aided Design (CAD), which was further developed and largely used in the construction industry (Ross and Ward 1968).

ICAM adapted the SADT activity model as IDEF0 which originated from the concept of Structural Analysis (SA) for Requirement Definition (RD). RD is to carefully assess, *why* a system is need, *what* system, *how* a system is to be constructed. Thus RD deals with three subjects: Context analysis (why), Function specification (what) and Design constraints (How). Through this RD led to the development of the Structured Analysis and Design Technique (SADT). SADT consists of both techniques for performing system analysis and design, and a process for applying these techniques in requirements definition and system development. Both features significantly increase the productivity and effectiveness of teams of people involved in system projects (Ross and Schoman, 1977). The two main representation of SADT are in the graphical techniques and the definition of personnel roles. The notation is simple, just boxes and arrows, where the boxes represent parts of whole in a precise manner, and the arrows represent interfaces between parts (see figure 1). Each box always has four arrows at the sides, that is, Input (I) Control (C), Output (O) and Mechanism (M), normally referred as ICOMs (Jongeling and Olofsson 2007). In 1993, the National Institute of Standard and Technology released IDEF0 as a standard for Function Modelling in Federation Information Process Standard (FIPS), (IDEF0 1993).

Figure 1: IDEF0/SADT Notation



Previous Application of SADT/IDEF

IDEF0 is a widely used technique for the structured analysis and design of systems. It is used in improving the productivity and communications in computer integrated manufacturing systems. IDEF0 has been applied successfully in hundreds of projects involving thousands of people in diverse industries as aerospace, telecommunications, and software development (Congram and Epelman 1995). Colquhoun *et al.* (1993),

Congram and Epelman (1995), Kim and Jang (2002), Presley and Liles (1995), and IDEF0 (1993) provide a comprehensive discussion on the use of IDEF0 in developing manufacturing-oriented models and its success. It has been discussed widely as a tool for business reengineering. Presley and Lies (1995) discuss applications of IDEF0 for design and specification of methodologies. The business process re-engineering modelling approaches reviewed by Gingele *et al.* (2002) conclude that only IDEF completely supports the criteria. Similarly, Cheng-Leong *et al.*'s (1999) development of manufacturing enterprise systems identifies some weakness in the traditional model approaches and advocates the use of IDEF techniques. Greswell *et al.* (1995) used IDEF0 to formulate and implement an improvement initiative in a major UK manufacturing company. Chin *et al.* (2006) used IDEF0 together with the colour Petri nets model to mould-making processes. Jongeling and Olofsson (2007) used IDEF0 model to describe their process to develop a model for workflow using 4D. Ohboshi *et al.* (1998) used IDEF0 to understand the medical emergency workflow. They concluded that the IDEF0 model holds promise as a method having the capacity of reproducing and designing systems like a Hospital Information System.

IDEF0 has also been discussed as a common mean of communication and it has also been applied to modelling of the construction process in Finland (Karhu *et al.* 1997, Laitinen 1999, Karhu 2001, Karstila 2003). Austin *et al.* (2002) adopted IDEF0 to represent the process in the development Analytical Design Planning Technique (ADePT). Generic Design and Construction Process Protocol considered the IDEF0 model for the 'as is' process because of the successful use of the model to represent processes (especially for Sanvido's Integrated Building Process Model (Kagioglou *et al.* 2000). Although it was claimed that the partners preferred to concentrate on the general principles of the process rather than the detail of the activities involve. Congram and Epelman (1995) established that IDEF0 methodology is flexible and it is recommended for adaptation for services. O'Donnell and Duffy (2002) adopted IDEF0 model as the tool for measuring and analysing design performance in engineering and construction design. They agree that, although IDEF0 does not explicitly represent the element of performance, it focuses on knowledge in design.

IDEF0 has been discussed extensively and used in industry, albeit not as much in the construction industry. However, none of studies have explored it as project planning technique. Nonetheless, the basic problem which drove development of SADT (IDEF0) as stated below is no different from the problems associated with construction projects.

> "The assertion that "a problem unstated is a problem unsolved" seem to have escaped many builders…All too often, design and implementation begins before the real needs and system function are fully known. The results are skyrocketing costs, missed scheduled, waste and duplication, disgruntled users and endless series of patches and repairs euphemistically called "system maintenance" (Ross and Schoman 1977)

The hypothesis is if "planning should answer these questions, *what* should be done (activities), *how* should activities be performed (method), *who* should perform each activity and with *what* means (resources) and *when* should activities be performed, and IDEF0 was developed for these questions", then IDEF0 is suggested to be an effective planning tool. Ross and Schoman (1977) explicitly stated that SADT/IDEF0 is for planning, managing, and assessing. Colquhoun and Baines (1991) found IDEF0 to be a powerful tool that offers a number of features which makes it easy to apply and most importantly to understand.

RESULTS & DISCUSSION

The result of the interviews shows that none of the interviewees had prior knowledge about IDEF0 or SADT. However, after its introduction to them by the first author, they found it to be simple and useful technique laudable to explore within the construction industry. The result was none after the first twenty interviewees therefore, additional ten were carried out which was the same results.

It must be acknowledged, however, that some participants questioned the desire of the construction industry to adapt to change. In as much as the construction industry has been criticised for lack of innovation and its conservatism approach, Sturges et. al., (1999) argues that, although the construction industry has adapted to change over the years, it is slow to drastic change. Consequently, IDEF0 has some commonalities with the existing accepted techniques; however, it is founded on different conceptual basis. The philosophy of IDEF0 model is, since there is a project then, there are processes and each process should have the Inputs, Controls (Constraints) and Resources (Mechanisms) to generate an Output.

The construction process is ambiguous, fragmented, and involves a significant number of participants. This affects the effectivity of planning construction projects. Although it is suggested that there is no one correct method for planning construction projects, there is a guided approach to achieve project objectives through effective planning. This planning approach should increase production by improving communication and the production process, which is the strength of using IDEF0 (Kuiak *et al.* 1993). Laufer and Tucker (1987) argue that CPM/PERT cannot be supplanted since better methods are unavailable. However, the US Defence who developed these conventional techniques sought to increase their productivity and later developed IDEF0. Yet, the construction industry has failed to explore its adaptability. This study identifies the following reasons for the adaption of IDEF0 for project planning:

- IDEF0 is completely general and applicable to any situation because it is unlike mathematical or logical methodologies or even programmes. IDEF0 methodology does not solve problems but provides tools that allow people to understand express manipulate and check problem elements (Ross 1985).
- The concept of IDEF0 can be used to illustrate the seven flows of Lean construction with the ICOM mode (see figure 2), where Inputs denotes, previous tasks and components and materials, Control denotes construction design, space and external conditions, Output the completed task, and Mechanism denotes workers and equipment.

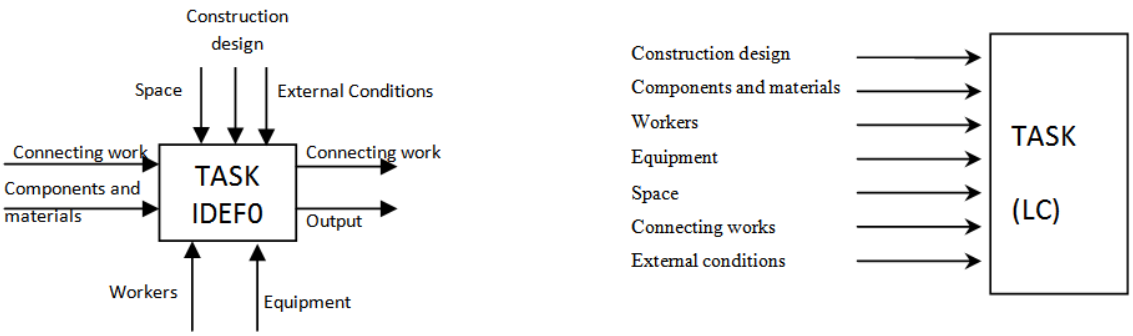


Figure 2: *Representation of Koskela's seven Flows in IDEF0*

- Using IDEF0 is relatively easy and is user friendly (Greswell *et al.* 2005)
- IDEF0 is a top-down design method which helps in dividing the project into deliverables or work packages and critically links the activities together. The connections between boxes indicate flow of control, information, objects or anything that can be described with noun phrases.
- IDEF0 promotes collaborative planning, thus, ensures planning efficiency is high for production. Nevertheless, it could be time consuming
- Use of IDEF0 benefits from communicating common understanding of the complex project to team. Therefore, IDEF0 increases productivity by improving communication and the production process (Kuiak et al., 1993)
- IDEF0 methodology incorporates the following for project management: WBS development, Task assignment, procedure definition, flow and communication. IDEF0 relates the activities in the production flow. The output of a preceding task is not necessary an input of the sequential task but could control or influence that activity.
- The use of graphical portrayal is a powerful means of representing the deliverables and how they connect or link with each other.
- It is well-tested and proven, through many years of use in many industries.

Barriers to implementation of IDEF0 in construction

In spite of the established use of IDEF0 in the US Airforce, manufacturing, computer and aerospace industries, it is seldom known and used in the construction industry. This could be due to the following:

1. *Lack of Knowledge:* Academics and practitioners of construction industry seldom know about IDEF0 or SADT methodology
2. *Limited exploration:* Some researchers in construction management suggest IDEF0 is used in the analysing of "as is" processes while other consider it is for IT programmes.
3. *Software distraction:* The shift of attention to extensive use of software for planning based on the traditional planning concepts. However, Laitinen (1999) advocates that the current problems in the construction industry cannot be solved with IT alone.

CONCLUSION

IDEF0 methodology is general and therefore could represent any process or procedure of planning and control. IDEF0 aids in understanding the process through its visual representation of the flow of activities. These will benefit from communication, resource and scope management, and common understanding for the project team.

This research established that IDEF0 is little known and seldom used in the construction industry; however, it is suggested that IDEF0 has the potential for adaptation for project planning and control. In addition, it could be used for project control since it explicitly takes into account all the seven flows and their management. Additionally, IDEF0 take into account the eighth flow (the common understanding). IDEF0 could be used for high level as well as detail project planning. It takes into account the input, control and mechanisms required carrying out a task to achieve the required output. This opposes the conventional technique of input to give output. Another inherent advantage of IDEF0 is its ability to assess the performance, efficiency and effectivity of an activity as discussed in O'Donnell and Duffy (2002).

The concept of IDEF0 as reviewed and discussed demonstrates the potential for adaption as a project planning technique and the critical evaluation of its implementation forms part of on-going research by the authors.

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THE ROLE OF PROBLEM SOLVING IN CONSTRUCTION MANAGEMENT PRACTICES

Casper Siebken Schultz[1]

[1] *DTU Management Engineering, Technical University of Denmark, Produktionstorvet bygn. 424, 2800 Kgs. Lyngby, Denmark*

Quality issues are a topic of continuous interest in the Danish construction industry. Not only can failures and defects be vital to the success of the single project but also the annual profits of the whole company can be put at risk. Moreover quality issues jeopardize the reputation of the entire industry. An Industrial PhD carried out at a large Danish contractor examined how failures and defects are produced and handled in the social practices of construction projects. The study addresses quality issues related to project management and examines the role of problem solving practices in the creation and redressing of failures and defects in construction processes. The theoretical framework is based on theory of structuration and enables the central analysis that includes underlying structures of the actors as well as the processes of structuration. The research project is designed as an abductive research process where theory and empirical data inform each other in iterations. A 15-month ethnographic field study comprised of workplace observations and qualitative interviews was carried out to be able to study the internal structures of the agents and the effect of their general-dispositions regarding quality issues in the decision making and redressing of defects and failures in the processes. The role of problem solving and trouble-shooting is analysed through the well-organized processes of erecting the pre-cast concrete structure and the chaotic processes of constructing the penthouse storey on top of the building. The research highlights reactive and proactive problem solving practices as important for the completion of the construction project. Problem solving practices are however often forced into a reactive problem solving. Implications to the company are to direct the attention not only to the planning but also to facilitate and support the problem-solving and trouble-shooting competencies of projects managers.

Keywords: building defects, problem solving, project management, quality, structuration.

INTRODUCTION

Quality issues in the form of failures and building defect are continuously debated in the Danish construction industry on a national level but also in relation to the specific projects and companies. A summary from the Danish authorities estimated the annual costs of failures in the Danish construction industry to almost 1.7 billion euros - close to ten percent of the total production value in 2004 (DEACA 2004). This correspond a

[1] cass@dtu.dk

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study from the Technical University of Denmark (Apelgren *et al.* 2005) and Josephson & Hammarlunds (1996) extensive studies in Sweden. The industry and the former Danish Enterprise and Construction Authority initiated a joint action plan against defects in 2005 and set an ambitious target to reduce the level by 50 % in 2008 (DEACA 2009). An important element was the introduction of a compulsory evaluation system for contractors, developers and consultants in state contracts. In 2009 it was concluded that the extent of defects and failures had decreased in the period 2001-2008 but from 2005 to 2008 the positive trend stalled (EBST, 2009).

The research material originates from an Industrial PhD project conducted from 2006-2010 in cooperation between the university and NCC Construction Denmark – one of the largest contractors in Denmark (Schultz 2012). The specific purpose was to examine how failures and defects are produced and handled in the social practices of construction projects in order to reduce the extent of failures in the building process. Benchmarking data from the company showed that quality issues related to both processes and products amounted to large sums and strategies to reduce this was imposed. Moreover a review of existing knowledge on failures in the industry and within the company revealed a substantial amount of data on the subject both outside and inside the company. However, despite the amount of knowledge on the subject a number of specific problems were produced across the portfolio of projects in the company. This led to the decision that the research should be designed as an in-depth study and focus on how the different knowledge of building defects and other quality structures influenced the processes and actions on the projects. The emphasis was put on the social practices of the project managers; their actions and decision making in general and the role of problem-solving specifically. Hence the paper examines the following question: What are the role of problem solving construction management practices in the creation and redressing of failures and defects in construction processes? By highlighting problem solving, the study has a focus that is often overlooked in construction management research, which often seeks to find prescriptive models to account for eventualities on site. The premise is that failure and defects cannot be seen as isolated incidents, but must be regarded as a correlation between the successful as well as the faulty processes. Failures and defects are moreover considered as consequences of something unexpected or unforeseen.

The paper proceeds with methodology and the theoretical framework of the study. The empirical material is presented in the form of two illustrative cases from a Danish housing project; the well-organized processes of erecting the pre-cast concrete structure and the chaotic processes when constructing the penthouse storey on top of the building. On basis of the method, theory and empirical data the analysis, discussion and conclusion is then presented focussing on the role of the reactive and proactive problem solving practices in the construction processes and how they are often forced into a reactive problem solving.

METHODOLOGY

The research project is designed as a qualitative abductive research process where theory and empirical data inform each other in iterations. The theory is the starting point - an eye-opener - and through an open empirical case-study divergence between theory and empirical findings is discussed and applied through continuous iterations. The study is primarily sociological but elements of an engineer-scientific approach are applied for understanding the rationality of management, the habitus of engineering as well as planning. Based on Alvesson & Sköldbergs (2000) reflexive qualitative

methodology the need for various types of interpretations of the empirical material is acknowledged.

The theoretical framework combines processual elements with elements of stability (structures) via Giddens theory of structuration (e.g. Giddens 1984). A study of preconditions of actions demands for an in-depth study rather than a wider approach so a single-case-study was selected. Single case studies "when compared with quantitative research or multiple case studies is ordinarily judged to be lacking in rigor, comparability, and replicability" (Barzelay 1993). However, it is an extremely valuable method of social science research when used for purposes of analysing how people frame and solve problems (Ibid.). A 15-month ethnographic field study comprised of workplace observations and qualitative interviews was carried out to be able to study the internal structures of the agents and the effect of their general-dispositions regarding quality issues in the decision making and redressing of defects and failures in the processes. As a result of the research design and the rooting of the study in the company the research contributes with an in-depth understanding of the relationship between the structural premises and the actions and decision-making of the project managers and craftsmen on the construction projects.

Empirical material: Reading papers, hanging out, asking questions

The case material stems from a larger turnkey housing project within the company. Corresponding Dingwall in Cicourel (1964) the strategy for gathering insights about the field of research was "reading papers", "hanging out" and "asking questions". In total more than 100 days of ethnographic observations of primarily on-site processes was conducted from September 2007 until autumn 2008. Participant observations and interviews primarily focussed on site management activities and the work tasks of the contractors' project team. Interactions with designers, suppliers, subcontractors, craftsmen as well as functions at the headquarters were also mapped. Numerous qualitative interviews were conducted with relevant actors as well as study visits at the suppliers' facilities. The output consisted of 120 comprehensively written pages of diary, numerous types of documentation, minutes from meetings plus 15 formal interviews.

Limitations are amongst others that not all failures were registered since it was not possible to pursue all parallel activities. Also the massive amount of impressions and data can induce "death by data suffocation" as well as it is difficult to present the nuances of the empirical data and analysis in the form of a conference paper. The possible bias to the investigation as a result of the researcher being employed by the company is included in the analytical reflections. But the Industrial-PhD program setup and the involvement of the research institution should also limit this bias.

STRONG STRUCTURATION THEORY

The theoretical framework is based on Anthony Giddens theory of structuration (e.g. Giddens 1984) which is adapted to the empirical analysis primarily on basis of Rob Stones 'strong structuration project' (Stones 2005). Stones concept of strong structuration is moulding the "dried out" abstract theory of Giddens into an applicable implement for empirical researchers (Larsen 2009). As an abstract grand theory the theory of structuration represents ontology-in-general: "concepts about the very nature of social entities over and beyond any particular empirical manifestation of them in specific social circumstances" (Stones 2005: 7). Supplementary theory on failures and defects as well as the interface and interactions between firm and project (e.g. Winch

1998 and Thuesen 2006) delivers insight of the practical level of the building projects as ontology-in-situ.

The social practice is the mediating term between action and structure and describes the relationship between agent, action and structure in a duality of structure where the three concepts are mutually related. On basis of structures the social practice constitutes individuals as conscious, knowledgeable agents and through "activities agents reproduce the conditions that makes these activities possible" (Giddens 1984: 2). I.e. structures are reproduced or perhaps reinforced or transformed - often unconsciously, which is described as an unintended consequence of the social practices. Structures are thus both the medium and the outcome of the process. Because the actors are knowledgeable, structures are a condition for actions embedded within the agent and moreover structures are media of power. The agents as knowledgeable are expressed through the agents continuous reflexive monitoring of actions either as discursive or practical consciousness (Giddens 1984: 7) but also on an unconscious level (cognition). Structural properties are both constraining and enabling (Giddens 1984: 25) and the unintended consequences introduce the reproductive nature of actions which may as a result of the agents' knowledgeability and reflexivity, or by incident, lead to a change over time.

The duality of structure and agents is in Stones version of structuration theory (Stones 2005) broken into four interlinked – but analytical separated – elements. The distinction is between 1) external structures (relative to the agent in focus), 2) internal (virtual) structures within the agent (separated into a) conjuncturally-specific internal structures and b) general-dispositional structures (resembling habitus to Bourdieu)), 3) active agency and 4) outcomes – as internal or external structures or events. Stones emphasis the notion of conjuncturally-specific internal structures as indispensible to the substantive level of empirical research (Stones 2005: 90). These are not reducible to knowledge gained within immanent interaction, but may well be formed long before they are drawn upon (Stones 2005: 91). Stones' quadripartite methodical structure delivers a tangible analytical framework to the analysis of agent actions. This includes external structures e.g. company procedures, regulation, physical building materials, machinery etc. as well as the agents' internal structures. The latter comprise both the specific knowledge on the different influences related to the task at hand but also the more general agents' disposition e.g. how they prioritize quality of the product to the schedule or the budget.

The assertion is that rational conceptions of failure mechanisms in the building process are not enough in itself since other structures (external or internal) often becomes predominating. Structures do not exist in itself per se; "only in its instantiations in such [social] practices and as memory traces orienting the conduct of knowledgeable human agents" (Giddens 1984: 17 and Kaspersen 2000) i.e. nothing is really a structure unless it affects the activity. This way traditional cause/consequence analysis' often fail to deliver applicable knowledge to the actors since quality focus infrequently structures the construction processes. The presumption is therefore that elements in project cultures and internal structures are essential in understanding the dynamics of problem solving and understanding why substantial catalogues of knowledge on failures rarely affects the decisions on the projects. In the specific situations on-site when the agents have to make a decision or solve a problem they must navigate between a number of different structures and considerations - often conflicting. The understanding of these decision processes seems vital in understanding why some problems are continuously produced across different project.

Moreover it is central to investigate these processes to understand how company structures affect the specific project processes e.g. why some central company quality structures seems to work in some situation while being peripheral in others.

TWO CASES OF PROBLEM SOLVING

The role of problem solving and trouble-shooting is elucidated through two cases from a larger residential construction project; 1) the well-organized processes of erecting the pre-cast concrete structure and 2) the chaotic processes of constructing the penthouse storey on top of the building.

The pre-cast concrete element phase

The first case illustrates a number of "ordinary" small problems and defects in the processes of erecting the precast concrete elements. Subsequently a series of observations from everyday processes around the assembly is included. The carcass structure is based on precast concrete elements and the structural project is modelled in 3D and evaluated by the on-site team as having an unusually high standard. The precast concrete elements are manufactured by three different suppliers and bathroom cabins from a fourth supplier is delivered and mounted with the carcass. The carcass is erected by an in-house team who work as a regular subcontractor on the project. There are a number of failures in the process of erecting the elements and at some point all the different parties are somehow involved in the initiation of a failure in the process. Failures and defects can be related to planning, the structural engineer project, the factories, on-site management as well as execution. However production flaws initiated by the manufacturers in the form of misplaced recesses, joint locks, inserts etc. as well as slanting elements and problems of keeping within the tolerances is common.

The problem solving practices in the pre-cast concrete element phase can be described as very routinized. The following example is the traditional procedure when handling a problem initiated by a supplier. When the production manager on-site becomes aware of a problem (perhaps told by the craftsmen), the problem is documented often supported by a photo and a short description which is typed into a spreadsheet back in the site hut. The problems are reported to the manufacturer and it is decided who is responsible and who will redress the problem. If an agreement cannot be reached the production manager initiates the redressing and the discussion of responsibility and expenses is put on hold until later. The procedure secures progress of the production which is considered vital. At some point there are three “finishing gangs” from the different manufacturers present at the site in addition to the original concrete assembly gang. At the completion of the project the parties make a final financial agreement to cover the expenses.

The otherwise mundane assembly story reaches a climax when a construction worker suffers a fatal accident, which puts everyday problems into perspective and test structures and practices to the extreme.

The penthouse storey

As a counterpoint to the concrete element assembly, the planning and construction of the buildings penthouse structure is observed. The processes appear much more unstructured and chaotic. Based on previous experiences in the company the project manager assesses this part of the building to have the highest risk in the project. The penthouse storey is constructed with heavy load-bearing walls and concrete slabs as a roof. The building envelope is steel clad sandwich panels with a core of insulation. A

range of lightweight concrete walls and plaster walls function as partitions. An interior balcony is placed at the rear of the house with a steel railing and a steel cover for the sun. In the processes a number of actors are present; two different carpenters, the concrete contractor, the roofer and a blacksmith among others. Moreover extensive safety work influences the processes. Especially the joints between the sandwich panels and the windows/doors as well as the roof membrane are critical interfaces. So are the interactions between the different actors.

The project managers have no experiences with tightening the building envelope. Aware of their lack of competencies they try to plan the processes meticulously prior to the execution. They review the project material and at a meeting they try to uncover all possible problems by dividing the processes in small pieces on post-it notes. They also visit the supplier of the steel clad sandwich panels to gain knowledge on how to execute the processes. However as expected a number of problems arise in the execution phase. An initial problem arises when the roofer hires in a subcontractor and the new contractor do not follow the instructions as originally agreed between the project management and the original roofer. However the biggest problems arise when it is discovered that the construction is leaky. Water is detected in several apartments at several occasions. A Blower Door test also reveals that the construction is leaking. Over a period of many months the actors try to solve the problems. Directed by the project managers the actors try to uncover a number of possible solutions as organized as possible. There are repeated adjustments and rework before the construction is considered tight enough to meet the requirements. At the end they succeed in making a tight construction from a number of corrections e.g. additional screws and sealant, additional layers of roofing felt and an extra focus on the quality of the interfaces. However at the end they are still not aware of the actual causes of the ingress of water.

ANALYSIS AND DISCUSSION

The observations from the specific project indicate that the project is the context in which the redressing of failures and defects are structured and reproduced. This despite a focus on activities from the company to enhance the link between business processes and projects. The cases in general illustrate how quality issues pervade the processes in the form of: a) external structures (e.g., corporate structures) and internal structures (relative to the agent), b) the knowledgeable agents (including the importance of routines and reflection), c) in the form of intended and unintended actions (e.g., planning and problem solving) and d) in the form of unintended and undesirable consequences of the processes of structuration.

A key contribution from the study is the understanding of the social practices of problem solving. Another key contribution of the study is the understanding of the unintended consequences of routinized practices; how routines and experiences in addition to helping to reduce the extent of failures and defects, also can be seen as instrumental in producing and maintaining a certain level of failure. Moreover the study show that understanding the causes of failures in the building process demands a wider scope and can seldom be narrowed down to simple causalities or prescriptive models to account for eventualities on site.

The successful project - with a number of problems in the processes

The primary project studied is successful in terms of measures as time and money. Furthermore the social construction of the projects as a success is seen from the articulation of the projects history although an occupational injury leading to the death

of a craftsman is somewhat damaging this picture. Factors as competencies and collaboration across the value chain, the project being very carefully worked out and a consistent project team throughout the design and execution phase is pointed out as important to this success. Despite of this the empirical data shows that a wide range of problems is present throughout the on-site production phase. Most of the failures can be described as minor problems leading only to a limited reflection and narrow actions to redress the problems. Only one problem - the fatal injury – can be said to have a direct impact on future processes outside of the project.

The social practices of problem solving

Failures are detected when the reflection of one of the involved actors is somehow triggered by the quality of either the product - e.g. the quality of the panels - or the processes. Their reflexive monitoring perceives that something is not as expected. The social practices of problem solving in the case of erecting the pre-cast concrete elements can be described as routinized. Moreover it is almost expected that the elements are flawed. In this case the production managers have a very structured routinized process of problem solving that is supported by corporate structures in the form of formalized spread sheets and procedures to address the problems related to the suppliers. It is also included in the contacts and thereby closely linked to the responsibilities of the actors. This way it is formalized both in respect to the external and internal structures relative to the agents which is a consequence of highly standardized processes; the processes and product resembles many other traditional housing projects in the company.

In the case of the penthouse it is by chance that the leak is discovered at all - it starts to rain! Causes can be related to both a lack of communication, skills, knowledge and execution. Nevertheless at the end they solve a problem without knowing the root causes. The processes of problem solving can be described as highly chaotic in spite of the projects managers attempt to organize the processes. This can be seen as a consequence of both the processes as well as the final product being relatively unique and unstandardized.

Problem solving is a repeated activity pervading most construction processes and can both be considered as social practices but also as the project staffs' general-dispositions (or habitus); as internal agent-related values. The latter becomes relevant when considering how the agents prioritize quality to other dominant structures e.g. the earnings/budget, time/schedule and/or responsibility/contracts. The social practices are both structured by actors' dispositions, their context-specific knowledge (internal structure) and sometimes also supported by external structures.

A continuum of problem-solving practices with unintended consequences

The cases illustrates two types of problem-solving practices; routinized and chaotic However, omitted empirical material reveals types of problem solving that combines elements of both. Hereby the two cases represent the extremes of a spectrum forming a continuum from; a) structured problem-solving activities to b) a large number of more chaotic and unstructured processes. Both "extremes" have different starting points and introduce a number of unintended consequences. The well-structured problem-solving practices introduce problem solving as a relatively pragmatic practice that does not address the root causes of the failures and defects. Hereby the on-site problem-solving strategy does not handle the underlying causal structures but only solve the manifested problems here-and-now. This is illustrated by the procedures where discussions on responsibility are postponed until later and eventually

transformed to a bargaining not addressing the causes at all. At the opposite end of the spectrum, one of the unintended consequences of the unstructured problem-solving practices is that the on-site staffs - in spite of the problems - reproduces themselves as strong problem solvers who are able to solve all problems themselves without seeking solutions, skills or competencies elsewhere in the company or industry. This can be seen as a hindrance to organizational learning. The extensive observations of the agents in the construction project this way shows some examples of firmly established hard-core routines and practices at the construction project, where agents reproduce practices that produce failures and defects; failures and defects are thus unacknowledged conditions of the actions.

The relationship between planning and problem solving

The research highlights the relationship between planning and problem solving. Design, engineering, planning and problem solving can all be considered as problem-solving practices. The parts that relate to the correction of the defects and failures often take the form of reactive problem solving, while the other activities can be described as proactive problem solving. The reactive problem-solving practices are highlighted as important for the realization of the construction project and as a vital element to ensure that planning and design is achieved in the finished project and that the project meets the clients' demands. The problem-solving practices are often forced into a reactive problem solving. Moreover the cases show that far from all failures can be traced back to the design, engineering or planning (the proactive problem-solving practices). The on-site staff and construction managers are often uncertain and vacillate about the premises, causes and consequences of their choices and actions in their problem-solving practices. The problem-solving activities are organized and structured in practice but at the same time the importance of these problem-solving activities can be seen as neglected or overseen in many of the planning paradigms underlying most of the planning of the construction processes.

Structures in problem solving

The project staffs draws on a varied, nuanced network of abstract structures. Corporate structures are often omitted or used in a different way than originally intended and specifically "quality structures" (that is both internal as well as external relative to the agent) often proves peripheral. There is a contrast between process engineering incentives and economic incentives; "economy" and partly "progress" (in the form of scheduling) becomes dominant structures, while quality is considered a lower priority. "Quality" and "responsibility" as structures are to a greater extent elements in efforts to achieve economic results and comply with schedule. Quality is only one of many considerations and purposes that shape and structure the processes. Other structures as time and money become predominating and among other structures also previous individual or project related experiences can be structurating. These experiences are highly dominated by individual experiences or experiences in the project network and seldom based on organizational experiences. Often the structures must create a direct sense of value to the individual or the project. This selection is also based on the experiences of the actors and the project network and to a great extent it can be seen as a social construction. This highly affects the selection and deselection of structures at hand. Moreover direct procedures, orders or commands can be structurating. In contrast or collaboration with incentive structures and rewards it creates a tense space to manoeuvre for the actors. These characteristics

can be seen as elements of project cultures that can be described as highly resistant to outside interference.

Knowledgeable agents

The knowledgeable agents are very "visible" in the processes of problem solving with different prerequisites to achieve their results. The results can best be described as mixed as it can be seen, that in both cases failures and defects arises.

The processes of problem solving in the penthouse case become very dependent on the agents' internal structures since it is unsupported by corporate structures. Moreover the agents do very little to access knowledge in the company environment outside the project. In the precast concrete panels' project a dedicated engineer is assigned for the project engineering which is not the case in the penthouse project. This way there is a lack of a professional anchoring and the quality of the processes becomes highly dependent on the project competencies. Because of the differences in the processes e.g. the many interfaces between different subcontractors as well as different materials it is a different set of knowledge and competencies that is required than what is the case of the precast concrete project.

Cultivate the reflective practices of the project managers

The complex problem solving processes in the tightening of the penthouse shows us that different sets of knowledge and competencies are required across the project. A solution could be to further facilitate and support the problem-solving and trouble-shooting competencies of projects managers; to create structures and practices that cultivate the reflective practices of the project managers. Moreover competencies on the interfaces both between actors, materials and processes could be further strengthened. These types of competencies could probably advantageously be in-house competencies of the contractor depending on the situation.

CONCLUSIONS

The paper examines the role of problem solving practices in the creation and redressing of failures and defects in construction processes. The significance of the reactive problem solving is considered neglected in the planning paradigms that underlie much of the planning of construction processes. On the other hand reactive problem solving practices are organized and structured in the project's daily practices and the reactive problem solving becomes an instrumental part to bridge the gap between planning and execution and secure a successful execution. The same expectation is seen on the level of the agents who often have a fierce belief that problems can be solved with better planning.

The research shows how observed problem-solving practices form a continuum from structured problem-solving activities to a large number of more chaotic and unstructured processes. Both have unintended consequences. The well-structured problem-solving practices introduce problem solving as a relatively pragmatic practice that does not address the causes of the failures and defects. At the other end of the spectrum the on-site staffs reproduces themselves as strong problem solvers which is a hindrance to organizational learning.

Planning and problem solving are both characterized by the identification and redressing/handling of a problem and are hence described as proactive and reactive problem solving. In various ways reactive problem solving creates a link between some more or less coherent design processes (planning) and execution processes.

Problem-solving practices in the project are often forced into a reactive problem solving. Empirical evidence show that far from all failures can be traced back to the proactive problem solving (planning). Moreover, the study shows that understanding the causes of failures in the building process demands a wider scope and can seldom be narrowed down to simple causalities or prescriptive models to account for eventualities on site.

Implications are focussed on the company structures and processes of the contractor as a consequence of the research rooting in the company. Implications are to direct attention not only to the planning but also to facilitate and support the problem-solving and trouble-shooting competencies of projects managers; to create structures and practices that further cultivate the reflexive practices. Moreover it is central to ensure that experiences and solutions of the local problem solving becomes available to the entire company; to facilitate proper structures and practices for knowledge sharing. Perhaps a trivial point - but highly relevant.

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PROJECT PERFORMANCE

IMPROVING PROJECT PERFORMANCE OF PPP/PFI PROJECT-BASED ORGANISATIONS

Doubra Henry Ndoni and Taha Elhag

Bartlett School of Construction and Project Management, University College London, UK

The concept of PPP/PFI promises a radical change to improve project performance and better service delivery to the public but evidence on cost and quality gains seems to be limited considering the financial commitments entered by governments around the world. This has encouraged significant number of researches based on diverse PFI projects in the United Kingdom to understand how PPP/PFI projects have performed based on cost, time, quality and operations. Nevertheless, these reports present inconsistent project performance outcomes as different data and methodologies are presented which can lead to more confusion to understand how well PFI projects have performed. Overall, the criticisms levelled against the construction industry concerning the performance of PFI projects executed have not been encouraging. Although, previous studies have identified and investigated factors that can assist to improve project performance recent studies still suggest that how to improve project performance is a perennial problem to construction professionals and project management researchers. In addressing this problem, this paper aims to re-examine these factors to consider which positively influences project performance. Also, the paper proposes the network perspective as a means to attract and transform new knowledge to improve construction delivery processes. By implementing the network perspective, practitioners and managers can explore new areas to create value to improve their project performance. This paper empirically identifies significant factors in the context of PFI projects to improve project performance, drawing upon case studies and questionnaire survey of PFI practitioners involved in on-going PFI projects in the United Kingdom. The main findings show that: 1) collaborative networks; 2) sustainable construction products; 3) clarity in project design for buildability; 4) life-cycle costing; and 5) benchmarking and market testing are significant factors to improve PFI project performance in the construction industry. Overall, the findings of this paper show that PFI projects are no different from non-PFI projects as these issues are critically applicable to all projects. Hence, the practical implication is that practitioners and managers can use the findings to plan and enhance the performance of their projects. Also, it provides guidance on how the network approach can be a potential means to improve the performance of construction projects.

Keywords: collaborative network, project performance, PPP/PFI, project-based organisations, United Kingdom

INTRODUCTION

There has been a wide range of initiatives across the construction industry to improve construction performance but these initiatives are not continuous in the United Kingdom (Smyth, 2010). For example the Department for Children, Schools and

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Families (DCSF), (2010) final report on 'Road to Zero Carbon' found that the major challenges faced to achieve sustainable school projects are: a) that it is technically difficult and costly to achieve as it is difficult to design, construct and maintain efficient buildings and few within the construction industry have practical experience of delivering low carbon buildings; b) the capital costs of achieving zero carbon schools are not accurately established as it is expected to be significant, in excess of £200 per square metre of school using on-site measures; and c) the attitude of occupants must be addressed to achieve project intentions. In a similar vein, based on an impact assessment conducted by the Department for Communities and Local Government, (2009) the technical difficulty and costs implication of zero carbon emission was equally acknowledged.

On the other hand, the performance of PPP/PFI has been investigated based on diverse projects in the United Kingdom. These reports present different project performance outcomes that suggest more research is needed to improve the delivery process to enable cost effectiveness and value creation. For instance the NAO (2010) investigated the performance and management of hospital PFI contracts in the United Kingdom. The findings suggest that most contracts are performing satisfactorily or better and meeting the expectations of the Trusts. But, the Capital Review conducted by Sebastian James (2011) on Building Schools for the Future projects suggest that 1) the design and procurement process for the BSF programme was not designed to create either high or consistent quality or low cost; 2) lack of good quality data on the condition of the BSF estate to control the lifetime cost of the schools built. The findings are contrary to the benefits suggested using PFI approach. A recent investigation conducted in healthcare PPPs around the globe indicated that spending on healthcare is growing at a pace that is likely to be unsustainable unless new funding sources are found (PricewaterhouseCoopers, 2010) and appropriate means to improve construction project performance because it is a perennial problem to construction professionals and researchers (Love *et al.* 2011).

The central point of departure for this paper is that although varied factors to improve PPP/PFI project performance has been identified in the literature, project-based organisations are limited by the short term focus of participating organisations to engage in long-term collaborative relationships to devise means to improve project performance. The paper proposes the network perspective as means to encourage knowledge sharing, innovation and cooperation to enable cost effectiveness and value creation.

Key issues from the literature on project performance

As suggested by Cooke-Davies, (2002) to determine the factors that are critical to project success depends on answering three separate questions: a) what factors lead to project management success; b) what factors lead to successful project; and c) what factors lead to consistent successful projects. An earlier study conducted by HM Treasury (1999) titled "Achieving Excellence" recommended that: a) construction supply chain integration and b) partnering could be used by construction organisations as means to improve the construction industry performance. Subsequently, "Building down Barriers" was launched to assess and demonstrate the benefits of supply chain integration. Nicolini *et al.* (2001) suggested the clustering of project functions with greatest independences and information processing as an organisational approach to construction supply chain integration. To improve value, eliminate inefficiencies, and reduce costs on projects.

Also, OGC (2003) conducted a study titled "Building on Success" initiative that identified key areas in construction to achieve success as: a) integration of construction supply chain, b) managerial skills, c) measurement of performance benefits, and d) standardisation of standard practices as key areas to achieve success in construction.

On the other hand, recent researches conducted have suggested varied means to improve project performance. Doloi, (2009) suggested that having individuals and project-based organisations with relevant capabilities can influence innovative approaches. In view of the fact that individuals or organisations that have capacity to identify and acquire new knowledge, assimilate and interpret information can exploit opportunities (Gluch *et al.* 2009) to develop sustainable products and processes to improve project performance.

Lam and Wong, (2009) using a questionnaire survey in Hong Kong, found that construction time performance has strong positive correlations with buildability in the a) design of external wall elements, b) simplicity of assembly and c) installation while other design attributes affect cost, quality and safety performances at diverge degrees. It suggests that to improve building project performance depends on how individuals or organisations can interpret clearly project design for buildability.

Wubbenhorst (1986) found that to reduce the total costs of a project or system it is essential to pay attention to the downstream costs of the system of which a typical way is to create systems with improved maintainability. But, the study conducted by Swaffield and McDonald (2008) that seek the opinions of quantity surveyors working for design and construction contractors regarding the application of life cycle costing principles in PFI projects found that quantity surveyors did not consider life cycle costs when procuring products. The practical implication is that the lack of consideration for life cycle costing means that facilities management contractors' are likely to face major financial risk in increased maintenance costs.

In addition, other studies have suggested the use of appropriate financing methods to ensure that value for money is achieved and to understand the main treats to a PFI project and mitigate them accordingly. Hellowell and Pollock, (2009) found that PFI funding of capital investment is highly problematic and highly costly. In addressing this, PFI practitioners are encouraged to benchmark and market test to monitor their PFI projects, as needs may be driven by policy, legislative or budgetary changes or operational requirements (OGC, 2007). On the other hand, Edkins *et al.* (2011) conducted an empirical study of on-going facility related operational expenditures of renewed comprehensive schools within England. The findings suggested that total facility services costs in PFI schools are higher. It implies that more needs to be done to improve the whole life costs of future PFI projects.

Furthermore, for the most part PPP/PFI projects are large and complex that it can affect the broader performance of the contractual relationships involved. Smyth and Edkins, (2007) point out that in the United Kingdom the public sector is weak to consistently manage interface with the private sector in ways that stimulate collaborative relationship in the management of PPP/PFI projects. The implication here is that relationship management can play a significant role to achieve successful PFI project. Nevertheless, since project-based organisations are companies temporarily established to specifically implement projects that are embodied with uniqueness, uncertainty and complexity and where time and budget are crucial factors (Ajmal and Koskinen, 2008), it may be difficult to implement these key issues

identified in the literature to improve project performance as the focus of most participating project-based organisations are often short-term. To address this problem, project-based organisations can embed themselves in networks of learning.

RESEARCH METHODS

Information sharing to support the benchmarking of project performance and effective ways of working to drive efficiencies are cited by the National Audit Office (2010) to improve PFI performance. Hence, questionnaire survey and case studies in on-going projects were considered appropriate to obtain the views of a large number of practitioners working within project-based environments in the context of PFI to identify the significant factors to improve project performance. The questionnaire survey was informed by literature reviews to provide insight on critical factors to improve project performance. Respondents are PFI managers, PFI directors, associates, partners and project managers working in both the public and private sectors. A total of 66 usable questionnaires were obtained. This represents a response rate of about 33 per cent. Factor analysis technique was chosen to capture/classify cluster of relationships within the variables through the help of Statistical Package for Social Software (SPSS).

Qualitative data was necessary in order to substantiate the analysed results obtained from the questionnaire survey. Hence, semi-structured interviews were conducted with the main project-based partners working for three separate consortiums in Leeds, Manchester and Blackburn with Darwen responsible for the delivery of three different BSF schemes in the United Kingdom. Interviewees are: a) the project clients, b) construction firms and c) project financiers. Overall, seven senior executives were interviewed and each interview took approximately one hour.

Questionnaire survey findings

The paper identified eight (8) essential factors to improve project performance from the literature. Table 1 shows PPP/PFI practitioners' views of the factors to significantly improve PPP/PFI project performance. The perspectives of respondents were obtained using a ‘likert style rating’ questions based on three-point scale. The scale intervals are interpreted as: a) not significant b) Moderately significant and c) very significant. The views of respondents on each variable were ranked according to their degree of significance between public and private sectors practitioners which the authors referred to as category ranking. Table 2 shows the factor loading after extraction and rotation. Factor loadings with an absolute value greater than 0.5 was interpreted and Kaiser-Meyer-Olkin measure verified the sampling adequacy for the analysis, KMO = .568. According to Kaiser (1974) the measure is satisfactory for factor analysis, and all KMO values for individual items > .522, which is well above the acceptable limit of .5 (Field, 2009). Barlett’s test of sphericity tests is 28.28 and the associated significant level is $p < 0.00001$. This indicated that correlations between the variables were sufficiently large for factor analysis. Three factors groupings are interpreted as: Factor 1) Clarity in project design - includes a) clarity in project design for buildability, and b) ability to reduce construction and development risks; Factor 2) Benchmarking and market testing; and Factor 3) Life-cycle costing. Following the factor extraction, four variables were not part of the factors grouping. A likely reason is that, as a rule during the process of conducting factor extraction the shared variance of a variable is partitioned from its unique variance and error variance to reveal the underlying factor structure; only shared variance appears in the solution. In the case of principal component analysis, it does not discriminate between shared and unique

variance which can produce inflated values. Factor analysis avoids the inflation of estimates of variance accounted for (Costello and Osborne, 2005).

Table 1 Respondents' ratings of factors to improve project performance

Factors	Private Sector respondents Severity Index	Public sector respondents Severity Index	Category Ranking (Private Sector)	Category Ranking (Public Sector)
Relevant human resource expertise	83.33%	92.75%	6	2
Clarity in project design for buildability	92.86%	97.10%	1	1
Appropriate project financing method	86.51%	92.42%	4	3
Risk/reward sharing mechanisms	80.95%	84.72%	7	6.5
Better understanding of project external factors such as government policies/market treats/public opinion	72.22%	80.56%	8	8
Experienced PPP/PFI practitioners/consultants	87.30%	90.28%	3	4.5
Life-cycle costing	84.55%	90.28%	5	4.5
Ability to reduce construction and development risks	88.10%	84.72%	2	6.5

Table 2 Rotated Factor Matrix for factors to influence project performance

Factor label	**Influential Factors**	**Code**	**Factor loading**
Factor 1: Clarity in project design	Clarity in project design for buildability	CTQ1bDS	0.549
	Ability to reduce construction and development risks	CTQ1hDS	0.528
Factor 2: Benchmarking and market testing	Better understanding of project external factors such as market treats, government polices	CTQ1eDS	0.634
Factor 3: Life-cycle costing	Life-cycle costing	CTQ1gDS	0.987

CASE STUDIES ANALYSIS

According to Patton (2002) 'there are no rules for sample size in qualitative inquiry it depends on what you want to know, what will be useful, what will have credibility, and what can be done with available time and resources' (p.244). Below is a summary

of the outcomes of the various interviews conducted: First and foremost, collaborative working was highlighted as a significant factor that contributed to the successful delivery of the school projects investigated. However, the co-location of the various teams was identified to play a significant role in enhancing project partners' cooperative behaviour.

Second, both the BSF project clients and project-based organisations stressed the significance of clarity in project designs seeing that construction organisations delivered the buildings to the vision of the schools. As most school Heads are not skilled in construction and project management practices. It was found that the consistent interaction between all project partners assisted in the development of project designs that enabled buildability.

Third, all the interviewees acknowledged that the school designs demonstrated the integration of whole life costing principle such as the selection of building materials for better building maintenance. Although, one of the BSF clients raised concern in the high costs involved maintaining the school facilities. Four, the interview analysis suggested that the BSF project consortiums are measuring project success on the PFI projects in terms of time and cost. However, with the current recession records kept may not be relied upon as no two schools are identical. From respondents' perspectives, there are significant benefits to be derived when project-based organisations embed themselves in networks to learn and develop sustainable products to improve construction performance.

DISCUSSION OF FINDINGS

Concerning the significance of collaborative relationships in construction project performance, Leverick and Littler (1993) found that collaborative arrangements can be useful means to reduce development and construction risks in projects. To achieve this, the trust and commitment of partners should be continually maintained to enable joint learning (Davies and Love, 2011) and knowledge sharing to improve project performance. However, this paper found that collaborative networks can play a more significant role in integrating project partners' capabilities to construct sustainable projects. The implication for project-based organisations working within the PFI contractual framework is that their embeddness in networks of learning can facilitate the transformation of their project knowledge to develop innovative architectural designs that takes into consideration whole-life costing.

Also, from respondents' perspectives, the ability to understand and evaluate project external factors such as government policies and market treats is crucial. Since better understanding of treats to a project can be significant to reduce project costs and time. Market treats relates to the unpredictability of actual unit prices. For example, a shift in the price of materials during project development and operation has the tendency to increase project costs and delay project completion unless contracts or guarantees are signed to guard against rising costs.

The first government’s policy, concerning PFI is set out in the Treasury Taskforce (1998) ‘Partnerships for Prosperity’ report. The report suggested areas of importance in the adoption of PFI such as clear and measurable output performance or specification, scope for innovation, and risk transfer. Middleton (2001) indicated that the cost of financing PFI projects between 1997 and 2001 reduced to the public sector clients because of better understanding of PPP/PFI working process. In a similar vein, NAO (2009a) demonstrated that construction firms involved in BSF schools, can

reduce costs and prices through the use of benchmarking tools. The purpose is to ensure that prices remain economical. The inference here is that project-based organisations (PBO's) that are skilled at project evaluation using benchmarking and market testing tools can be successful at delivering successful projects. But, it is worth emphasizing that the short-term focus of PBO's makes it impossible to maintain clean data on project performances. Hence, it is crucial for PBO's to embed themselves in networks to share vital knowledge and experiences.

However, there are still shortfalls across government establishments for commercial skills needed to deliver projects according to NAO (2009b) report titled 'Commercial skills for complex government projects'. The report also confirmed that value for money has often been compromised by a lack of commercial skills and experiences. A possible solution mentioned in the literature of PPP/PFI is to retain and recycle expertise within the public sector. Overall, the implication of the findings from the studies conducted suggests that project-based organisations need to focus their effort in facilitating cross-organisational learning and continuous knowledge and experience transfer between projects to encourage sustainable project designs. Also, it suggests the importance of integrating life-cycle costing concepts in project designs to improve project buildability and maintainability to reduce project delivery time and costs.

Implication of collaborative networks on project performance

The embeddedness of project-based organisations in networks of learning can result to the development of new processes, patterns and practices in construction management to improve project performance. Partnering and alliancing has been extensively researched as a means to improve the performance of construction projects. To date research on partnering initiatives are mix with divergent outcomes which may suggest that the main contribution of partnering might lie in its intangible effects, such as creating better working environment (Nyström, 2008). The pursuit of long-term collaborative relationship between PBO's can be a significant approach to stimulate innovation to improve project performance in the construction industry. Gambatese and Hallowell, (2011) suggested that better communication among project teams, better integration of varied disciplines, development of effective processes and sharing lessons learned are critical to enhancing innovation in construction. But, failure to transfer and integrate knowledge within organisational boundaries or along construction supply chain may impair project performance (Leseure and Brookes, 2004) as well as not having the required capabilities.

In view of the fact that, innovation and knowledge management practices have been acknowledged to be important components to improve the construction industry's performance. This paper opinion is that taking a network approach can play a significant role in this direction to encourage project-based organisations to focus their capabilities on specific performance outcomes through knowledge sharing. Networks provides entry to project-based organisations or construction organisations to fields in which relevant knowledge resides or is widely distributed and not easily produced inside the boundaries of an organisation or acquired through market transaction. "A network serves as a locus of innovation because it provides timely access to knowledge and resources that are otherwise unavailable, while also testing internal expertise and learning capabilities" (Powell *et al.*1996:119).

It is crucial that diversity is encouraged in networks formed to attract specialist knowledge across the construction industry and outside the industry to exploit opportunities to develop sustainable products. The intent of a network should

determine relationships that need to be maintained. Potentially, networks can also act as a channel to collect project performance data for analysis to address specific construction issues. Fig 1 presents a typical collaborative network. The network includes likely practitioners or organisations that should be involved to effect change in the industry. Overall, the inference here is that embracing the network perspective can be a significant means for project-based organisations to learn, innovate and disseminate new knowledge.

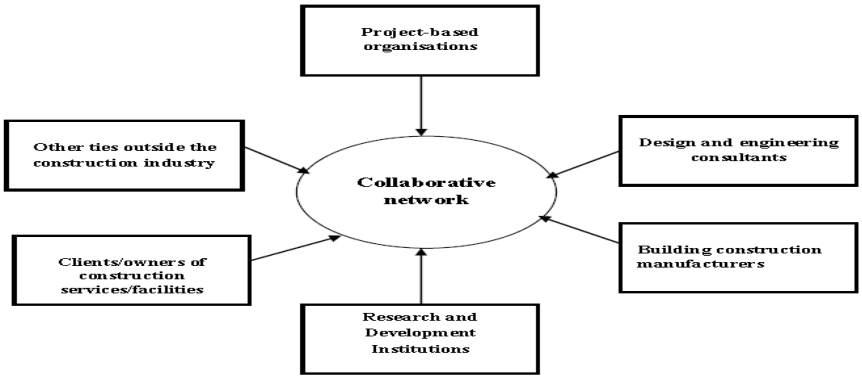

Fig 1 network of relationships between different construction practitioners

IMPLEMENTATION AND CONCLUSION

Looking at the vast scope of literature on how to improve project performance, practitioners and academia should be able to draw upon considerable knowledge on how to address poor performance that has continually confronted project-based organisations in the PPP/PFI market. Evidence informed by literature reviews on construction project performance still suggest that costs over-run, delays and high maintenance costs are key problems to construction practitioners. The introduction of new management tools and techniques from more technologically advanced industries has not changed or resolved this problem (Love *et al.* 2011). Nevertheless, a number of conclusions could be drawn from this paper with significant academic and practical implications in the construction industry.

From a practical perspective, there is an opportunity for project-based organisations to embed themselves in networks of learning to support their projects. The case studies investigated demonstrated that long-term collaborative relationships are needed to develop sustainable approaches to improve project performance. Overall, the studies conducted demonstrated that if project-based organisations need to improve project performance it is required to emphasis more on the identified key factors: 1) collaborative networks; 2) sustainable construction products; 3) clarity in project design for buildability; 4) life-cycle costing; and 5) benchmarking and market testing. The findings and recommendation presented here are applicable to the whole industry and not just PPP/PFI projects. It implies that regardless whether one is involved in PPP/PFI projects or not these issues are critically important which makes PPP/PFI projects no different from projects delivered through conventional methods.

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GLITCHES, SNAGS AND CRISES: A STUDY OF CHANGE IN HOSPITAL ADAPTATION PROJECTS

Pamela M. Garthwaite[1] and Claudia Eckert[2]

Faculty of Mathematics, Computing and Technology, Open University, Milton Keynes MK7 6AA.

Design and programme changes during refurbishment projects remain a considerable cause of concern for UK National Health Service (NHS) Estates managers, due to their potential to disrupt or delay projects and increase cost uncertainty. Similar concerns also impact on the engineering sector, especially in the production of complex, highly engineered products. The techniques developed to study and manage engineering change may have positive benefits for construction. This research looks at the mechanisms of change that operate in refurbishment projects with the aim of identifying commonalities with engineering change. Hence, the research adopts an engineering approach to change and evaluates three very different NHS refurbishment projects, to explore change events and identify options for limiting the consequences of change. The projects chosen for this study were markedly different, with specific drivers, procurement methods, contracts and building systems. One project concerned the construction of a factory-fabricated, modular extension to a UK hospital, whilst a second entailed a "state of the art" refurbishment of an existing neo-natal unit. A third project involved a heavily constrained ward refurbishment. Factors which influenced the level and complexity of change frequently resulted from the lack of accurate information at crucial stages, particularly related to the existing building structure and condition. However, the necessary changes followed very different trajectories. This study forms part of a much larger investigation which aims to develop sustainable adaptations for hospital buildings in response to the changing climate.

Keywords: change propagation, refurbishment, hospitals, constraints, engineering.

INTRODUCTION

The issue of project change has been highlighted as a major cause of delay and cost escalation (Buratti *et al.* 1992; Love and Li 2000; Olawale and Sun 2010, etc). The aim of this research is to investigate the problems associated with changes made during refurbishment projects. In engineering, the development of highly complex products presents similar change issues and the techniques that have been developed to understand, predict and manage the consequences of engineering change may have significant application for construction. A key concern is the risk of a change in one project area proliferating and hence, requiring further widespread changes across the project. This expansion of change is known as "change propagation".

[1] p.m.garthwaite@open.ac.uk; [2]c.m.eckert@open.ac.uk

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Change Propagation

Change propagation can be described as a cascade of unplanned changes that result from a necessary change (Eckert *et al.* 2004). For example, the late discovery of a structural problem during a refurbishment project may entail additional changes to floor plans; increased structural support; revision of designs including Mechanical & Electrical systems (M&E); circulation; fire-safety and surveillance systems; in addition to sustainability concerns. The problem may be compounded by the need for revised project documentation, additional costing and the need to renegotiate contracts with sub-contractors. Still further effects may include delays to schedules and the depletion of float-time, reducing project resilience. Hence, a single change can result in the need for further significant changes, which can propagate widely across the project. The increased volume of change is a significant problem both for construction and engineering projects. By exploring patterns of change propagation it may be possible to develop a deeper insight into the process of change and how changes spread from anticipated or planned areas to other unintended areas. This research will contribute to the development of a tool, designed to assist decision makers in identifying the consequences of change. Two detailed but very different case studies are examined here to explore the range of change patterns that occur. A third study has been included to validate the methodology adopted. This research does not attempt to compare the benefits of one system over another, but highlights that change issues can emerge regardless of the construction system and that an understanding of the change process will improve the prediction and management of such change.

LITERATURE REVIEW

Research by Sun *et al.* (2006) highlighted the ad hoc way changes are managed during construction projects and presented a toolkit comprising of a change dependency framework; a change prediction tool; a workflow tool; and a knowledge management guide, to assist decision-makers in coping with changes. They developed an integrated system which related project characteristics, initial causes and major effects and this clear linking of the multiple context-related factors to a change effect, significantly developed the understanding of the change process in construction. Analysis of very similar change problems had been taking place in Product Engineering research (Eckert 2004). The engineering approach, rather than trying to link the multiple causes and constraints to individual change events, instead sought to locate individual change events within pathways or sequences of connected changes that resulted from a common cause. In consequence, the engineering change process has been closely modelled; change propagation pathways identified; and the risk of change propagation has been quantified and analysed (Jarrett *et al.* 2011, provides a comprehensive review). Research in engineering has also been directed towards investigating how changes flow across a system (Eckert *et al.* 2004). They documented a range of "mechanisms" involved in change propagation (see Table 1.).

Table 1. Change Mechanisms

Mechanism	Effect	Example
Change "multipliers"	Generate more changes than they absorb.	A change to the position or size of a lift shaft may require many further design and M&E changes.
change "absorbers"	Pass on less change than they receive.	Ensuring adequate float time; or including flexible or multi-purpose spaces in designs.
change "resistors"	Highly connected elements that restrict or reject change.	Changes to the building footprint, legislative requirements, or executive office size.

Looking at change in this way helps to provide an alternative perspective, focusing on both the predictable and the less obvious causes of change. This type of analysis encourages the consideration of options for managing change during a project by including "change absorbers" at appropriate points, or by ensuring that design effort is directed away from "change resistors". Giffin *et al.* (2009) studied 41,500 change requests and identified recurring change patterns or "motifs". These "motifs" helped to identify components that resisted or rejected change, pin-pointed areas of wasted effort, and revealed relationships between successful changes. This has led to improved methods for predicting where problematic or repeated changes will occur.

RESEARCH METHOD

The approach to this research derived from a critical realist perspective, based on the work of Bhaskar (as in Collier 1994). In essence, this view recognises that interpretations of the world may be inconsistent and that there is a consequential requirement to investigate widely, using a range of methods, to relate knowledge as closely as possible to reality. The case studies presented here were undertaken during the course of a larger EPSRC funded project, which has developed low-cost adaptive and sustainable solutions for UK hospital buildings in response to the changing climate. A review of the literature was carried out and selected case studies were investigated. Project teams were invited to take part in semi-structured interviews, either on an individual basis or in groups. The format of interviews differed slightly for each study, depending on the availability of key actors at each site. Notes were taken throughout case-study meetings and compared for consistency. In addition the meetings were recorded and transcribed. A deep "grounded theory" analysis was not attempted owing to the volume of interviews; however the transcripts were evaluated against themes that were identified in an initial post-project review. A framework was then developed to clarify and map the change process in refurbishment projects (see Figure 1). Documentary evidence, in the form of reports, change orders and drawings has been reviewed and the process is ongoing. Two case studies were undertaken and a further study was drawn on, to validate the outcomes.

Analysis Framework

The framework illustrated below was developed to assist in understanding how change may propagate from one area of a project to other connected areas (Fig. 1). Specific strands or project "layers", which encapsulated particular project activities, were identified. These "layers" were organised to connect the range of possible change pathways. This process resulted in the development of an organising framework, which differentiated between project activities, for each of the case-studies. A change can propagate along any of the layers at any time, from project start until handover. A change can also cross between layers and the framework allows this complex

sequence of change to be mapped. The framework also includes external influences or drivers of change, along with the possible consequences to associated systems that extend beyond the project boundary. In this way, the total trajectory of the all changes related to an initiating change can be identified.

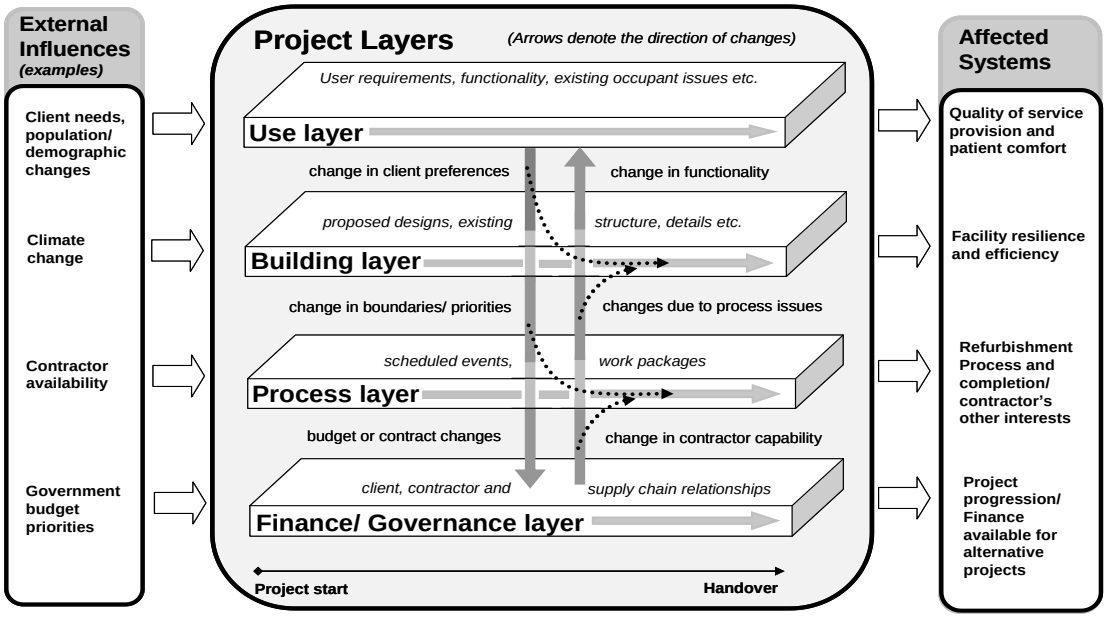


Figure 1. Project layers showing direction of changes (Garthwaite and Eckert 2012)

Case Study 1: The Neo-natal Unit Refurbishment

This case-study followed the refurbishment of a neo-natal unit based on the second and fifth floors of an aging NHS hospital building. The hospital is a Foundation Trust and provides maternity and neo-natal services for a population approaching 300,000 people and delivers 10,000 babies each year, attracting clients from well beyond the catchment area. The hospital had planned a major new-build Private Finance Initiative (PFI) facility but late cancellation meant that the Trust's portfolio of aging existing buildings required a significant level of upgrading.

The neo-natal service was split between two distant sites and this was felt to present the Trust with a high risk situation. Hence, rationalisation to merge the two sites was a high priority. The total value of the project was in the region of £10m and the Trust adopted the relatively new NHS procurement system "P21" to accelerate progress. The requirement to limit disturbance to patients in adjacent wards severely restricted the survey process and there was scant information regarding the condition of the existing structure and services. Although the original plan was to refurbish both floors of the unit, concerns over budget issues limited the project scope and work to the upper floor was postponed until further funding could be secured. The refurbishment of the lower level continued as planned. As part of the P21 process, a post project review was carried out with all parties represented and the authors (as observers) were given access to this critical meeting. Follow-up interviews were arranged with key actors (Table 2) and transcriptions were analysed using themes identified in the post-project review.

Table2. Neo-natal Unit (Case Study 1) Interview Participants

Team	Role	Description	Time (mins)
Client	Client Project Director	Project lead. Liaison with Trust Board	48
	Internal Project Manager	Develop and coordinate Trust projects	103
	Clinical Lead	User group design development lead	31
	Nurse Manager (Matron)	User group design development	55
	Consultant Project Manager	External consultants (procurement)	59
	Cost Advisor	Project cost control	41
	Project Site Supervisor	Site supervision	41
PSCP*	Construction Manager	Strategic support (all projects)	32
	Project Manager	Project planning /liaison	15
	Design Manager	Management of design information	55
	Senior Quantity Surveyor	Cost control and advice	42
	Quantity Surveyor	Cost control and advice	53

**Principal Supply Chain Partner*

Case Study 2: The Modular Extension to Foundation Trust Hospital

This study explores a very successful £10m modular ward extension to an existing hospital building. A key feature of this project was the highly condensed timescale for the work. The pressing need to meet government infection control targets was a key driver for the project, as failure would expose the Trust to penalties in excess of £1m. In addition, the lack of overflow beds for seasonal 'flu patients and the need for decant space made a strong case for an extension to the existing accommodation. In July of 2007, the estates department were tasked with finding a solution which could meet the government reporting deadline of 24th December 2007. The Estates Team posed a challenge to the Trust's selected Framework partners, to work together to achieve what appeared to be an impossible task and surprisingly, the contractors "bought in" to the project with real enthusiasm. The risk register identified planning permission as the most significant early risk factor but in the event, permission was granted within five weeks. Weekly team meetings were programmed and important project meetings were arranged to coincide with Trust Board meetings.

Table 3. Modular Extension (Case Study 2) Interviews

Client Team: Deputy Director of Estates (Project Lead); Assistant Director of Estates (Project Team - Design); Assistant Director of Estates, Policy and Development (Trust Liaison); Director of Estates (Strategic planning).	90 minutes (group session).
Consultant Architect Team: Architect (Design Consultant); Design Specialist (Senior M&E Design); Design Specialist (M&E Design); Structural Specialist (Structural Design)	61 minutes (group)
Consultant Cost Control: Principal Quantity Surveyor (Cost and programme control)	44 minutes
Modular Contractor: Construction Manager (Strategic management); Project manager (Project management)	45minutes (group)

The architects, along with key Project Team members, prepared sketch layouts based on their knowledge of ward operations and hospital design guides. Due to the very

tight timescale, modular construction was felt to be the only option. The design was based on 2 x 24 bed wards on two upper stories. The ground floor of the extension was to be added at a later date. A crucial aspect of the project was the choice of separate contractors for the enabling works and the modular construction. The Trust felt that separate specialist contractors would be better able to use their particular expertise to deliver on time. However, there was no contractual relationship between the contractors and this imposed a degree of risk for the project. Tender documents were prepared, sent out and returned within a few weeks, rather than the usual months. Work often began before formal documentation arrived, due to the level of trust engendered by the client Project Team. The site was very steeply sloping and the enabling works involved the removal of 12,000 cubic metres of earth and the construction of a 4.5m retaining wall. The key date for the critical path of the project was the module delivery date. All other project dates were determined by working back from this date. Problems that emerged related to supporting the crane (required for the placement of the modules) presented a crisis for the project. However, the Project Team hastily found a suitable solution and the 700 tonne crane was delivered on six lorries and assembled in situ. In the event, the placement of the modules was slightly delayed as the wind speed exceeded the maximum 12 mph crane operating conditions for two days.

Case Study 3: The Ward Refurbishment

This study concerned the refurbishment of an oncology ward in a large NHS acute hospital built in the late 1960's. A children's charity presented £2.9m to the Hospital Trust exclusively for the refurbishment of the teenage cancer ward and the Trust contributed £800,000. The donation would provide the trust with the opportunity to group the existing oncology wards together, and in addition, opened up the prospect of rationalising other clinical specialities to improve their connectivity with essential services. A complex sequence of ward decants coupled with additional refurbishment works to accommodate the transferred patients, was set in motion. Hence, for the oncology refurbishment to progress from design to construction, a considerable amount of "enabling" work had to be done. Clearly, this was not enabling work in the traditional sense, however the sequence of decants and refurbishments was essential for the cancer ward refurbishment to proceed (Kagioulou *et al.* 2000). The process was plagued with programme changes resulting from incomplete building information due to the constraints of carrying out surveys in an occupied hospital.

Table 4. Interviews with Case Study 3 participants

Team	Time
Hospital Trust Project Team (Four NHS project managers)	66 minutes (Group session)

The whole process took approximately twelve years and the total cost was in the region of £11-12m. The section of the building identified for the new teenage cancer ward had not been refurbished before and there was a total absence of current information regarding the condition of the structure or services. This resulted in some significant surprises and work was rescheduled accordingly.

PATTERNS OF CHANGE IN CASE STUDY PROJECTS

Each of the case studies showed examples of "within" and "across" layer propagation and each had developed strategies for mitigation. In comparison, engineering change is very highly constrained and few options exist for containing change propagation.

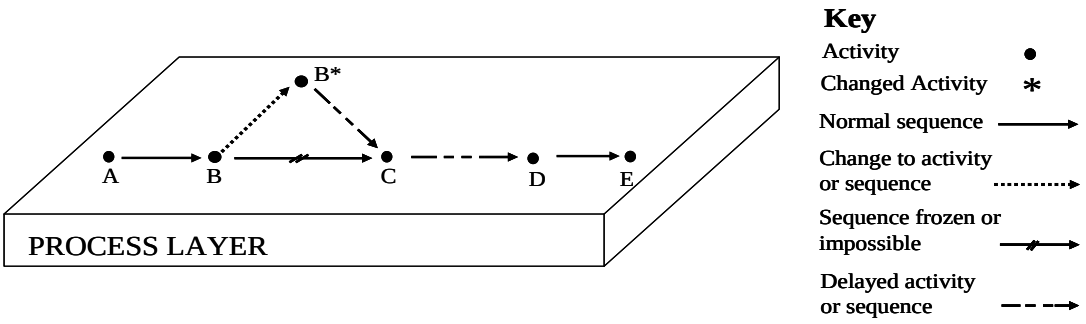


Figure 2. Neo-natal Unit: changes within a layer

Mapping changes across the framework (Figure 1) helped to reveal the patterns of change and the mechanisms that operated. Common problems within a project layer were often mitigated by well understood strategies, typically these included rescheduling a sequence of tasks or the inclusion of additional resources. The need to avoid disturbance to patients in adjoining wards, meant that a comprehensive survey was not possible (Figure 2). The Estates team were aware that asbestos was present, but the extent of the problem was greatly underestimated. Hence, the stripping out of the ward was delayed (activity C) while a second, more thorough asbestos survey was carried out (activity A*) and additional asbestos removed (activity B*). A very similar pattern was observed in the Cancer Ward case study, where again pre-construction survey information was limited. Changes due to the presence asbestos and unexpected details corresponded to the change patterns in the Neo-natal study. Where change patterns were repeated it was possible to identify "motifs" of change (See fig 5a).

Change propagating between adjacent layers

Changes to the Modular Extension project (Figure 3) involved supporting a 700 tonne crane, 2m from the top of a newly erected 4.5m high retaining wall. However, at a very late stage the enabling works sub-contractor intimated that their designers could not provide an adequate support solution (B) for the additional crane loads.

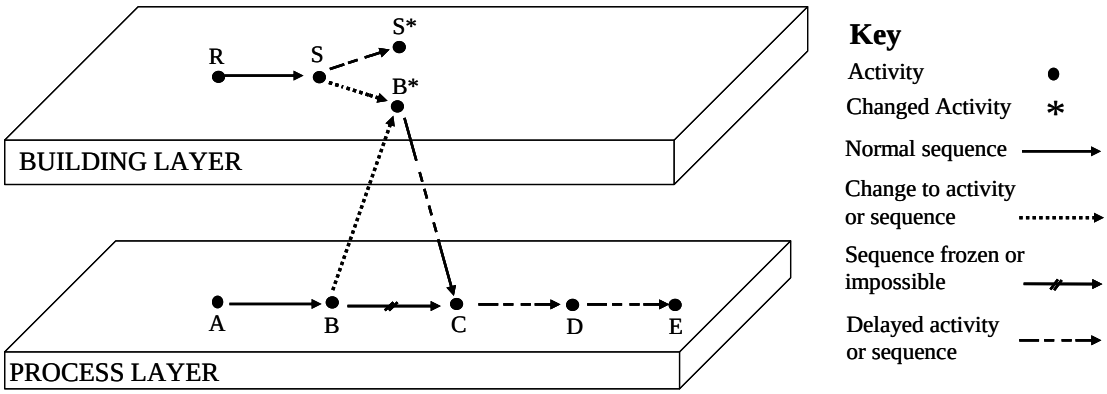


Figure 3. The Modular Extension: changes across layer boundaries

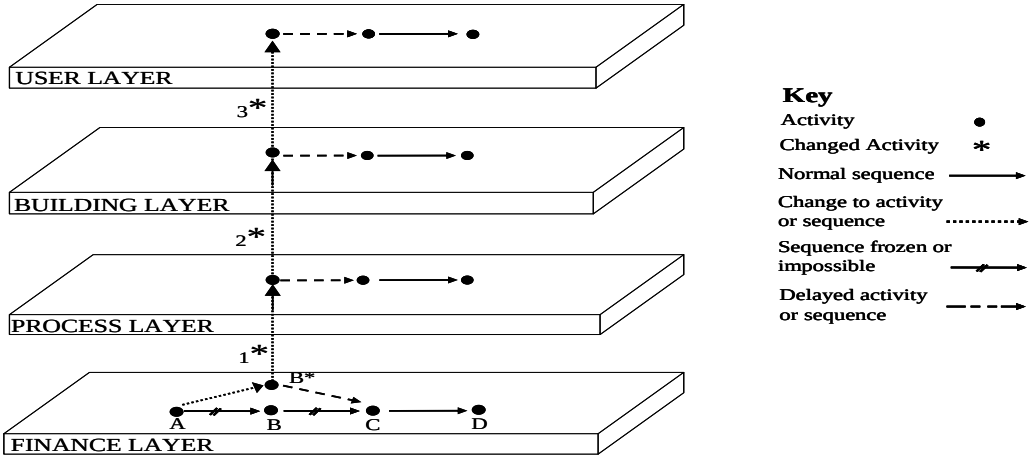
This diverted key team members from other tasks on the Building Layer (S) to provide an additional design support (B*). Hence, the process of constructing the crane

support (C) was delayed. The crane positioning was slightly delayed (D), and severe weather delayed the module placement for two days (E).

Global Change: Change propagating across all layers of the project

Insufficient funding for the Neo-natal Unit (Figure 4) meant that refurbishing both floors of the unit would not be possible and pathway activity (A) could not advance.

Figure 4. Neo-natal Unit change propagation across all layers.



The project was re-scoped to concentrate on the refurbishment of Floor 1 and the change, originating in the Finance layer, propagated to all other project layers. This funding crisis affected the project globally requiring the reorganization of the design process; the project programming and work flow; the contractual arrangements; and ultimately it affected the user's operational processes and aspirations. However, later in the project, charitable funding along with unspent risk mitigation from the work to the lower floor enabled the work to the upper floor to be completed.

Mapping groups of change

Other patterns of change (at various scales) became evident as the individual changes were grouped and mapped. The illustration below (Figure 5) shows a representation of groups of changes or "motifs" similar to those described by Giffin *et al.* (2009) that were observed during the case-study analysis. The changes shown in (A) related to an emergent event: In this case, wild pigeons were found nesting on the Neo-natal site, and under UK legislation (Wildlife and Countryside Act, 1981), the birds could not be disturbed until the young had fledged. The site accommodation could not be installed and delayed the project by three weeks. However, work flows were rescheduled to make up for lost time. The changes in (B) map the processes involved when the water supply system to the Neo-natal unit and to the whole building, was found to be in extremely poor condition. The cast-iron water main had to be replaced and the resultant changes were costly and time consuming and affected all the central areas of the building and propagated to other layers of the project. The severity of the propagation was largely due to the stage at which the problem was identified.

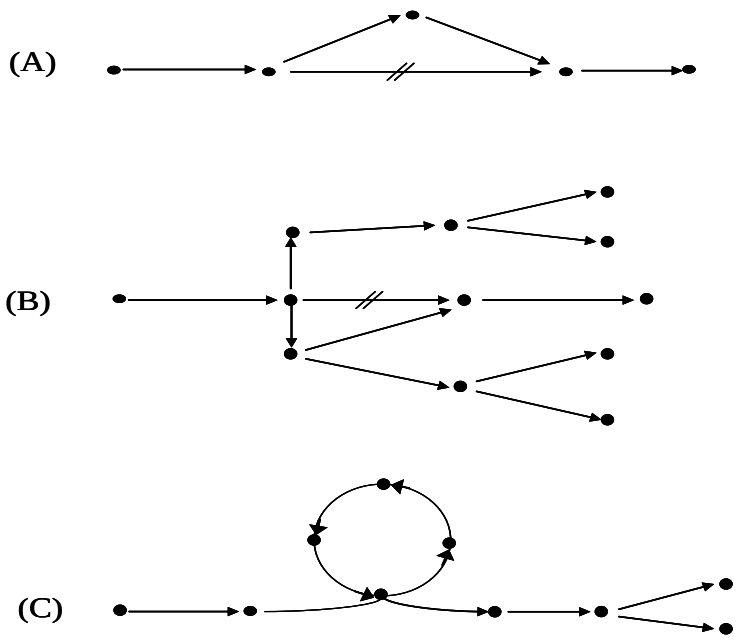


Fig 5. "Motifs" or representations of specific change episodes (note: not time dependant).

If the problem had emerged prior to the agreement of the Guaranteed Maximum Price, the costs would have been included in the contract. Eventually, the extra costs were agreed by the Trust Board, work schedules were reorganised and small but significant layout changes were included. The changes at (C) map the initial ward decant processes and refurbishments for the Teenage Cancer Ward (Table 3).

Table 5. Sequence of events to enable the completion of the Teenage Cancer Ward Project

Decant 1	Level 5 patients (respiratory medicine) relocated elsewhere in the hospital.
Refurbishment 1	Level 5 ward refurbished
Decant 2	Level 9 (transplant) high dependency patients transferred to refurbished Level 5
Refurbishment 2	Level 4 VATC system rearranged and additional showering facilities added to accommodate Level 8 orthopaedic patients
Decant 3	Level 8 patients (orthopaedic) relocated to Level 4 (Short-term)
Refurbishment 3	Level 9 Survey and services work begun (knocking though to Level 8) and Level 9 refurbished
Patient Transfer	Teenage cancer ward opens on Level 9 and final transfer of patients to ward.

To provide a refurbished teenage cancer ward on Level 9, the high dependency transplant patients presently on Level 9, had to be transferred to Level 5. However, this could not occur until Level 5 had been refurbished. The patients occupying level 5 would be relocated elsewhere in the hospital (which involved additional work beyond the scope of the study). Following this transfer, Level 5 was refurbished. The orthopaedic patients on the floor below Level 9 (i.e. on Level 8) would also have to be temporarily transferred to Level 4, to allow essential survey and services work to be done. However, to accommodate the transfer of the orthopaedic patients from Level 8 to Level 4, the Vertical Terminal Air Conditioning (VATC) system on Level 4 would have to be completely refigured, following the installation of additional showers

needed for Level 8 patients. The patient transfers had to be orchestrated with care, and additional funding streams established, hence the extended time-scale for the project.

DISCUSSION AND CONCLUSIONS

From the change patterns identified, what might be considered minor "hitches and glitches" can be surprisingly problematic. The need to replace the aging cast-iron water main for the Neo-natal Unit was originally considered an unexpected hitch and given low priority, but as the extent of the problem became clear, it propagated widely, becoming a significant change multiplier. This led to changes to all layers of the project and involved delays to schedules, layouts and additional costs, which required approval by the Trust Board. Similar costly "glitch" patterns were identified in the Cancer Ward Project, also resulting from the lack of survey information. Conversely, the failure of the sub-contractor to design a crane-support system at a critical point was immediately identified as a serious crisis for the Modular Extension Project. The critical event of placing the modules was directly dependant on the crane being in place and adequately supported. In consequence, this challenge galvanised key decision makers and a solution was promptly identified, absorbing the possible propagation effects that might have developed. A similar high-level intervention was observed as the Neo-natal funding crisis developed. Senior decision makers reduced the scope of the project and although change propagated widely, it did not get out of hand. This was because the strategies that were adopted to reduce the pressure on the project and increase tolerances, functioned as absorbers of further change. The pattern of decants and refurbishments required for the Teenage Cancer Ward to progress was particularly interesting. The changes propagating from the charitable donation of £2.9m resulted in the Trust spending £11 - £12m on a project that spanned 12 years. However, the project funding allowed the Trust to achieve other connected goals during the process and forwarded the Trusts rationalisation plans and the general refurbishment needs of the building. From the interview evidence, it appears that changes within the framework layers, tended to be less problematic than changes that escaped to other layers. This is not surprising because the tolerances and strategies designed to manage expected change within each layer are usually well understood. Propagation beyond layer boundaries may be more complex or untimely, with fewer options for mitigation, as these types of changes tended to be less predictable. However further research will be directed towards improved understanding and prediction for these "change pathway" risks. Towards the later stages of a project, tolerances or buffers may be exhausted and change may be difficult or impossible within the existing budget or time frame. The situation in product engineering is somewhat different. Changes are extremely constrained, often by the product volume restrictions or by other factors, such as vibration effects, overheating, electrical connections etc. so that changes are frequently refused and no option for change exists. From the case-studies, situations were very rarely encountered where a solution of some form could not be achieved and construction change appears considerably more malleable than engineering change and follows quite different trajectories. Further work will consider the effects of constraints on the change process and how, by varying the constraints, the probability of serious propagation may be reduced.

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EVALUATION OF KEY METRICS FOR MEASUREMENT OF PROJECT PERFORMANCE

Saleh Alsulamy[1], Sam Wamuziri[2] and Mark Taylor[3]

School of Engineering and the Built Environment, Edinburgh Napier University, Edinburgh EH10 5DT, UK

In the construction industry particularly in developing countries, minimal attention has been given to the application of Performance Measurement Systems [PMS], despite being one of the most important factors for assessment of project success. Consequently, there appears to be always a gap between actual results obtained in relation to delivery of major projects and stakeholder expectations. The application of performance measurement systems in the construction sector has tended to rely on three basic criteria: time, cost and quality, which can be applied to determine the extent of project success. At organisational level, performance measurement systems are largely based on financial measures which are almost always lagging indicators. In response to the Egan Report, the UK construction industry developed specific Key Performance Indicators (KPIs) which include construction cost and time, cost predictability and time predictability, defects, client product and service satisfaction, safety, profitability and productivity. The primary aim of this paper is to evaluate the main project and organisational performance metrics including financial and non-financial measures that have been developed in recent years. Lagging indicators focus on past data and offer little or no opportunity for process improvement. Previous research indicates that credible performance metrics should consider all construction project stages alongside stakeholder needs and expectations. In this work, the fundamental requirements for suitable performance metrics are identified. Finally, it is concluded that the shortcomings of current performance measures utilised by the construction industry can be considered as marketing tools as opposed to tools for process improvement.

Keywords: performance measures, performance metrics, performance measurement systems, construction projects, project performance.

INTRODUCTION

The construction industry is an important contributor to the economy despite its unstable nature and uncertain performance (Chan and Chan, 2004). Many previous studies have concluded that poor performance of industry was related to traditional thinking focussing on product and goals only. Realizing the same, the performance measurement focus has been shifted from product-orientation to process-based measurement systems (Haponava and Al-Jibouri, 2010). However, developing such

[1] s.alsulamy@napier.ac.uk
[2] s.wamuziri@napier.ac.uk
[3] m.taylor@napier.ac.uk

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systems would require setting the measurable targets and performance indicators throughout project life and across various stakeholders. To achieve the stated goals of efficiency and quality in construction projects, the very concept of performance measurement must be reconsidered (Egan, 1998). This paper describes the performance measurement practices at project, organization and stakeholders' levels followed by critical valuation of various performance measurement models. After highlighting the limitations of current approaches, a new approach has been introduced based on critical success factors and their measurement across projects stages and various stakeholders.

PMS AT PROJECT LEVEL

Performance measurement as a concept can be traced back to 1970s when financial indicators (lagging indicators) were first applied in the accounting sector (Nudurupati *et al.* 2007). In 1973, the traditional performance measurement system was created by Teague and Eilon for three purposes, namely; (a) to achieve goals; (b) to assess, improve and control processes; and (c) to benchmark the performance (Sapri and Pitt, 2005). However, in the 1990s there was a change in the purpose of measuring the performance towards meeting customer satisfaction and quality (Neely *et al.* 2003). Since then, many systems and frameworks have emerged and developed to include non-financial indicators (subjective indicators) such as quality, customer satisfaction and innovation in these systems. On overall basis, the concept of PMS has been improved in three generations; the first generation designed the measures from financial dimensions only; the second generation considered strategies and success factors and deployed them in the process while the third generation linked the financial and non-financial dimensions to the concept of cash flow (Neely *et al.* 2003).

PMS AT ORGANIZATIONAL LEVEL

Performance measurement was applied in local government organizations during early 1980s for 'improving the efficiency and effectiveness of managers and the organization'. Key performance measures included productivity, effectiveness, efficiency, and quality of delivered service reflecting the organisations' aim, environment and priorities (Ghobadian and Ashworth, 1994).

Kagioglou *et al.* (2001) has likened to view such PMS as the data system used to refine various processes in line with organisation's long-term goals. However, Kennerley *et al.* (2002) has suggested that measurement systems must evolve to avert measurement crises. They identified 'process, people, infrastructure and culture' as the main factors affecting the evolution of measurement systems. In line with the evolutionary school of thought, Amaratunga and Baldry (2002) emphasized that PMS should have the capability to: (1) report changes in organisations' external and internal environments; (2) review and redefine the priorities in lieu of changes; (3) update objectives and translate them to key areas in organization; and (4) maintain and improve the deliverables regularly. Hence, performance measurement at organizational level must answer three key questions: 'How well is an organization performing? Is the organization achieving its objectives? How much has the organization improved from a last period?'(Phusavat *et al.* 2009).

PMS AT STAKEHOLDER LEVEL

Construction project success is influenced by a set of factors, for instance project attributes such as size, cost, environment and other, contract and specifications, the relationship and cooperation between stakeholders, qualification of engineers and

teamwork (Cheung *et al.* 2004). As such, there can be two perspectives of PMS: i.e. macro, which considers the overall all project progresses across phases; and micro, which focuses on results of each project phases treating stakeholders and participants as owners and users (Lim and Mohamed, 1999).

From a micro perspective, a construction project is a group of activities involving a number of participants seeking to achieve their objectives within the overall project objectives. Such stakeholders are owners, contractors, consultants, designers, mangers, investors, users, suppliers and sub-contractors (Saqib *et al.* 2008). From their point of view, Performance measurement is *''the measurement and monitoring of the project's performance under the criteria defined by the stakeholders as representative of the project performance dimensions''* (Barclay and Osei-Bryson, 2010). Of these stakeholders, the managers are involved at the key stages of project execution and therefore attain a central position. Beathem *et al.* (2004) has identified seven reasons for performance measurement to be added to the manager's list of priorities, i.e. 1) the dynamic nature of work, 2) increasing competition, 3) specific improvement initiatives, 4) national and global quality awards, 5) changing organizational roles, 6) more enlightened consumers and 7) increased use of information technology in construction industry.

KEY PERFORMANCE MEASUREMENT MODELS

The Balanced Scorecard (BSC)

The balanced scorecard was designed in 1992 by Kaplan and Norton as a new method to measure the performance of organizations through four dimensions of financial, customer, business process, and innovation (leading indicators) with focus on financial measures (lagging indicators). This focus on lagging indicators is the key weaknesses of BSC responsible for many problems in its application in the field. Letza (1996) has stated that this method must be integrated with the participants' goals and general strategies, for affective measurement.

European Foundation Quality Management (EFQM)

EFQM business excellence model was formulated by European Foundation of Quality Management in 1989. Its primary focus remains on the results deemed as project success criteria, while organizational characteristics are taken within the critical success factors (Westerveld, 2003). The EFQM model uses nine fundamental concepts of excellence based on the continuous improvement. These are results orientation, people development and involvement, customer focus, continuous learning, innovation and improvement, leadership and constancy of purpose, partnership development, management by process and facts, and public responsibility (Beatham *et al.* 2004).

Malcolm Baldridge Criteria for Performance Excellence (MBNQA)

The Baldridge Award criteria were designed during the 1980s in USA by Public Law to improve organisational competitiveness. It focuses on the outcomes of customer satisfaction and organisation performance in six dimensions of leadership, information and analysis, strategic planning, human resource, quality of products and deliverable service, business results and customer satisfaction (Jacob *et al.* 2004). Traditionally, MBNQA gave more attention to leadership and customer satisfaction; however, there has been a shift towards quality and operational results in recent years (Hodgetts *et al.* 1999). Other weaknesses in the Malcolm Award include high cost in time and money with financial measures also deemed to be poor (Jacob *et al.* 2004).

Key Performance Indicators (KPIs)

The first usage to KPIs was in 1961 in the companies by D. Ronald Daniel to achieve business strategy. The performance measurement indicators theory is driven from the concept of benchmarking (Haponava and Al-Jibouri, 2009). 38 KPIs have been established and improved by government represented in the Movement for Innovation and the Construction Best Practice Programme (CBPP) for the purpose of performance measurement (Egan, 1998). KPIs assess the performance of activities deemed as critical success factors to gain desired organisation goals. The process starts with measurement and then benchmarking to gain information for decision-making related to improvements (Enoma and Allen, 2007). Despite the fact that KPIs have been extensively investigated in research, there are some obstacles such as reservations towards providing financial data, weaknesses in the accuracy of recording accidents and the manner of profit calculation which becomes more complicated in government projects due to the emphasis on supply of services (Chan and Chan, 2004).

CRITICAL EVALUATION OF PMS

The performance measures can be classified into three categories: financial and non-financial, soft and hard, and process and output parameter measures. Historically, financial measures have been the most widely used performance measure (Gautreau and Kleiner, 2001), and net profit and investment reward, time and quality have been the main stay of performance measurement in UK: However, in the current school of thought, the old "hard" measures are combined with the "soft" measures which gives a quality dimension to performance. *''Hard measures are those which are quantifiable, such as profit and market share, while soft measures include innovation and flexibility''* (Ingram, 1996). The process approach considers the measurement as an organized technique to evaluate performance by *''evaluating the inputs, outputs and final project outcomes''* (Ankrah and Proverbs, 2005).

In majority of construction projects, performance is measured through financial indicators. Despite their usefulness, they are considered lagging indicators focused on the past events. Further weaknesses include poor strategy, lack of information on environment, cooperation between partners and quality (Cheung *et al.* 2004). To overcome these weaknesses, two distinct attempts were launched in both Australia and the United Kingdom (Cheung *et al.* 2004).

In Australia, Project Performance Evaluation (PPE) framework has been introduced by New South Wales Public Works Department. It is designed to include a variety of conventional performance indicators such as time, cost, quality, safety, contractual and environment while covering new subjective parameters of communication and dispute resolution. In UK, Construction Industry Best Practice Programme came up with KPIs as measurement instruments, implemented in three main steps: identifying what should be measured, data gathering and calculation and analysis of KPIs result. In addition to both, Project Performance Monitoring System (PPMS) has been built on the basis of KPIs and PPE measures consisting of eight groups of performance measures, i.e. people, communication, time, cost, quality, environment, client satisfaction and health & safety (Cheung *et al.* 2004).

LIMITATION OF CURRENT PMS

Traditional measures have been applied to measure financial aspects such as profit and turnover, and thus they are appropriate to businesses. Despite their importance in

strengthening the financial aspects, they do not raise the level of competition and technology. Moreover, they have been criticized for encouraging short-term goals, focusing on minimisation of conflict rather than continuous improvement and being internal focused.

In terms of PMS application, lack of information and insufficient training on how to use them remain the major barriers (Costa *et al.* 2004) whereas Neely *et al.* (2000) identified three obstacles, i.e. non-acceptance of performance measurement, computerised problems and weak commitment of senior managers. In line with their findings, Bracegirdle (2003) has also opined that resistance towards the acceptance and application of PMS from the managers was a vital factor. Pollanen (2005) has taken a broader view and identified four categories of obstacles which prevent performance measurement's acceptance and execution. These are 1) institutional, such as resistance to transparency; 2) technical, for example, lack of specifications and standard; 3) financial, for instance, significant investment of resources and time, and 4) pragmatic, such as insufficient convenience and reliability. The use of performance measurement is thus limited as a consequence of difficulties in measurement, long duration and costly expenditures being needed, and difficulties created in the process of performance measurement by being an inherently project-directed business (Ankrah and Proverbs, 2005).

According to Nudurupati *et al.* (2007) the key restrictions for PMS in the construction industry are resource allocation, record and storage of data and information, and the logistics. Construction projects in both public and private sectors have been facing challenges and obstacles as performance has not been measured due to the lack of methods and approaches to discover the strengths and weaknesses (Luu *et al.* 2008). Other significant potential sources of problems that hinder the construction projects are the lack of consensus on defining the concept of the project success among stakeholders before beginning of the project, thus do not achieve desired goals, accordingly, critical success factors and success criteria must be determined at pre-project phase (Lim and Mohamed, 1999).

To sum up, the challenges of execution and improvement of PMS can be seen clearly in some key areas such as the consumption of time and resources, difficulties in data gathering, enabling the citizen role in using performance measurement output and moreover creating a sense of performance measurement inside the governmental authorities (Bracegirdle, 2003).

A NEW APPROACH TO PERFORMANCE MEASUREMENT

Given the project-based natural of the construction industry, the general measurement systems that are driven from the business market which are based on measures of profitability, are not appropriate for measuring and improving performance of construction projects (Ankrah and Proverbs, 2005). Löfgren and Eriksson (2009) have suggested that construction projects can achieve outstanding costumers' satisfaction, productivity and controlling performance in terms of quality, time and cost through superior partnering and collaboration between stakeholders. Keeping such guides in view, Takim and Akintoye (2002) proposed a new conceptual model based on incorporating and integrating some key success factor of construction project, i.e.: the relationship between success factors, project performance, efficiency, effectiveness, stakeholders' performances, needs and expectations, stakeholders' continual participation. Based on his model, a new approach for performance measurement is proposed where performance indicators are measured in the three phases of project

life cycle: the procurement, the process and the termination. The basic strands of this approach i.e. project phases, critical success factors, characteristics of good measures and criteria for performance measurement has been explained in the following sub sections.

IMPORTANCE OF PROJECT PHASES

A typical construction project is unique; however, processes are generally similar, and have been named in various ways by researchers who have approached the subject at different levels such as feasibility, pre-project stage, pre-design stage, project initiation stage and pre-project planning stage are synonymous. Project construction has two essential phases which are the preparation stage including project plans and design and the execution stage which includes the implementation process. According to Takim and Akintoye (2002) construction projects are practiced in seven complex phases: initiating, planning, financing, designing, approving, implementing and completing a project.

NOTION OF CRITICAL SUCCESS FACTORS

Critical success factors (CSFs) are crucial indicators, whether objective or subjective, which have significant impact on project results. These factors can be used to direct the organizational strategy for optimum use of resources and meet outstanding performance levels (Nguyen *et al.* 2004). Critical success factors have a long list and aim to achieve effective communication, dispute resolution, sufficient resources management, mutual trust and cooperation between all stakeholders, commitment, coordination and inventiveness (Cheung, *et al.* 2004). However, despite the significance of these factors, they cannot fulfil the desired goals if they are not linked properly to each other to serve as the organizations' overall strategy. Thus, establishing relevant and reliable critical success factors is deemed a fundamental requirement to evaluate project success in terms of both objective and subjective measures.

Chan *et al.* (2004) have identified the most important success factors and classified them into five groups of project attributes, procedures, project management, human resources and environmental factors. Within these groups, "quality workmanship, honesty, having good subcontractors, customer communications, reputation, having good employees, and completing projects on time, respectively" were deemed significant success factors by US construction companies, whereas, "employee development, effective risk management, innovation, partnerships with customers, and lean organizational structure" were important for German firms.

CHARACTERISTICS OF GOOD MEASURES

Beatham *et al.* (2004) have suggested that good measures have certain characteristics, which are explained below:

1. A comprehensive overview of the industry should be used to select leading and lagging indicators.
2. Differences between KPIs (leading), KPOs (lagging), and perception measures (individuals' judgements) must be understood and applied.
3. Indicators need to be balanced between the organisations' strategy and interests.
4. The stages of design and execution have to be recognised and clear.

5. They must be used as a fundamental component of the system and the process of execution.
6. The measures should take consideration of processes and sub-processes.
7. There should be active staff participation in the improvement of the measures.
8. The measures could be updated and used by organisation to benchmark their performance internally and externally.
9. The selected measures should support the decision makers with updated information.

RESEARCH METHODOLOGY

The present research is based on the key hypothesis that poor performance of Saudi municipalities' construction projects during various stages of construction projects is primarily associated with the weaknesses in existing performance measurement approaches. These approaches are hampered by the presence of significant barriers and obstacles at both project and organizational levels. Besides that understanding of the critical success factors and their measurement through performance indicators vary among various stakeholders. The challenge of performance improvement has become even more daunting as process improvement measures also vary among stakeholders involved in the construction projects. However, given the fact that an integrated system of performance measurement is supported by various stakeholders (personal knowledge), the researcher has proposed a new model for performance measurement of construction projects in Saudi Arabia building on the previous researchers especially the works of Beatham *et al.* (2004), Chan and Chan (2004), Ankrah and Proverbs (2005) and Haponava and Al-Jibouri, (2009).

CONCLUSIONS

As a result of rapid change and increasing uncertainty in terms of technology, budgets and operation process, the construction industry has become more complicated and dynamic (Albert, 2001). Performance measurement systems are widely applied in the construction industry (Edwards and Thomas, 2005) with main intentions of providing accountability, optimization performance and determining expenditures (Bracegirdle, 2003).

The tradition indicators cost, quality and time (the Iron Triangle) are being utilised by the construction industry to measure its performance despite their insufficiency to measure project successes (Haponava and Al-Jibouri, 2009). However, the need for measuring performance in construction projects has led to the evolution and implementation of key performance indicators related to various aspects of a typical construction project. Within different types of KPIs, shortcomings have persisted related to time, cost and quality; however, by following a process approach and focussing on multiple project stakeholders, their usage in the industry could be continued (Haponava and Al-Jibouri, 2009). Indeed, from the authors' review of literature, it can be found that very few performance indicators are process oriented, which therefore necessitated the authors' study and their attempts at developing process-based KPIs. The author recommended measuring the process of execution and the outcomes as well (Haponava and Al-Jibouri, 2009).

Using a framework in which the construction process has been divided into various stages, the researchers defined process-based KPIs, defining the initiative, feasibility and project definition phases. However, it is important to note that the identification of key performance indicators is not sufficient for the success of performance

measurement, but should be considered carefully in the process of measurement and its application (Enoma and Allen, 2007). The major issue in using the KPIs is that they are concerned with past events (lagging indicators). That is to say, that the performance is not affected by the results of KPIs. On the contrary, the leading measures deal with the current activities which are being performed. As a result, these measures offer little chance to the change in future.

In summary, most of the measurement approaches mentioned in the paper, do not focus on measuring project performance through financial and non-financial factors at each project phase. The majority of frameworks that have been proposed are developed theoretically based than empirically. While suggesting a new approach to performance measurement based on critical success factors applicable to various project phases and stakeholders, we shall remind ourselves what Phusavat *et al.* (2009) have stated that in the past, performance measurement was a critical management instrument that enhanced responsibility and quality management systems, whereas, in the future, it will be as a driver to increase government capability, transparency and accountability.

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EVALUATING POLITICAL ASPECTS OF SUCCESS FOR PPP/PFI SPORTS HALL IN CROATIA

Danijel Kušljić[1] and Saša Marenjak[2]

[1] *Center for monitoring business activities in the energy sector and investments, Miramarska ulica 24, 10 000 Zagreb, Croatia*

[2] *Faculty of Civil Engineering, University Josip Juraj Strossmayer in Osijek, Full Professor, Drinska 16a, 31 000 Osijek, Croatia*

Private Finance Initiative (PFI) is used to deliver public services that are not commercial in nature (e.g. public schools or public health care). Naturally Public sector Clients want to achieve successful PFI projects and they need to a have tool for evaluating achieved success. Due to fact that PFI projects are often capital projects, they have essential development purpose and attract lot of political attention. Possibility of measuring political aspects of PFI project success for Public sector Clients is explored. Important success criteria called "Achievement of political goals (APG)" and "Political support (PS)" for evaluating political aspects of PFI project success are identified with application of analysis and synthesis methods. Every success criterion in context of PFI project contains inherent characteristics and different measuring method used for each criterion. To enable comparison of achieved success results by different success criterion, model for application of considered success criteria on evaluating political aspects of PFI project success for Public sector Clients is suggested. Empirical applicability of proposed model for evaluating success with considered criteria is demonstrated at Sport hall in Town Varaždin, as one of the pilot PFI project in Croatia. The political determinants of success for PFI project "Sport hall in Town Varaždin" have achieved considerable success level.

Keywords: PPP, PFI, project success, Croatia

INTRODUCTION

Public Private Partnership (PPP) is a partnership between the public sector and the private sector for the purpose of delivering a project or a service traditionally provided by the public sector (European Commission 2003). It can be stated that PPP presents method of realizing public projects which apply resources of private sector under control of public sector. Two main forms of PPP can be distinguished: PPPs of a purely contractual nature, in which the partnership between the public and the private sector is based solely on contractual links, and PPPs of an institutional nature, involving cooperation between the public and the private sector within a distinct entity (European Commission 2004). Contractual PPPs can be further distinguished as "Concessive model" who is characterized by the direct link that exists between the private partner and the final user and „Private Finance Initiative (PFI) model" in which the remuneration for the private partner does not take the form of charges paid by the users of the works or of the service, but of regular payments by the public

Kušljić D and Marenjak S (2012) Evaluating political aspects of success for PPP/PFI sports hall in Croatia *In*: Smith, S.D (Ed) *Procs 28th Annual ARCOM Conference*, 3-5 September 2012, Edinburgh, UK, Association of Researchers in Construction Management, 1111-.1120

partner (European Commission 2004). According to HM Treasury (2003) PFI helps ensure that desired service standards are maintained, that new services start on time and facilities are completed on budget, and that the assets built are of sufficient quality to remain of high standard throughout their life. There are also some disadvantages of PFI for it requires long-term preparation and contracting procedure which can be expensive process (Marenjak *et al.* 2003). PPP is recognized in Croatia as framework for long term sustainable economic development and higher level of public services to population (Croatian Government 2009). Due to emphasized Government's objective to deliver world class public services HM Treasury (2003) and constantly increasing acceptance for PPP application to acquire public infrastructure (Marenjak *et al.* 2005) it can be stated that public sector has generic intent to improve success of PPP/PFI projects. Current research practice recognize that there are still no accepted frameworks for assessing project success and there is no agreement on a standard, or even an operative framework for assessing project success (Ahadzie *et al.* 2008; Shenhar *et al.* 2001). Need for further research of measuring PFI projects success is recognized by some expertise's in United Kingdom (Audit Commission 2003), (Association of Chartered Certified Accountants 2004), (PartnershipUK 2005) that recommend development of an evaluation template for retrospectively assessing the success of PFI schemes. This paper increases understanding of measuring political aspects of PFI project success for Client.

RESEARCH METHODOLOGY

Research hypothesis states that it is possible to measure political aspects of PFI project success for Public sector Clients in manner that achieved success for different political success criteria is mutually comparable. Scientific contribution of this paper includes proposed model for evaluating the success of PFI projects, which allows comparability of achieved success as measured by various success criteria. This allows a comparison of the resulting success of various PFI projects. Research methods of analysis, synthesis and descriptive statistics mean values are applied for hypothesis conformation. Recognition of political aspects as important determinants of PFI project success for Public sector Clients is conducted with application of analysis method which implies analysis of complex concepts to their simpler constituent's parts and study of each part for themselves and in relation to other parts. Identification of relevant political success criteria and generation of respective adjustment model for representative political success criteria is conducted with application of synthesis method which implies merger of parts or elements or simple constructs in the whole constructs. Conformation of empirical applicability of proposed adjustment model for respective political success criteria and referent success of PFI Case study "Sport hall in Town Varazdin" in Croatia is derived with application of descriptive statistics mean values. Research constraints are extent of literature review used as knowledge base for identification of criteria used to describe political aspects of PFI project success, assumption for adjustment model that attitude of each political representative and each political goal is equally significant for success evaluation, range of available sources for identifying political objectives and extent of analyzed media coverage of politician's perception for evaluating political support of PFI project "City sports hall Varazdin".

CHARACTERISTICS OF PFI CONCEPT

Private Finance Initiative (PFI) is used to accomplish certain public function which is not commercial in nature or cost-effective using profit criteria for private sector (e.g. public Schools or public Health care) and Client pay provision of contracted services during contract period to Contractor (National Audit office 2009). The centre of any PFI project is a contract within which the public sector specifies the outputs it requires from a public service facility, and the basis for payment for those outputs (HM Treasury 2003). Private finance contracts are built around a performance regime that outlines service levels and applies penalties to providers if they fail to deliver them (National Audit Office 2009). PFI contract is a long term service contract usually concluded to period longer than 25-30 years (National Audit office 2009). According to Marenjak *et al.* (2003) PFI project life cycle encompasses feasibility stage, procurement and contracting stage and contract management stage. Employer is public sector authority that initiates and conducts realization of PFI project (Dixon *et al.* 2005). The prime responsibility of the public sector is to ensure value for money for society and main aim is to realize cost effective infrastructure and public services (European Commission 2003). The employer is under a constant obligation to secure best value with PFI project Dillon (2010). Generic contract structure of PFI project and associated stakeholders is presented in Figure 1.

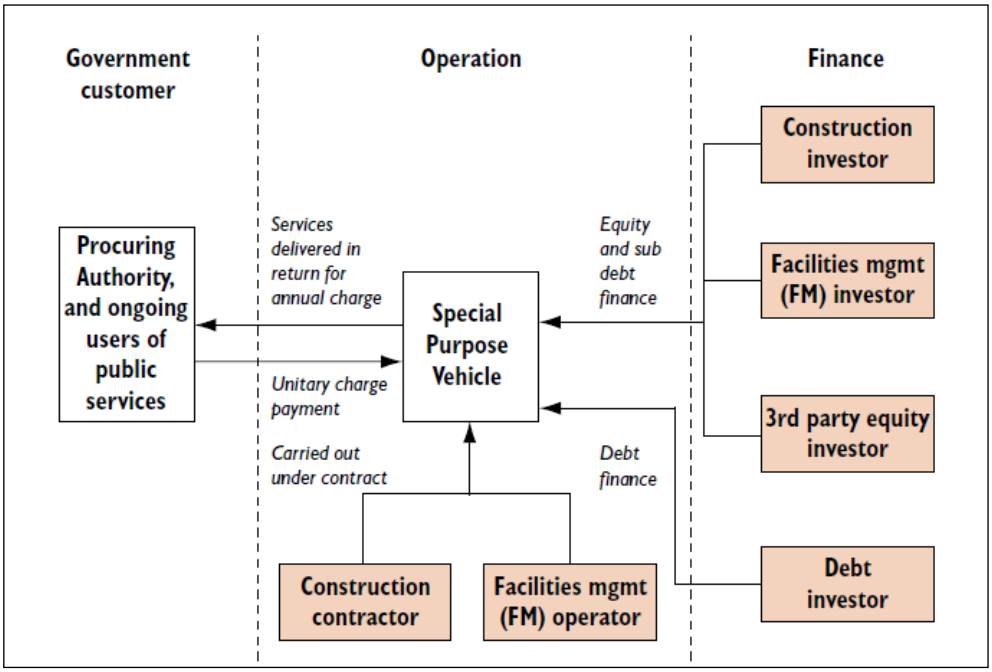

Figure 1: Typical commercial structure of a PFI project (HM Treasury, 2003)

MEASURING POLITICAL ASPECTS OF PFI PROJECT SUCCESS

Project success is difficult to define and trying to explain meaning of project success can be compared with attempt of group of individuals to achieve definition of good art (Jacobson and Choi 2008). Measuring project success is multidimensional concept (Shenhar *et al.* 2001). Project success should not be measured by applying only one criterion, but success evaluation should encompass different criteria and aspects of success (Chan 1996). Project success can be evaluated only when valorisation criteria are adequately defined (Diallo and Thuillier 2004). Criterion is a principle or standard

by which something may be judged or decided. Decision about project success or failure is based on achieved results measured when applying certain success criteria (Lim and Mohamed 1999). Among numerous PFI project success determinants (ex. project efficiency, service realization, satisfaction etc.), political aspects are recognized as one of important determinants of PFI project success for Public sector Clients (Kušljić and Marenjak 2011). Due to main objectives of public administration are improvement of citizen standard, achievement of economy interest and goals, investment in communal economy and infrastructure and investment in development programs for achievement of public requirements (Mihalj 2000) it can be stated that respective objectives mainly refers to strategic aspects whose Public sector Clients aims to accomplish with realization of PFI projects. Consideration of strategic aspects during PFI project development is essential for project success (Allport *et al.* 2008). One of most important aspects of PPP project realization is determination of public sector needs and project objectives (Agency for Public-private partnership 2010). According to (Harris, unknown year) for politicians it is most difficult to define actual political goals for PFI project (ex. budget savings, public sector reform, public servicer development etc.). Moreover, PPP contracts for political authorities represent important political subjects (Draženović 2008). Most activity of public administration is based on political support (Jacobson and Choi 2008). Political and social acceptance of private sector is essential for partnership success and public must experience private sector involvement as useful if partnership is to last (Biloš 2008). According to (Harris, unknown year) most important principle for PPP project success is big level of political support. Respectfully, it can be recognized that important political success aspects of PFI project for Public sector Client can be described with following representative success criteria: "Achievement of political goals (APG)" and "Political support (PS)".

ADJUSTMENT MODEL FOR "APG" AND "PS" SUCCESS CRITERIA IN PFI CONTEXT

Success measuring of PPP/PFI project requires consideration of numerous success determinants for which different success criteria are used. Every success criteria in context of PFI project contains inherent characteristics for Public Sector Client and different measuring methods are used for each success criteria (ex. quantitative or qualitative techniques). In order to enable complete and articulated success assessment of PPP/PFI projects for Public sector Client there is necessity to model success assessment results of each success criterion so that those results are comparable and overall project success can be considered. Adjustment model for PPP/PFI project success criteria is based on 5 degree Likert scale (1-5) which is used in similar research topics (Diallo *et al.* 2004), (Takim *et al.* 2004), (Lam *et al.* 2010), (Muller and Turner 2007) and called Local Measure Scale (LMS). In proposed model, LMS differentiate achieved project success in 5 levels (success grades) as follows: completely successful, mostly successful, half successful, mostly unsuccessful and completely unsuccessful. This adjustment model is also recommended for success criteria "Starting Date of Operation (SDO)" in analysis of PPP/PFI project success measuring (Kušljić and Marenjak 2011). Proposed adjustment model for success criteria "Achievement of political goals (APG)" and "Political support (PS)" reduce measured achieved success in percentage values that can be assigned in linearly distributed equal intervals that represent success grades according to LMS as presented in Table 1:

Table 1: Intervals that represent success grades used in adjustment model for "APG" and "PS" success criteria

Intervals	0% – 20%	21% – 40%	41% – 60%	61% – 80%	81% – 100%
Local Measure Scale (LMS)	completely unsuccessful (1)	mostly unsuccessful (2)	half successful (3)	mostly successful (4)	completely successful (5)

Achievement of political goals refers to PFI project contribution to theirs fulfilment. Determining political project goals depend on political strategy and considered PFI project features. Political project goals can be quantitative (ex. incensement of school capacities for 10% or 650 school chairs regarding existing state) or qualitative (ex. increasing educational services in certain region). Due to fact that political goals can embrace wide spectre of aims, identification of project political goals is based on analysis of official public administration documents which are publicly accessible (ex. strategies, programs, decisions etc.) that regards to possible application of PFI project. After identification and definition of political project goals, appliance of algorithm [YES/NO] is used to determine accomplishment of each of these goals with PFI project. Level of political goals achievement (LPGA) is calculated by comparison of number of accomplishment goals (NAG) with number of defined goals (NDG) that are mutually divided and in mathematical form is presented with respective equation 1.

Equation 1: LPGA (%) = [NAG (number) / NDG (number)] * 100

Political support refers to politician's attitude at appliance of PFI model for considered project realization of those politicians that have interest in that specific department or project. Adequate political representatives for respective PFI project attitude analysis are identified in manner that public authority organization structure is first recognized which in political terms consist of ruling and opposition political entities and secondly relevant departments and associated officials that have interest in PFI project are identified and they constitute base for assessing political support. Respective politician's attitude is identified with analysis of publicly accessible information sources in media (ex. daily newspapers, internet, formal journals, meeting record), interview or survey directed to public official. Due to subjectivity involved political support is qualitative success criteria. With appliance of algorithm [YES/NO] positive (YES) or negative (NO) political support for PFI project from respective public official in certain information source is determined. Level of political support (LPS) is calculated by comparison of number of positive attitudes (PA) with total number of analyzed attitudes (TNAA) that are mutually divided and in mathematical form is presented with respective equation 2.

Equation 2: LPS (%) = [PA (number) / TNAA (number)] * 100

Detailed explanations of success grades meaning is important for Client to understand what achieved success means considering numerous of different success aspects (ex. Public sector Client interest and project goals, fulfilment of project goals, PFI project characteristics, success criteria characteristics etc.) and are described as follows. For success criteria APG success grade „completely successful or 5" implies that all identified political project goals are achieved at highest level and can be argued that present small deviations from ideal realization of political goals are result of political environment dynamics where although politicians have clear political course of action often tactical management of political goals is present in political arena. It can be stated that with this level of political goals achievement project has completely

fulfilled its political mission. Success grade „mostly successful or 4“implies that all identified political project goals are mostly achieved and can be argued that the proportion of achieved political goals in set of identified political goals is sufficient for justification of the political implementation of PFI project, while smaller portion of unrealized political goals may be due to the unfavourable project circumstances that realistically couldn’t be neutralized. Success grade „half successful or 3“implies that all identified political project goals are partially achieved and can be argued that half of achieved political goals in set of identified political goals justify the political implementation of PFI project, while the second half of unfulfilled political goals, regardless of the reason that led to their failure to fulfil, calls into question the political justification of the project. Success grade „mostly unsuccessful or 2“implies that all identified political project goals are mostly not achieved and can be argued that significant proportion of unfulfilled political goals in set of identified political goals do not justify the political realization of the project, but due to smaller share of achieved political goals there are certain political arguments to justify PPP/PFI project implementation. Success grade „completely unsuccessful or 1“ implies that significant proportion of all identified political project goals are not achieved and can be argued that realization of PFI project has generally in political context brought damage to the ruling political option and eventually some achieved political goals are result of random positive circumstances.

With this level of political goals achievement project’s political mission is not fulfilled and project can be characterized as political failure. For success criteria PS success grade „completely successful or 5“implies that PFI project enjoys greatest degree of political support. Success grade „mostly successful or 4“ implies that PFI project enjoys high degree of political support and can be argued that high level of project acceptability among politicians indicates a positive political support for the project, while the noticeable absence of support can be justified with higher dynamics of the political scene where probably the representatives of political opposition are using the project as instrument for collecting political points. Success grade „half successful or 3“ implies that PFI project have partial political support and can be argued that moderate level of project acceptability among politicians represents crossroad for project’s political support where differentiation could be emphasized between balanced ruling and opposition parties. Success grade „mostly unsuccessful or 2“ implies that PFI project mostly lack political support and can be argued that small level of project acceptability among politicians indicates a politically conditioned political support for the project while trying to minimize political damage from project realization. Success grade „completely unsuccessful or 1“ implies that PPP/PFI project lack significant proportion of political support and can be argued that project has no support among politicians.

SUCCESS EVALUATION OF CASE STUDY “CITY SPORTS HALL VARAŽDIN” APPLYING “PS” AND “APG” CRITERIA

Due to fact that application of PFI model in Croatia for delivering public services is relatively new concept where first pilot projects begin contracting in 2005. (Marenjak *et al.* 2005) there is only a few PFI project in operation today. One of pilot PFI projects in Croatia, which is currently in operation, is City sports hall in Town Varazdin. For conformation of empirical applicability of proposed adjustment model for political success criteria this project is used due to fact that only for this case study

it is realistically possible to identify and analyze significant extent of political goals and media coverage of politician's perception to test the model. According to Nadilo (2008) construction of City sports hall in Town Varazdin begins in mid-August 2007 and works are completed on 15 November 2008. Total area of sports hall is 19.340 m^2 with capacity for 5000 spectators. Contract period is 25 years and sport hall is currently 3,5 years in operation. Public sector Client for PFI project City sports hall Varazdin in Croatia is town Varazdin which is leading public partner with Croatian Government as associated partner. Divisions of employer's organization structure that participated in realization of PFI project are Office of Town Varazdin Mayor, Administrative office for finance and budget of Town Varazdin, Administrative office for communal system, urban development and environment preservation of Town Varazdin, Administrative office for culture, sport and technical culture of Town Varazdin, Administrative office for implementing urban development and construction legislation of Town Varazdin, Varazdin Town Council, Office of Croatian Prime Minister, Ministry of finance, Ministry of science, education and sport and Ministry of environmental preservation, urban development and construction. Private partner is Special Purpose Vehicle "Max Bögl – Tehnobeton d.o.o.". Political support for PFI project "City sports hall Varaždin" is analyzed from February of 2008. to March of 2010. from relevant Croatian internet media. Due to research limitation, analysis of other media sources (ex. newspapers, television) and longer period of media coverage is beyond extent of this paper and will not be analyzed. Political attitude at PFI project "City sports hall Varaždin" is analyzed for representative of relevant employer's divisions. Political attitudes at PFI project "City sports hall Varaždin" are presented in Table 2.

Table 2: Application of transformation model for "PS" success criteria for PFI project "City sports hall Varaždin"

Employer's political representatives	Political attitude [YES/NO]
Mayor of Town Varaždin	YES
Chief of administrative office for finance and budget of town Varaždin	NO
Chief of Administrative office for communal system, urban development and environment preservation of town Varaždin	YES
Chairman of Varaždin Town Council	YES
Councilman of Varaždin Town Council	NO
Croatian Prime Minister	YES
Minister of Finance ministry	YES
Minister of Urban development and construction ministry	YES

Number of positive attitudes (PA) for "City sports hall Varaždin" is 6 and number of analyzed attitudes (TNAA) is 8. Level of political support (LPS) for "City sports hall Varaždin" is calculated by application of equation 2 with 75% level of achievement. Applied transformation model of "PS" success criteria to PFI project "City sports hall Varaždin" results in success grade (4) that indicate mostly political support for project for which can be stated that is pretty good regarding history of immense competition between political parties in Croatian society. It can be argued that this present absence of support is result of the political scene dynamics where probably the representatives of political opposition are using the project as instrument for collecting political

points. Important political goals regarding PFI project "City sports hall Varaždin" are identified with analysis of relevant public documents (Official gazette of town Varaždin 2008), (Town Varaždin city council 2008) and they regards to following aspects: sports hall capacity, sports hall type, source of financing, starting date of sports hall operation, development of sports potentials and development of sport magnitude. Determined political goals indicators and level of theirs achievement with PFI project are presented in Table 3.

Table 3: Application of transformation model for "APG" success criteria for PFI project "City sports hall Varaždin"

Expected political goal	Realized political goal	Achieved political goal [YES/NO]
Required sports hall capacity is 2000 to 3000 sitting places.	Number of sitting places without telescopic stands is 3789 and with telescopic stands is 5033.	YES
Required type of Sports hall is multifunctional hall for all indoor sports and other public events (ex. fairs, cultural or entertainment programs).	All indoors sports and public cultural or entertainment events are in progress.	YES
Expected project finance needs to have minimum loading on budget and proposed sources are credit, public-private partnership, central government investment etc.	Private Finance Initiative does not count as employer's debt.	YES
Required completion of sports hall construction is in year 2008.	Starting date of sports hall operation is 04. December 2008.	YES
Development of sports potentials requires construction of network of sports facilities.	City sports hall Varaždin is largest sports hall in town Varaždin and local region.	YES
Required sports hall needs to enable organization of major international sport events that contribute to sport magnitude development.	City sports hall Varaždin hosted World handball championship of 2009.	YES

Number of defined goals (NDG) for "City sports hall Varaždin" is 6 and number of accomplishment goals (NAG) is 6. Level of political goals achievement (LPGA) for "City sports hall Varaždin" is calculated by application of equation 1 with 100% level of achievement. Applied adjustment model of "APG" success criteria to PFI project City sports hall Varazdin results in success grade (5) that indicate complete achievement of political project goals. It can be argued that that all identified political project goals of City sports hall Varazdin are achieved and project has completely fulfilled its political mission.

CONCLUSIONS

Public sector Clients perceive PPP/PFI procurement as important political tool to deliver public service and range of benefits to society where it is essential to be able to measure political aspects of success for those projects. It is recognized that these aspects constitutes of political goals of project and political support for project which are important PFI project success criteria for Public sector Client called "Achievement of political goals (APG)" and "Political support (PS)". Proposed adjustment model for "APG" and "PS" success criteria transforms achieved success measured with each criterion to uniformity scale based on 1 to 5 Likert scale so that results can be

comparable. To clarify meaning of each success grade for respective criterion, respective description is presented. Empirical applicability of proposed adjustment model for political success criteria is confirmed on City sports hall in Varazdin in Croatia. Project has achieved all political goals and according to success criterion "Achievement of political goals (APG)" has success grade of 5 while contains considerable political support and according to success criteria "Political support (PS)" has success grade of 4. It can be stated that political determinants of success for City sports hall in Varazdin have achieved considerable success level and achievement of political goals is greater than political support for City sports hall Varazdin. It can also be argued that determined level of political goals fulfilment does not condition equal level of political support for project. Derived success grades for this case study confirm the possibility of comparing achieved success between different success criteria and also suggests possibility to compare achieved success between different PFI projects.

Further research can focus on identification and modeling other PFI project success criteria for Public sector Clients as well for other important stakeholders like End users and Contractors. Extensive empirical application of identified success criteria and this adjustment model on PFI projects success evaluation can enable creation of achieved success referent bases for different success aspects and PFI project categories (countries, sectors etc). These could lead to formation of generic regression model for success evaluation whereby criteria are in depended variables and achieved overall success is depended variable.

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DELIVERY OF COMPLEX CONSTRUCTION MULTI-PROJECTS IN CONTRACTOR-LED PROCUREMENT

George Hagan[1], Denise Bower[2] and Nigel Smith[3]

School of Civil Engineering, University of Leeds, Leeds, LS2 9JT, UK

As the demand for Contractor-led procurement routes for large and complex projects increases, the pressure for improved delivery also increases, putting the construction contractor at the fore-front of creating value through innovation, collaboration and integrated working. Companies have to adopt approaches that not only successfully deliver a single project at a time but which recognise the multi-project environment of the construction contractor. This research builds upon a theoretical socio-technical systems framework for understanding and managing complex construction projects. The paper outlines the evaluation and revision of the framework through a series of expert interviews and pilot case study. Empirical feedback is used to provide a better understanding of the nature of complex construction projects and an insight into how they can be managed accordingly.

Keywords: socio-technical systems, contractor, framework, collaboration

INTRODUCTION

Within the construction industry, the increasing demand for contractors to play an integrated role especially in contractor-led procurement systems (such as design and build, Private Finance Initiative (PFI's), etc) has increased the pressure to improve performance. According to Constructing Excellence in the Built Environment (2009), the "era of client-led change is over, at least for the moment, and that it is time for the supply side to demonstrate it can create additional economic, social and environmental value through innovation, collaboration and integrated working". For project-based firms, such demonstrations mean improved performance when managing complex projects in their multi-project environment. This view had been previously articulated by Winter *et al.* (2006) who stressed that the performance of the industry could be improved if the current conceptual base of project management were made relevant to practice. Winter *et al.* further argued that there was the need to develop new models and theories which recognise and illuminate the complexity of projects in order to enrich the industry's understanding of the actuality of projects and project management practice.

[1] g.n.hagan01@leeds.ac.uk
[2] D.A.Bower@leeds.ac.uk
[3] N.J.Smith@leeds.ac.uk

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Construction contractors are moving towards multidisciplinary teams offering diverse services ranging from design to management services. Most projects take place in a multi-project environment. However, project management literature and research have predominantly been carried out as if projects take place without the impact of the environment in which they are executed. Project-based organizations tend to run more than one project at any time, which may be interdependent at least on resources. These projects are undertaken simultaneously and managing them not only to cost or budget and timely completion but also to create value for a business is a challenge. The consequences faced by a construction contractor, who plays a leading role in the procurement process are significant, especially in terms of integrating and co-ordinating the entire supply chain to achieve client satisfaction and also anticipated repeat business. For such companies, the focus of management goes beyond achievement of individual project objectives to pursuing approaches that deliver value for the organization and its stakeholders.

In this paper, the authors present the final stage of a research project, the aim of which was to develop a suitable approach for managing complex construction projects in a multi-project environment by the contractor. The paper builds on a theoretical socio-technical systems framework for understanding and managing complex construction projects which can be found in Hagan, *et al.* (2011). The outcome of an empirical evaluation of 21 expert interviews and a pilot case study is described to revise/confirm the framework and evaluate its use in delivering complex multi-projects. In addition, the framework and its underlying relations are discussed along with how it delivers complex construction projects.

COMPLEX CONSTRUCTION MULTI-PROJECTS

The bundling of construction work into fewer, but larger contracts means that more responsibility is transferred from major clients of the construction industry to contractors. The construction contractor in such leading role is faced with the challenge of managing the interrelationships of the whole supply chain which makes the projects complex. According to Ruuska *et al.* (2011), such large complex projects present unique challenges due to the: 1) the dynamic network of organizations that combine resources, capabilities and knowledge of participating actors to achieve clients needs and 2) differing and often conflicting objectives and expectations not evident if the projects were carried out by individual firms. However such challenges are not easily dealt with, resulting in lack of performance and in some situations project failure.

Several reasons have been attributed to this lack of performance, some of which are: reluctance to accept and adapt to change (Constructing Excellence, 2009); project complexity (Remington and Pollack, 2007); lack of committed leadership, focus on customer and commitment to people (Egan, 1998); and procurement issues (Bower, 2003); among others. Another important reason given is the lack of understanding of the effect of running projects in a multi-project environment (Artto and Dietrich, 2007, Payne, 1995).

The players in the construction industry therefore are under immense pressure to perform, and especially more now, in the current economic downturn. All parties involved in the construction process will be expected to make changes in order to improve performance and remain competitive. Thus there is the urgent need for clients, contractors, subcontractors, suppliers, or consultant organisations of the industry to reshape and align their strategies and structures to meet the challenges of

their environment and the complexity of projects. According to Winch (1987: p.970), "construction projects are amongst the most complex of all undertakings". Baccarini (1996: p.201) also emphasises this view by stating that "the construction process may be considered the most complex undertaking in any industry". However, there are no well-defined frameworks for describing the key dimensions and characteristics of project complexity according to Xia and Lee (2004). It is therefore vital that the dimensions of complexity are understood and appropriate approaches developed for the delivery of such projects.

Construction contractors like any project-based organization, with the responsibilities of integrating the entire supply chain, run more than one project at any time or several projects that may be interdependent on each other. Thus they operate in a multi-project environment which is dynamic and unstable. In any typical construction organization (i.e. project-based firm), there would be one or more projects being executed at anytime with limited resources and information. These projects may be executed at different sites or locations and may also have different start times or be at the same stage of construction. The dependencies connecting the different projects may be organizational, technological, knowledge-oriented, systems or inter-linked by the deliveries made to the client (Baccarini, 1996, Danilovic and Borjesson, 2001). Additionally they may share important resources with other independent projects such as people. Irrespective of this practical situation, mainstream literature in the field of project management has been dominated by single project environment as if companies execute one or more projects independently or as loosely interdependent projects (Hossain and Ruwanpura, 2008, Pellegrinelli, 2011). According to Payne (1995), managing complex projects in a multi-project environment is concerned with dealing with issues wider than in the single project environment. For example, in a single project environment, scheduling are performed independently for each project, while productivity methods focus narrowly on individual activities (Sacks, 2004).Also the multiple interfaces between projects and resources utilization are not harmonized (Eskerod, 1996).

Antoniadis *et al.* (2011) argued that understanding the characteristic of interconnections in a construction environment and how they affect project performance will contribute to a more efficient project delivery system. Typically this environment is a challenge to the construction contractor who has to undertake several projects of different sizes and types at different sites with limited resources (Danilovic and Borjesson, 2001). Hossain and Ruwanpura (2008) also argue that the ability of the construction contractor to optimise schedules and resource utilization while competing with other projects executed by other contractors is critical.

To better understand and conceptualise the real world context within which organizations manage projects, there is the need not only to:

- Conceive the organization as a structured, bounded phenomenon, existing in an ordered and given social context; capable of skilfully organizing flows of action and information in an unstructured, fluid, dynamic interrelationships (Chia and King, 1998, Tsoukas and Chia, 2002), but also more importantly,
- Encapsulate the relationships between projects and the intricate network of intra and inter organizational relations which define the way many project-based activities and operations are nested and embedded (Engwall and Jerbrant, 2003, Sydow *et al.* 2004).

The systems concepts provide the basis for thinking about organizations and the environments in a holistic manner. In the context of the systems approach in relation to the construction process, Walker (2007) argues that "the attraction of systems theory as a medium for identifying a conceptual framework for the management of the construction process lies in the basic premise that a system is an organized or complex whole: an assemblage or combination of things or parts forming a complex or unitary whole, which is greater than the simple sum of its parts".

EARLIER WORK - THEORETICAL FRAMEWORK

In the early stages of the research, an extensive literature review was conducted in order to identify a gap and establish the opportunity for the research. The review also lead to the development of a theoretical framework which identified the main themes and factors that influence the management of complex projects in the multi-project environment of the construction contractor. The set of factors and themes identified were used in a causal relationship to develop the framework which was based on the underlying logic of socio-technical systems approach. With the help of the relevant literature, the framework was adapted to suit contractor organisations in construction. Figure 1 illustrates the resulting framework, more details of which can be found in Hagan, *et al.* (2011).

The underlying logic of the framework is based on the philosophy that the effectiveness of an organisation is related to the joint maximization of its social and technical factors (Cherns, 1987, Clegg, 2000, Katz and Khan, 1978). On this basis, an organisation is viewed as a system comprising various interrelated, co-dependent sub-system in a state of dynamic interplay (Clegg and Shepherd, 2007). It becomes necessary therefore, to view the organisation as a single, interrelated system whose sub-systems must be considered jointly for maximum performance. Thus to the extent that organisations are effective and efficient in delivering complex projects, there is the justification for viewing all that is involved in the organisation as interdependent and given joint consideration. Therefore for effective and efficient delivery, the whole system including its people, processes, product, goals, decision-making and resources should be viewed as interdependent and given joint consideration.

In this way, the different factors that have impact and causal changes to the system can be observed, investigated and managed. It can also increase understanding on how other factors that emerge may affect the system. This understanding should provide a basis for manipulating the system to maximise its performance or delivery.

The framework uses the socio-technical systems approach to draw out links that exist between identified themes or factors. The logic of the framework is that a whole variety of relationships exist within executing organisations, the nature of which may determine the impact such interactions have on the delivery of projects.

The framework also reflects the importance of integration as a key business function for bringing together the product, goals, people, process, and resource. These factors, along with its inherent uncertainties, aid good decision making that enable better field performance. The framework focuses attention upon the need to bind together the differentiated yet interdependent contributors to project delivery in a multi-project environment.

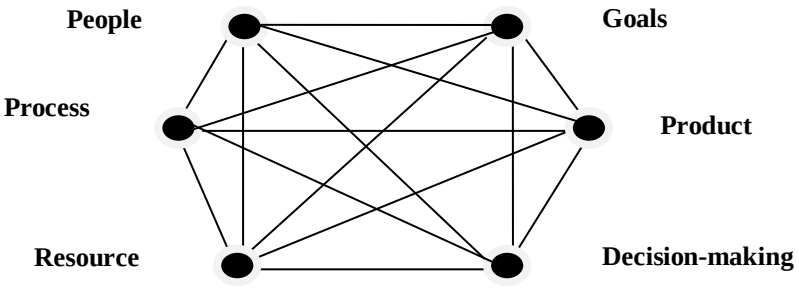

Figure 1 – Theoretical framework - interrelated factors involved in delivering complex projects in multi-project environment (Adapted from (Challenger et al. 2009))

EXPERT INTERVIEWS

Twenty-one construction project management practitioners with long and varied experience of managing complex projects were interviewed. The practitioners included chief executives, managing directors, project directors, project managers, planners, design director, commercial director and human resource manager. To provide form to the interviews and also allow probing, semi-structured interviews were used to collect data (Fellows and Liu, 2008). The objectives of the interviews were to seek both qualitative feedback of the framework and also detailed description of the interrelationships involved in managing complex projects.

Feedback

Missing themes/factors and any underlying logic among the factors were identified using the semi-structured interviews. The interview sessions were recorded with the permission of the interviewees, transcribed and coded. Interviews were usually between an hour and two. The coding was formed into clusters of contextual areas so that relationships that otherwise would not have been clear was brought out. Patterns and revisions resulted from the analysis which was worth considering in revision or confirmation of the framework. The main feedback resulting from the interviews can be summarized as follows:

- Risk was identified a common factor inherent in all the other factors already identified. The impact of risk not only in the individual factors but also in combination with other interrelated factors were considered crucial to effective delivery of complex projects
- Organizational culture in terms of understanding and how the organisation do things was considered as very important when dealing with other organisations or stakeholders in the delivery of complex projects. This was however considered to be embedded in the people and processes of the organisation.
- The qualitative feedback on the framework's usefulness, practicability and applicability was very positive. The framework was mostly seen as easy to use and understandable in capturing factors which could affect the delivery of projects. Factors that feature predominantly can easily be identified, monitored and addressed.

CASE STUDIES

The research included a pilot case study at the exploratory phase to test the theoretical framework developed, gain feedback and test the methodology / data analysis method adopted. Four further case studies were conducted at the investigative phase to gain understanding of how construction contractors manage complex projects in their multi-project environment. The case studies complemented the semi-structured interviews by providing deeper insights (Rowley, 2003). Using a triangulated approach for the data collection encompassing evidence from interviews, documentation and archival records, the cases were formulated. The analysis of the case study was based on the theoretical framework acting as a prior proposition and evidence gathered used to either confirm or revise the framework (Yin, 2003). The case studies involved construction contractor companies within the construction industry delivering integrated contracts like design and build and PFI, which have high levels of interdependencies and uncertainties. All the five cases were major UK based construction contractors. The criteria for selection of cases were: that the company was a major UK company with multiple projects being currently delivered simultaneously; and one or more of the projects included an integrated contract type. The unit of analysis was the complex projects delivered by the organisation. The analysis of the cases was dependent on using the theoretical framework as a prior proposition and the evidence gathered either used to revise or confirm the framework. This paper presents the results of the pilot case study and semi-structured interviews which were conducted as part of the investigations carried out for the study.

Pilot Case Study

To gain feedback on the theoretical framework and also test the research methodology adopted, a pilot case study was carried out. The pilot case study refers to a major UK construction contractor with employees over 1500 and turnover over two billion pounds. In 2008, the company won a PFI multi-projects made up of 4 primary schools; 4 secondary schools and 4 special needs schools. The company set up a special purpose company to deliver the multi-projects with its own Chief Executive Officer and Board to oversee the delivery. Although set up as a self sufficient company, the new company relied partly on the main company's processes, people, and resources to meet its objectives set by the Board. The delivery of the individual projects were also carried out with project managers whose main aims were to execute their projects without much regard to what was happening with the other projects. Some subcontractors employed on the projects had more than one project to work on. Similarly, the planning of the works was carried out in isolation of the other projects. The main company has been successful in delivering this kind of integrated procurement over the years and pride themselves in being able to create value by their drive for innovation and constant quest for change and improvement. They company's delivery system consist of in-house governance structures that includes decision-making, people and processes. However, this delivery system is carried out in isolation without considering the interrelationships that exist and how they may impact the delivery of complex projects. Using the framework developed interrelationships were mapped out and dependencies shown which provided a different way for the company to view its delivery approach.

In working with the framework, the company identified which factors influence complex project delivery. The interrelationships between these factors were easily linked and monitored to learn the appropriate actions to be taken. The emphasis of the

framework on factors such as people, process, product, decision-making, resources and goals together with the risk factor of each of them were highly accepted by the company. The overall alignment of the framework to construction was also a favourable trait encountered as feedback. The underlying relationships and logic were seen as important tools for interpreting complex construction environment and identifying possible outcomes and also showing management the probable future consequences for the company.

EMPRICAL EVALUATION AND REVISED FRAMEWORK

Feedback was gained from the semi-structured interviews and pilot case study. The feedback helped to revise the framework to provide better understanding of the dynamic factors at play in the delivery process. It showed how conceptually the factors may interrelate to affect the delivery or management of complex projects. The feedback arising from the evaluation of the interviews and pilot case study are summarized below:

- The framework was perceived as very simple and easy to understand. It provided at a glance the multiple interdependent factors which are at play at any given situation. The Project Director referred to it as being a “a very good tool for capturing all the issues one deals with in delivering projects of this nature.”
- The underlying relationships among factors were identified as naturally intricate and not necessarily causal by the practitioners. Risk was therefore identified as a fundamental factor that would result from such interrelationships. According to one of the interviewees "complexity drives risk which is also at the heart of each factor of complexity. What makes it (complexity) extremely difficult is when they tend to combine and come against you with full force".
- The framework was seen as a tool for capturing lessons learnt and helping to plan and manage future projects. By populating the issues affecting the project around each factor, managers and all parties involved in the delivery process could find ways of coping with the unique combinations of factors coming together in ways unanticipated.
- The evaluation of the theoretical framework through the semi-structured interviews and pilot case study resulted in revising the framework to include risk as shown in Figure 2.

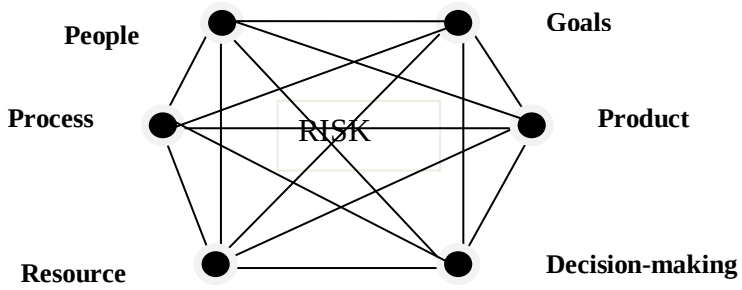

Figure 2 – The revised framework

- Using the framework it was possible to elucidate the differing objectives of the multiple organizations involved in the delivery system. This provided a better understanding of the wider effect of the project objectives on individual organisational objectives.

Risks as identified in this framework will deal with what may be associated with any individual factor in relation to others, and also enable the construction contractor to consider contingency plans for the combinatorial risks which may be at play.

DISCUSSION

The revised framework provides a more robust framework for understanding and identifying key prominent factors which require managing to deliver complex projects. According to Clegg and Shepherd (2007), any change that is driven by technology without consideration given to the social and organisational factors could result in failure. The framework not only focuses on tools, techniques, procedures, skills, or knowledge but also considers the people in the organisation, their relationships and expectations of the organizations delivery mechanism. This is in contrast to other frameworks for managing projects advocated by professional bodies such as Association of Project Management and Project Management Institute (APM, 2006, PMI, 2006) which essentially dwell on processes. The factor of process in managing projects is well articulated in project management body of knowledge as the established procedures used by organisations to deliver projects. However used on its own, it ignores the context, interactions or interrelated actions necessary for achieving the desired project or product.

The inclusion of risks is central to the way construction contractors manage complex projects. Specifically, risks that may seem minor on their own such as logistics, stakeholder expectations, etc could occur simultaneously with say city centre construction and environmental issues to result in major risks. Having a framework that can map these factors and their interdependence is a helpful step towards effective delivery. The analysis of results highlight the importance of managing the factors outlined above in the delivery of projects. These factors should not be considered in isolation as all the parts including the organizational units, subsystems or components fit together as a functioning unit and integrated whole in line with the project and organizational goals (Stuckenbruckt, 1983). Viewed as a system, the contractor organisation can be considered as comprising a range of interrelated, co-dependent subsystems in a state of dynamic interplay to achieve desired goals (Clegg and Shepherd, 2007). The framework therefore provides a means for evaluating the whole project to gain better understanding. The advantages of using the framework include:

- Relative ease of use and understanding, as well as its suitability for use in construction organisations.
- Enabling the conceptualisation of the relationships among the varied factors as not simple cause and effect, but non-linear which should be managed differently.

CONCLUSION AND FURTHER WORK

The aim of this paper has been to develop a conceptual framework for understanding and managing complex construction projects by the contractor. A theoretical framework had been developed in previous work that formed the basis of a conceptual complex project delivery framework in construction. The work conducted in this research empirically evaluated and revised the framework to produce a more robust framework. Twenty-one semi-structured interviews with practitioners and a pilot case study were conducted to assess the robustness and underlying logic of the framework. The empirical interviews and case study resulted in revising the framework to include another factor (risk) in the framework. The framework was found to be easy to use,

understandable, and of good fit to the construction industry. Based on the discussions above, the potential implications for using this framework by practitioners for effective delivery of complex construction projects are: 1) for construction contractors to embrace the concept that when delivering complex projects, it is critical to focus on and manage both the interdependent technical and social factors at play in order to be effective; 2) focus of research and practice to shift from single towards multi-project delivery; 3) shift from viewing projects as stand alone entities towards a systems approach that recognises the interrelationships that exist between inter and intra project elements. The conceptual framework developed and the research conducted open up several areas for further research. The difference between client, consulting and contracting organisations, with respect to the framework need to be further researched. The nature of relationships among various combinations of factors needs to be measured in other to quantify their outcome. Additionally, socio-technical systems approach could also be applied to offer deeper understanding of how time delays due to project complexity can be managed in the delivery of complex construction multi-projects.

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RESEARCH METHODS AND NEW PERSPECTIVES

A NEW RESEARCH AGENDA INTO COMMUNITY-BASED PROTEST IN CONSTRUCTION

Teo M.M.M[1] and M. Loosemore[2]

[1] *Queensland University of Technology, Brisbane, Australia*

[2] *University of New South Wales, Sydney, Australia*

Many countries face enormous development challenges in adapting to demographic change, urbanisation and emerging issues such as housing affordability and climate change. These challenges are best resolved in consultation with communities rather than in conflict with them. A rich tradition of research and intellectual frameworks exist in the fields of urban geography and planning to understand and manage community concerns during the pre-development approval stages of new projects. However current theoretical frameworks are inadequate in construction management and a new research agenda is needed to develop conceptual frameworks to guide thinking about the role of communities in the construction process. By discussing the components of such a model, it is concluded that this would require a fundamental shift in thinking which challenges traditional structuralist paradigms. Anew constructivist paradigm is presented that conceives community consultation as a negotiation process which does not stop at the pre-development planning stages but which continues over the entire life of a project.

Keywords: community, protest, social constructivism, development, housing, infrastructure

INTRODUCTION

In the face of climate change, demographic shifts and increasing global urbanisation, the way we design, construct and operate our increasingly dense cities has become a key determinant in society's stability, health, prosperity and well-being (UN-Habitat 2008). For example, in Australia, a growing and ageing population has created the need for substantive infrastructure investment and much of this will be directed towards existing urban environments: retooling, reshaping and reconnecting neighbourhoods and cities to address growing social, economic and environmental challenges. It is estimated that if the population grows as anticipated, by 2050 Australia will need 6,911,586 more homes and 173,348 km of new roads (CoA 2010). Similar challenges are faced by many other countries, creating growing community concerns about the ecological, social, economic and cultural impacts of development. While tensions between developers and communities have always existed, they have been exacerbated by the new nature and scale of these developments (UN-Habitat

M.Teo@qut.edu.au

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2008). Addressing these urgent development needs in a way which involves rather than marginalises communities will therefore be crucial to achieving sustainable outcomes for developers, governments and communities. Recognising this, community-industry-government partnerships have become increasingly popular with governments around the world to effectively address community concerns over the environmental, social and cultural degradation associated with future urban development (Gilmour *et al.* 2010). As Sharpe (2004: 4) argues, such partnerships bring construction teams into closer contact with communities than ever before and they 'live or die' on their relationship and reputation within them.

Unfortunately, current theoretical frameworks in peer-reviewed construction management literature tend to marginalise communities and are not adequate to address these new challenges (Teo and Loosemore 2010). While a rich tradition of research and intellectual frameworks exist in the fields of urban geography, urban planning and sociology to understand and manage community concerns during the pre-development approval stages of new housing and infrastructure projects (for example: Hackworth 2006), theoretical frameworks guiding thinking during the construction stages tend to dismiss community concerns as irrational, uninformed, ignorant or driven by nostalgia (McManus 2002; Cleland and Ireland 2007, Murray and Dainty 2009, Chinyio and Olomolaiye 2010, Teo 2010).

This leads us the following problem statement:

"There is a common and problematic assumption underpinning construction project management literature that communities have been adequately consulted during the pre-development approval stages of projects and that no further consultation is required during the construction stages. Yet in reality, residual community concerns from pre-development stages often continue into construction stages to develop into costly and acrimonious disputes. Construction management research needs a new intellectual framework that is able to acknowledge that community concerns can emerge during construction as the scale and nature of development becomes physically evident to communities and as major decisions continue to be made which have significant potential community impacts, sometimes over many years".

The aim of this paper is to address this problem and to discuss how this deficiency in knowledge could be addressed in theoretical and methodological terms.

THE NEED FOR A THEORY OF COMMUNITY PROTEST

Controversial housing and urban infrastructure projects are those that have obtained government sanctioned 'development approval', but not 'community approval', and have triggered NIMBY and grassroots protest that escalate into lengthy, costly and often acrimonious conflicts between communities, industries and governments (Chinyio and Olomolaiye 2010). A good example of this is the controversial Barangaroo development in Australia which is currently an unused 22-hectare site on the forseshore of Sydney Harbour that includes parklands, cultural space and a large business and urban residential area. State Premier Barry O'Farrell was forced to to debate the controversial development in Parliament when protesters amassed more than 10,000 signatures opposing the project. As Sydney lord mayor Clover said "There is significant concern across the community about the future of Barangaroo - a very important public site, adjacent to our city and on our precious harbour," (SMH 2011: 4). Sapountzaki (2007) found that while housing and urban infrastructure projects like this can serve important local and national needs, triggers to protest are

typically situated at a local level and associated with negative community perceptions of a project's ecological, social, cultural, and economic impacts. For example, new housing developments, while needed to alleviate national housing shortages, may be perceived by local communities to exert unacceptable stress on natural ecosystems, existing social infrastructure such as hospitals and schools and to potentially disturb social harmony or balance (Glasson 2005). As seen through an increasing number of community protests in response to new housing and urban infrastructure projects, they can become a site of contestation reflecting a conflict between provision of a 'public good' determined at a national or metropolitan scale and the perceived impacts of those decisions at the neighbourhood level (WRI 2007).

The perception of community irrelevance which persists within the construction project management literature has created a significant gap in theory and knowledge which, in contrast to urban planning research, maintains a poorly conceptualised understanding of community protest in this field. Consequently, while government approval procedures provide opportunity for community consultation on proposed developments during planning stages, they rarely flow-through to the construction stages, where frustrated and resentful communities are too often forced to engage in protest (Teo and Loosemore 2009; 2010). While practical initiatives like the UK's Considerate Constructors Scheme (http://www.ccscheme.org.uk/) monitor construction companies against a Code of Considerate Practice, which considers the community, without guiding theoretical frameworks, construction professionals will remain intellectually ill-equipped to understand and manage community concerns.

A THEORY OF COMMUNITY PROTEST FOR CONSTRUCTION

Avoiding community conflicts and their significant costs to communities, industry and government is critical to creating socially cohesive, healthy and sustainable communities. But it raises big questions which require new ways of thinking for those involved in the construction of this new infrastructure and the development of different theoretical frameworks by those who research it. As Loosemore *et al.* (2005) and Murray and Dainty (2009) point out, construction management research lacks appropriate theory to understand such issues and currently relies on linear structuralist paradigms which make many untested assumptions about the role of communities in the construction process. These assumptions include the view that: communities behave irrationally when they protest; community concerns are the responsibility of urban and town planners to resolve before work starts on site; community consultation should primarily occur during early planning processes; and that community consultation during construction phases will only delay progress and cost money to little advantage (Teo 2010; Chinyio and Olomolaiye 2010).

In an attempt to address these theoretical deficiencies, Teo's (2009) research into community protest against controversial housing projects in Australia produced a conceptual framework which highlighted the importance of social identity, social contagion, social networks, social capital and collective action in understanding community protest. In summary, Teo found that community-based protest networks are anarchic, unstructured and deliberately complex and dynamic, resulting in shifting and unpredictable identities between construction project teams and community groups. It also contends that protest is sustained by common perceptions of community risk and opportunity associated with development, high degrees of interconnectivity and overlapping membership with other protest groups, by relational multiplicity between activists and by strong emotional connections which are built,

reinforced and expanded over time through the act of protest participation. Social cohesion and social identity also features as a powerful driver of protest continuity, influenced by social participation rates, common emotional experiences of external threats and by cultural experiences of activism provided by protest activities such as marches, and symbolic artefacts such as community pickets, embassies and permanent meeting places where protestors can exchange 'war' stories and information. Collectively, these social processes and forces promote the positive internalisation of a collective protest identity and enables the strategic development and sharing of social, human, financial and intellectual capital to address imbalances of power with developers who typically have access to far more resources than community groups.

Teo's (2009) research findings offer a new and potentially powerful perspective to inform and challenge current thinking within construction management research about community protest during the construction stages of controversial housing and urban development projects. In particular, it shows the potential power of using social constructivist theories to inform new thinking in this area. For example, social identity theory can provide new theoretical insights into the construction of distinct and conflicting social identities (e.g. protestors, communities and developers) during the construction stages of new projects; why and how people form cohesive protest groups; their resultant norms and behaviours; and why group members are likely to avoid contact with others categorised as different, meaning that in-group favouritism and out-group discrimination can persist at a local level despite shared interests at a regional and national level (Brewer 2007). Theories of collective action can complement these insights by revealing the processes that collectively harness the community's resources, expertise and networks in opposing controversial projects. Theories of collective action can also help explore the social drivers that inspire protest group formation and collective action, strategies to build group cohesion and mobilise participants and how mass media and social networks facilitate collective action (Ansell 2003). Social networks play a particularly critical role as conduits for the transmission of information, ideas and perceptions through communities and social network theory can provide new insights into this social contagion effect by explaining how community relationship structures (friendships, kinships, neighbours, protest group memberships etc) can amplify or attenuate common perceptions of risk and opportunity associated with development (Shemtov 2003, Son and Lin 2008).

By explaining community protest using these theories, within the context of controversial housing and urban infrastructure projects, we argue that a new theoretical framework can be developed to inform construction management research and practice about the importance of community interaction. To this end, we propose that a number of further questions need to be asked beyond Teo's foundational work to begin to develop such as framework. These are:

1. How do community concerns and perceptions about the risks associated with the construction stages of new housing and urban infrastructure projects spread through communities?
2. Is there a social contagion effect in creating common risk perceptions and how does it work?
3. What is the role of community-based networks in promoting or hindering protest group formation, participation and recruitment during the construction stages of projects?
4. Are these protest groups stable or do they change over time?

5. What is the nature of relationships and narratives linking protest groups to each other and to developers and how do these relationship change over time?
6. What determines the strength of protest group identities? i.e. identification of members with the group and its symbols, loyalty to the group and other group members, perceived shared interests and values?
7. What defines protest group boundaries? Who are perceived to be in-group members, how inclusive is each group, what defines “us” vs “not us” and do groups perceived themselves to be part of a larger super-ordinate (state, nation, industry, NGO etc)?
8. What are the perceived relations to other groups e.g. overlapping in-groups (shared members, resources and interests), or allies (distinct identities but perceived convergent interests), or enemies (in-group and out-group distinction, perceived conflicting interests)?

To build trust within communities, Teo and Loosemore (2010) argued that the objective in answering the above questions should not be to find solutions to reduce protest during construction. This could be construed by community members as serving the dominant enterprise culture which characterises the construction industry (Ness and Green 2009). Rather, the aim should be to build a better theoretical framework to understand, explain and manage community concerns, alongside the challenges of delivering projects within increasingly demanding programs and budgets.

METHOD

The research questions proposed above are best addressed using case studies and ethnographic methods. The value ethnographies lie in developing an insider's view of what is happening when a project is being built (Hammersley and Atkinson 1995). This means that the researcher not only sees what is happening but "feels" what it is like to be part of the group. This in turn requires protestor’s behaviour to be studied in everyday contexts, the research team getting close to the protestors being observed in a natural protest setting, understanding protestor’s points of view and sharing as intimately as possible in the life and activities of the people in the protest setting. This also requires the intensive study of a small number of protests, through an omnibus field strategy that simultaneously combines different forms of data collection such as documentary analysis, interviewing of protestors, direct participation and observation, and introspection. Past and current research in sensitive areas such as community activism and protest indicates that triangulation using multiple sources of data is especially important when investigating emotive topics where many different versions of events may emerge from different perspectives. The case study approach has also been used extensively by researchers investigating community activism in different contexts from gay and lesbian rights to homelessness , environmental activism and social injustice (Baxter *et al.* 1999; Snow and Trom, 2002; Klandermans and Staggenborg, 2002 Gamson, 2003). In particular, case studies are ideal to explore longitudinally and intensively the way that networks of protest form, evolve and shift over time during the construction stages of housing and urban infrastructure projects. Finally, case studies are well suited to the practical and emotional challenges of research into highly emotional and protective community groups. In this risky context, where relationships between researchers and respondents can be fragile and strained, establishing open, honest and trusting relationships with community members is

crucial to gaining access to quality data and is an essential part of the data collection process.

To study community protest during the construction stage, it will be important that the case studies are controversial projects which have recently transitioned from planning to construction stages. These case studies will need to be projects embroiled on-going community protests during their construction phase after development applications have been approved, and the construction firms have been left to handle a hostile community. These case studies should be selected on the basis of their longevity and the complexity of issues posed which may include social, cultural, ecological, heritage and economic. These case studies should also be mature protest movements that have been on-going for at least one year since research indicates that such protests have a greater tendency to be more stable than emergent movements, which have variable memberships (Hirsch, 2003; Whittier, 2002; Klandermans, 2003). Having said this, past research indicates that no matter how suitable the case study seems, ultimately it will depend on the researcher's ability to gain access to the respondents.

Previous studies have shown that the emotional, sensitive, anarchic and factionalised nature of protest groups can make gaining permission to undertake research challenging (Blee and Taylor 2002). Teo's (2009) experience was that this is best overcome by cultivating relationships with people in local networks where protest is based over several months, before making an approach to undertake any research. It is highly likely that the leadership structure of protest groups will not be immediately apparent (a deliberate tactic to avoid legal action by developers) that they will comprise a number of sub-protest groups with overlapping memberships. Research in this area indicates that access is also likely to involve presentations at community meetings, meeting protest group leaders to discuss the research and allowing due diligence on our backgrounds. Indeed, it is not uncommon for initiation ceremonies to be gone through in order gain acceptance into a group. Within the movement, these rituals or symbols serve to reinforce activists' basic moral commitments, stir up emotions, and reinforce a sense of solidarity within the group (Jasper, 2003). Emotions are a product of an individual's participation in collective action and its internal rituals serve as symbolic embodiments, at salient times and places, of the beliefs and feelings of a group. These rituals can take a variety of forms, including singing and dancing, which serve to provide and harness the positive emotional energy (Jasper, 2003). For example, Teo's (2009) experiences of initiation into protest groups against construction projects involved sitting (and sleeping) on community pickets, attending rallies and even being verbally abused by one particular group gate-keeper.

Once commenced, the construction of ethnographies will require the researcher to be deeply involved with each protest over a considerable amount of time (perhaps years). Previous research shows that levels of protest activity will fluctuate over time as issues come-and-go and that the researcher will need to have the flexibility to respond to these changes. Ethnography relies on up-close, personal experience and participation, rather than just observation. Therefore, the ethnographic process will involve being involved in community protests, attending community meetings, rallies and protest events, participating in email discussion networks and circulation lists etc. In additional, where permitted, researcher should seek to film and photograph aspects of the protest activities such as meeting places for protest groups and artefacts which are symbolically important for group cohesion. For example, Cadena-Roa (2002) reported on the effectiveness with which a movement in Mexico City utilised dramatic

representations and culturally embedded symbols in the form of a masked crusader to reflect the injustice, corruption and political mismanagement they opposed. In a construction context,

Teo (2009) pointed to the importance of a community picket which was built out of locally salvaged materials, as a meeting point and source of identity for a community protest. Collectively, previous research indicates these methods of data collection will allow rich descriptive accounts to be produced of activists' experiences of protest that can be cross-referenced to construct context-specific explanations of the experience of protest as understood by protestors. Activist stories will need to be validated through narrative-orientated semi-structured interviews with a representative selection of members from each identified group to yield a series of shared stories that will transcend the accounts of individual protest participants. Again, previous protest research indicates that the number of groups will likely vary from one case study to the next meaning that it is not possible to accurately identify in advance the number of interviews to be conducted. As with all ethnographic research, sampling for interviews will involve selecting knowledgeable respondents who are familiar with the activities of the community protest. Using snowball sampling (Brace-Govan 2004), respondents can be asked to identify other respondents who represent the community protest, also revealing common social denominators connecting protestors into groups and sub-groups.

CONCLUSION

In proposing a series of key research questions emerging out of Teo's formative research and a methodology for investigating them, this paper sets a new agenda for construction management research. This agenda will begin to address a vital and pressing need to develop new ways of thinking which will help managers balance the needs of developers and communities affected by construction activity. It is crucial that construction management research has a conceptual framework which recognises that community engagement does not stop after the predevelopment government approval process and is not the sole preserve of Town Planners but the collective responsibility of all stakeholders involved throughout the entire life-cycle of housing and urban infrastructure projects – from inception to completion. The social benefits of improved community relations resulting from this research should not be underestimated in strengthening the social fabric of our cities and rebuilding eroded public trust between communities, public institutions and private firms, creating more harmonious, happier, healthier and productive communities.

However, this will require a fundamental shift in thinking and the adoption of a new constructivist paradigm that enables researchers to conceive the construction process as an ongoing negotiation between communities and industry representatives. Communities are traditionally neglected as legitimate constituents by many construction management researchers and practitioners and research into these issues is badly needed in overcoming long-standing and ingrained theoretical positions that alienate communities in the development process. Not only will this research contribute novel insights to construction management research, it will also contribute new transferable insights into more established mainstream research on community activism and group psychology.

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PARADIGM INTERPLAY TO DEVELOP A SUSTAINABILITY RELATED KNOWLEDGE MANAGEMENT STRATEGY

Hervé Leblanc[1] and Craig Thomson[2]

School of Engineering and Built Environment, Glasgow Caledonian University, Glasgow, UK

In the construction industry two approaches to Knowledge Management (KM) can be distinguished. First, a functionalist perspective encourages the development of KM strategies and systems aiming to capture, reuse and manage technical knowledge usually with the help of databases and computerised systems. Second, an interpretivist perspective where knowledge is viewed as not existing independently from human interactions with a focus on the development of social structures and processes within organisations. This paper presents the methodological approach to develop a Sustainability-Related KM Strategy (SKMS) for Housing Association (HA) planned works (cyclical replacement of housing components). In this research the authors acknowledge the managerial benefits for construction practice of the functionalist approach but also argue that the socially constructed nature of knowledge requires the interpretivist approach to be considered within the development of the research methodology. As a result, the authors advocate the use of an interpretivist research paradigm with a functionalist perspective to knowledge and explore this through the context of this research, with the benefits and challenges to paradigm interplay considered.

Keywords: research methodology, knowledge management, interpretivism, functionalism, paradigm interplay.

INTRODUCTION

Increasingly, the efficient management of knowledge is being seen as an important part of developing sustainable practice (Renukappa and Egbu, 2007). However, it is not clear how to efficiently map or manage this knowledge which is referred to as 'sustainability-related knowledge' (Malone and Yohe, 2002). Recent years have seen an emerging body of literature relating to the development of KM strategies in the context of the construction industry. However, this is broad by nature, tending to reflect the delicate task, diversity of factors and context specific characteristics of organisations (Tiwana, 2000). In fact, KM approaches are numerous and include among others efforts to capture and reuse structured knowledge, projects that build a

[1] Herve.Leblanc@gcu.ac.uk

[2] Craig.Thomson@gcu.ac.uk

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repository of best practices, initiatives that identify sources of expertise and establish a network of experts, projects that structure and map knowledge, efforts that measure and manage the economic value of knowledge and initiatives that synthesize and share knowledge from external sources and embed it in products and processes (Davenport and Prusak, 1998; Schultze, 1998). As a result, it is difficult for construction organisations to select an appropriate approach and develop KM efforts appropriate to the organisation's needs and culture (Kamara *et al.* 2002).

This paper emerged from a research conducted by the authors focused on improving the sustainability of HA planned works. The research applied knowledge mapping to understand the flow of sustainability-related knowledge during such projects and developed a SKMS consisting of recommendations with a view of improving mechanisms of capture, storage, retrieval and exchange of sustainability-related knowledge. A methodological challenge was observed during the development of the research. To effectively conduct knowledge mapping it was apparent that neither a purely functionalist or interpretivist research paradigm was able to engage with the complex dynamic nature of sustainability-related knowledge and the specific requirements HA planned works context simultaneously. The danger with relying on a purely interpretivist approach was a tendency to reinvent the wheel, when established and recognised KM approaches, and definitions for knowledge forms and sustainability are widely understood. Moreover, the research also needed to recognise phases and activities associated with HA planned works to frame the knowledge mapping exercise around and structure the SKMS in a way that was meaningful to practitioners. On the other hand, the functionalist approach considers knowledge as an object and does not consider the dynamic socially constructed nature of knowledge and therefore would potentially reduce the practical application of the SKMS within HA planned works.

The authors therefore sought to consider the potential for paradigm interplay between interpretivism and functionalism in order to take advantage of both theories. As a result, this paper presents an interpretivist research methodology that addresses the socially constructed nature of sustainability-related knowledge using established functionalist knowledge categories, sustainability dimensions and planned work activities to guide the analysis.

The first section introduces the context of the research (HA planned works) and the approach to knowledge mapping. Next, the two popular KM perspectives in the construction industry are presented: functionalism and interpretivism. The third section explains the rationale for an interpretivist research paradigm with a functionalist perspective on knowledge and defines the forms of knowledge adopted in this research. Fourth, the qualitative research methods adopted are explored. Fifth, the research methodology is illustrated through the sixth stages of the SKMS development. Finally, the authors discuss the research limitations and conclusions.

DEVELOPING A SKMS FOR HA PLANNED WORKS

In the United Kingdom the social housing sector is mainly managed by local authorities (LAs) and HAs, and is at the forefront of the development of sustainable practices (Leblanc *et al.* 2011). In Scotland where this study was conducted, the growing number and financial capacity of HAs places this sub-sector in a privileged position to develop sustainable practices compared to LAs. Furthermore, an aging housing stock and limited budgets for new housing or large refurbishment projects, places maintenance and more precisely planned works at the centre of future efforts.

Although evidence suggests that amongst HA practitioners, awareness of the concept of sustainability is growing, changes in practice remain relatively slow (ibid). The authors argue that despite governmental initiatives and existing sustainable guidelines and frameworks, insufficient emphasis has been placed on the management of sustainability-related knowledge which is held by and is exchanged by practitioners.

The research which forms the context for this paper aims to improve the management of sustainability-related knowledge through a triple bottom line approach to sustainability considering the social, economic and environmental dimensions. In addition, knowledge mapping allows the identification, location and form of sustainability-related knowledge within HA planned works and appears central to the development of an effective SKMS (Renukappa and Egbu, 2007). More precisely a knowledge mapping social network analysis approach with an application purpose was adopted (Eppler, 2008). In this sense the developed knowledge maps (Kmaps) aimed to reflect knowledge transfer, sharing and communication between HA planned works practitioners and were built around a process model reflective of the planned works phases and activities. In the absence of a commonly accepted Planned Works Process Model, the research developed its own Generic Planned Works Model (GPWPM) to provide a structure around which the Kmaps could be structured with a view to reflect practice and to aid comparison between different projects (Leblanc, 2011). The development of a knowledge mapping exercise around such a structure reflects a knowledge application mapping approach that can be found in the work of Egbu *et al.* (2006) or Thomson *et al.* (2011). It aims to reflect practitioner 'realities' of practice and therefore to increase the potential application of related findings.

ADOPTING A KM PERSPECTIVE

From the many existing KM approaches two schools of thought can be distinguished. Those who concentrate on the benefits an organisation can derive from managing its knowledge usually through information technology and those focusing on the control of KM process through management issues (Offsey, 1997). In the former henceforth referred to as the 'functionalist perspective' knowledge is considered as an 'object' existing in a number of forms and locations while in the latter henceforth referred to as 'interpretive perspective', knowledge is considered "not to exist independent of the human experience, social practice, knowledge and knowledge use and where such knowledge is shaped by the social practices of communities of individuals" (Venters, 2002:2). The functionalist perspective considers knowledge through categories that can be managed differently according to their form (ibid). This view represents an objectivist perspective to knowledge as discussed by Nonaka and Takeuchi (1995). These authors categorise knowledge as either tacit or explicit. The interpretive perspective, on the other hand, considers that knowledge cannot be located in one place because it has no existence independent of human experience and the social practice of 'knowing' (Schultze, 1998).

In this research the functionalist perspective to knowledge was adopted since (in the context of implementing sustainability in HA planned works) it is argued that the distinction between the forms of knowledge through established categories could help practitioners to identify and manage sustainability-related knowledge. In fact, the functionalist KM perspectives corresponds to the majority of KM strategies developed in the construction industry because it aims to capture and reuse knowledge and therefore addresses the 'reinventing wheel' syndrome often described as a barrier to improving the construction industry (Ahmad *et al.* 2007). However, the authors also

suggest that the dynamism of knowledge and its socially constructed nature, as described by the interpretivist perspective, cannot be ignored and that the research methodology should reflect it. The authors were therefore faced with a methodological challenge relating to cross paradigm boundaries.

RESEARCH PHILOSOPHY

Research management is divided in two schools of thought that each reflects a philosophical perspective. These are the modernist perspective which gathers functionalism, positivism, objectivist, mainstream, traditional or conventional and the post-modernist perspective which gathers interpretivist, subjectivism, phenomenological or constructivism (Jones, 2009). Jones (2009) further explains that the management researcher might therefore disagree about philosophical assumptions regarding the nature or being (ontology) and what they can know about the phenomena they study (epistemology).

In this study, the research paradigm was directly linked to the adopted knowledge perspective. According to Darmer (2000) the functionalist perspective of knowledge corresponds to a neo-positivism research paradigm. The neo-positivism or post modernism approach differs from positivism in terms of ontology, epistemology and methodology. Neo-positivism advocates an ontology of modified realism as opposed to realism in positivism, where humans are not capable of finding definite answers to what knowledge is. In addition, neo-positivists do not believe that humans can be completely objective (as positivists think). Finally, regarding the methodology neo-positivists modify positivist controlled experiments by doing research in fields that they cannot entirely control (Darmer, 2000). As a result it can be said that neo-positivism criticises the purely positivist research paradigm described in *table 4* below.

Table 4: Description of interpretivism and positivism research paradigm methodology

	Interpretivism	Positivism
Assumptions	Inter-subjective world which science can represent with concepts and indicators; social construction or reality	Objective world which science can measure and "mirror" with expert, privileged knowledge.
Aim	To uncover socially constructed meaning of reality as understood by an individual or group	To discover universal laws that can be used to predict human activity
Stance of the researcher	Becomes fully involved with stakeholders and subject matter to achieve a full understanding of the stakeholders' world	Stands aloof and apart from stakeholders and subject matter so that decisions can be made objectively
Values	Values included and made explicit	Value free; their influence is denied
Types of reasoning	Inductive	Deductive
Research plan	Flexible, and follows the information provided by the research stakeholders	Rigorous, linear and rigid, based on research hypothesis
Typical research methods and type(s) of analysis	Ethnography; participant observation; interviews; focus groups; conversational analysis; case studies	Experiments; questionnaires; secondary data analysis; quantitatively coded documents; statistical analysis
Goodness of quality criteria	Trust worthiness and authenticity; Fit with social norms; interpersonal consensus validated by rightness of advocacy (speech acts) and actions	Conventional benchmarks of "rigor"; internal and external validity; reliability and objectivity; technical excellence validated by objective truth

Adapted from Guo and Sheffield (2008)

Despite the adoption of a functionalist perspective to knowledge in this research, it can be argued that the rigid theory testing methodology of the positivist research paradigm cannot address the specific research context aiming to understand the exchange and transformation of sustainability-related knowledge between HAs practitioners involved in planned works. Moreover, it can be argued that the neo-positivist approach is just a variation of positivism based on the criticism of its strict ontology, epistemology and methodology and its adoption would equally not address the research context.

The research context required a paradigm that considers knowledge to be viewed as part of a social interaction. According to Guo and Sheffield (2008) the interpretivist research paradigm described in *table 4* enables knowledge to be viewed in this way.

The research interpretivist paradigm provided a framework to direct research methodologies. The next section describes the influence of the interpretivist paradigm over the research methodology and how the functionalist perspective of knowledge adopted by the authors was integrated to the process.

Paradigm interplay in this research

The adoption of a philosophical position is of importance within research as it influences the analytical framework, modes of analysis and analytical process. However, in this research the contrast between positivism (more precisely functionalism) and interpretivism research paradigms poses challenges (Jones, 2009; Schultz and Hatch, 1996). More precisely, it is in the modes of analysis that the functionalist perspective adopted by the research needed to be applied. The

interpretivist associative analysis which consists of "reading meanings and exploring the association between them" (Schultz and Hatch, 1996: 537) was carried out, but integrating the functionalist categories to the analysis. This inclusion of the functionalist knowledge perspective within an interpretivist research paradigm corresponds to paradigm interplay (Schultz and Hatch, 1996). Paradigm interplay or paradigm crossing takes the view that it is impossible to ignore the multiplicity of perspectives and researchers should take advantage of the various theories offered.

In this research the adoption of an interpretivist paradigm helped to free up the rigid nature of functionalist categories. Equally, the adoption of functionalist categories within the interpretivist research helped to maintain control over the analysis and ensured that the mapping exercise reflected the established definition of knowledge and sustainability. It can also be said that paradigm interplay recognised the multi-faceted nature of knowledge which its meaning may vary according to the practitioner and context (Egbu, 2006). Finally, in this research the methodological approach considered the dynamic nature of knowledge that transform between the functionalist categories.

Defining the functionalist forms of knowledge

In this research three types of knowledge are defined: explicit, tacit and implicit. Explicit knowledge is codified and digitised for example in books, documents, reports, white papers, spreadsheets, memos and databases (Awad and Ghaziri, 2003). Tacit knowledge is not easily transformable and defined as 'know-how', past experiences, expertise, through interaction between individuals and through the memories of others (Renukappa and Egbu, 2007). Finally implicit knowledge corresponds to the part of tacit knowledge that can be easily transformed into explicit form (such as opinion and idea) (Frappaolo, 2008). Furthermore it can be said that implicit knowledge resides between tacit and explicit knowledge in the 'middle ground' zone (Frappaolo, 2008). Although the above definitions of explicit, tacit and implicit knowledge are widely accepted in the literature the lack of clear distinction between implicit and tacit considerably complicates the task of knowledge mapping. To avoid any confusion and for the sake of clarity, in this research tacit knowledge is the knowledge that resides in practitioners' minds which cannot be shared while implicit knowledge indicates the part of the practitioner tacit knowledge that can be shared through discussion or transformed into explicit form.

ADOPTING A QUALITATIVE METHODOLOGY

Within the context of this research, the research methods were used to carry out a knowledge mapping exercise. Knowledge exchange includes a human dimension that quantitative research approaches based on mathematical analysis would have difficulty capturing. As a result, qualitative research methods were considered more logical under the interpretivist paradigm, allowing for a deeper understanding of HA practitioners sustainability-related KM practices.

Multi-case study

In this research knowledge mapping aimed to develop an understanding of the flow of sustainability-related knowledge between HA practitioners in planned works, a case study approach appeared a logical choice. KM systems or strategies need to be specific and tailored to practitioners' reality of practice. The case study approach under the interpretivist research paradigm allows for the study of real-life examples and the emergence of findings grounded in reality. Despite the recognised potential

benefits, the case study approach faces criticisms such as insufficient precision, objectivity and rigor (Yin, 2003). To increase the research reliability and support data collection and analysis a protocol describing the case study objective, field procedures, questions to practitioners (both general and specific) and guiding the report was developed (table 2 below).

Table 5: Case study protocol

Objective	To map sustainability-related knowledge exchanges for every phase/activity.
Field procedures	
Respondents	Practitioners potentially having an impact on the project sustainability
Record keeping	Digital Dictaphone
Location	HA office or field
Data	Qualitative
Data collection	Interviews and sustainability policies/action plans
Data analysis	Open coding and categories
Case study questions	Does the GPWPM corresponds to the HA planned works practice?
	What are the economic, social and environmental sustainability aspects and associated knowledge source(s) and associated communication method for each planned works phase/activity?
Report	
Reporting	Presentation of steps of analysis and discussion of Kmaps per phase/activity
Unit of analysis	Organisation

In this research a multiple case study approach (4 projects) allowed for comparison of management approaches to sustainability-related knowledge amongst HAs representing a cross section of specific HA contexts. This comparison led to a relatively general strategy, potentially addressing a large number of HAs and planned works while including specific variations reflecting the case studies specificities. Semi-structured interviews ensured that sufficient control was maintained in pursuit of the objective but allowed enough room for open-ended discussion when desired by a respondent (Glaser and Strauss, 1967).

Coding under the grounded theory principles

Grounded theory coding principles were adopted to analyse the data collected in order to develop findings emerging from respondent answers in concordance with the interpretivist research paradigm. The interviews were transcribed and coded following open coding principles (see SKMS development stage 3). Respondent answers were openly coded but these codes were then classified under the case study phases and activities and categories (see SKMS development stage 4). The research coding strategy aligns with Strauss and Corbin (1990) principles who allow a certain degree of structure to the coding as opposed to Glaser's (Glaser and Strauss, 1967) 'purist views'. In the context of this research this analysis approach allowed the theory to emerge from the data as prescribed by the interpretivist research paradigm but enabled the coding to be aligned with the functionalist categories facilitating Kmaps development.

DEVELOPING THE SKMS

The knowledge mapping exercise leading to the SKMS development consisted of sixth stages as illustrated in the figure 1 below.

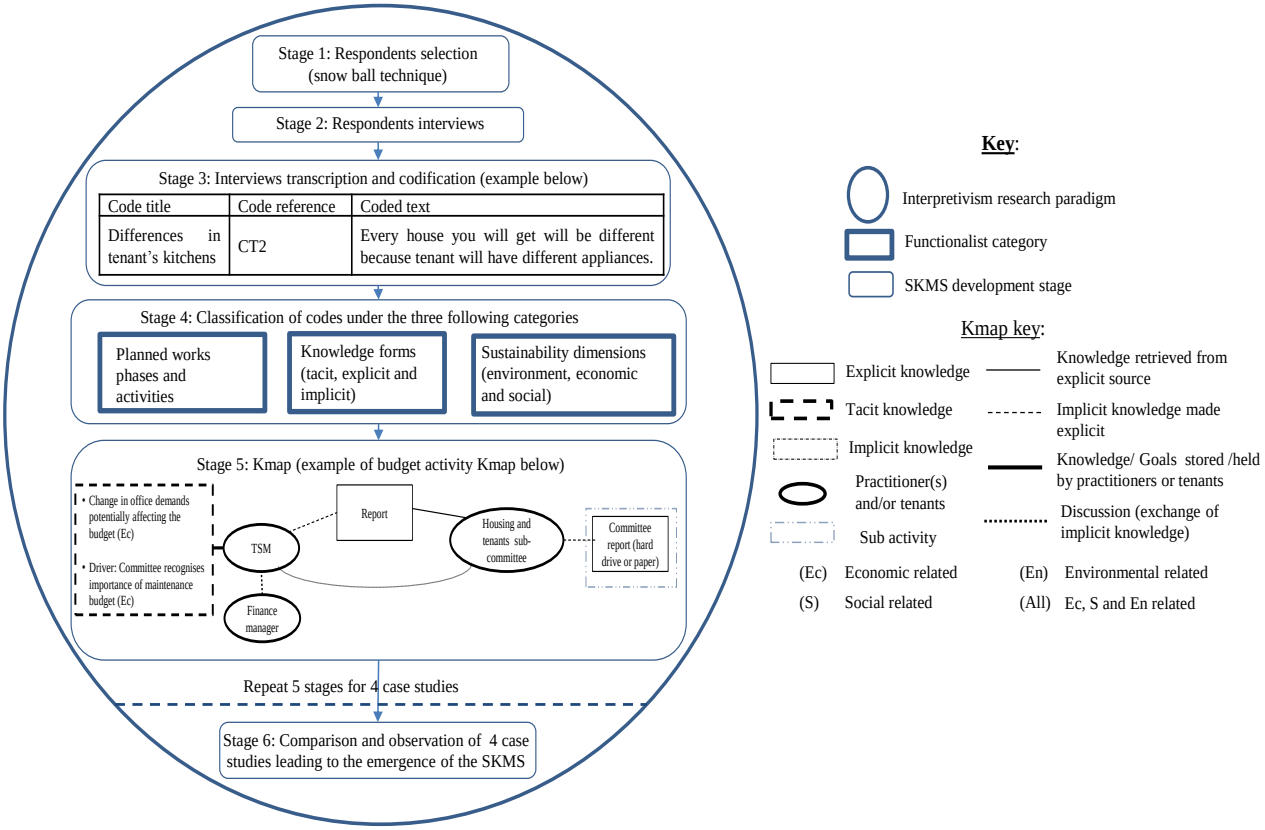

Figure 15: SKMS development stages under the interpretivist paradigm and using functionalist categories

First, HA practitioners with potential influence over the planned work project and its sustainability were selected. Based on emergent principles, it was not possible to randomly select practitioners to interview because it was acknowledged that this would influence the case study findings. As a result, the authors asked HA practitioners to help identify other practitioners as appropriate units of analysis. This approach is referred to as the 'snow ball' technique and is often used within emergent studies because it limits researcher assumptions about whom to interview and instead relies on respondents' knowledge. Second, selected respondents were asked to describe for each project activity what sustainability aspect was considered, what related knowledge was required and its nature, source and communication pathway. Third, digitally recorded interviews were transcribed and analysed under the open coding principles. The text was divided into meaningful portions that were assigned a code title and a code reference. This process allows codes to be compared and grouped together to form categories and subcategories and to let the findings emerge from the data (Strauss and Corbin, 1990). The code title was developed to briefly describe the text with the respondent's vocabulary and the code reference is composed of the respondent's abbreviation and assigned number. Fourth, the codes were classified according to the project phases and activities, the three sustainability dimensions and the functionalist knowledge forms. Fifth, based on the previous stages Kmaps for every case study planned work activities were drawn. Finally, following

the emergent principles of the research, observational themes were identified around which the sustainability-related KM strategy emerged:

- Management: Practitioners/tenants role and responsibility in the phase/activity.
- Knowledge: The type of the mapped knowledge and its flow between practitioners/tenants.
- Economic: The amount and scope of economically related knowledge or goal mapped within the phase /activity.
- Social: The amount and scope of socially related knowledge or goal mapped within the phase/activity.
- Environment: The amount and scope of environmentally related knowledge or goal mapped within the phase/activity
- Sustainability: The sustainability dimensions addressed within the phase/activity compared to the triple sustainability bottom line approach.

The structured observation and discussion of case studies knowledge mapping exercises allowed for lessons to be drawn for general practice that can then be contextualised to individual projects. The SKMS is therefore composed of 56 recommendations for improving mechanisms of sustainability-related knowledge creation, capture, storage and exchange between practitioners for every planned work activity. For example, in three case studies the 'progress meeting' activity was a formal opportunity for practitioners to discuss (exchange implicit knowledge) matters in order to solve problems and suggest solutions. Furthermore progress meeting activities were identified as formal meetings where the contractor was asked to propose sustainable solutions. Finally, progress meetings were generally explicitly summarised in minutes which therefore represent a source of knowledge that practitioners use before to take decisions. As a result the following recommendation was proposed: "HAs should emphasise the exchange of sustainability-related knowledge during progress meetings and should make the meeting minutes easily retrievable. "

LIMITATIONS

The presented methodology following paradigm interplay allows the development of a SKMS that is rooted in the practice based context through case studies. However, there are some shortcomings and limitations. The knowledge mapping exercise is time consuming and the specification of its findings can only be related in detail to its context. As a result, additional mechanisms of sustainability-related knowledge capture, exchange, storage and retrieval might be found in other HA planned works. The developed SKMS could therefore be improved through the expansion of the number of case studies. Expanding upon the number of case studies could enrich the sustainability-related KM observations allowing for a better understanding and leading to the improvement of proposed recommendations for improvement.

However, care is required to ensure that the functionalist categories applied during coding analysis respect the interpretivism paradigm and its emergent principles.

CONCLUSIONS

The presented methodology allowed for the development of a SKMS for HA planned works that emerged from a variety of practice based case studies. This paper has explored the role of paradigm interplay in allowing for the development of a strategy to draw on established definitions of knowledge types and sustainability dimensions, while considering the socially constructed nature of knowledge through an emergent

approach. Authors took advantage of the interpretivist research paradigm through the use of the snow ball technique, semi-structured interviews, case studies and open coding allowing findings to emerge from respondents' answers and their context. Furthermore, the structured approach to knowledge mapping and the adoption of functionalist categories allowed the development of Kmaps which can be compared across different studies. This also helps to minimise modernist critics about interpretivist emergent principles and the need for focus. It can be therefore concluded that in this research the authors take advantages of the interpretivist paradigm and established functionalist research approaches to increase the potential usefulness and applicability of the findings. The result is a SKMS that manages explicit, tacit and implicit knowledge like many existing KM efforts but also integrates the dynamic nature of sustainability-related knowledge reflective of context.

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MODELLING THE IMPACT OF EXTREME WEATHER EVENTS ON HOSPITAL FACILITIES MANAGEMENT USING A SYSTEM DYNAMICS APPROACH

Vivien W. Chow[1], Martin Loosemore[2] and Geoff McDonnell[3]

[12]*University of New South Wales, Faculty of the Built Environment, Sydney, NSW 2052, Australia*

[3]*University of New South Wales, Centre for Health Informatics, Sydney, NSW 2052, Australia*

Heatwaves kill more Australians per year than any other type of natural disaster and are predicted to increase in intensity and frequency due to climate change. Effectively designed and managed hospitals are therefore a critical and central part of a community's response to such events. While our understanding of these impacts is increasing, the impacts of potential knock-on effects from other critical infrastructure are not well understood. Using a case study approach, system dynamics is used to investigate the impact of heatwaves on community infrastructure and healthcare facility management outcomes. This provides hospital facility managers with a new way to understand and maximise the resilience of hospitals to the effects of extreme weather events.

Keywords: facility management, heatwaves, system dynamics, hospitals, risk management, health, extreme weather events

INTRODUCTION

The United Nation's Intergovernmental Panel on Climate Change (IPCC 2011) found that in the 21st century "it is *very likely* that the length, frequency and/or intensity of warm spells, or heatwaves, will increase over most land areas" (the italicised phrase "very likely" is one of the IPCC's standard terms, used to denote a probability of over 90%). They predict that these heatwaves will have greatest impact on sectors with close links to climate such as "health" and "infrastructure" (IPCC 2011: 12). In Australia, heatwaves present a particularly high health risk and kill more people than any other natural disaster (PWC 2011). While new Australian hospital buildings are reasonably resilient to climate change, there is considerable scope to improve the resilience of existing building stock through new adaptation strategies (DEWR 2007, Loosemore *et al.* 2011). Not only do heatwaves increase the demand for hospital services by affecting morbidity and co-morbidity, they also have the cumulative effect of disrupting critical hospital and community infrastructure such as electricity supply with subsequent knock-on effects to other critical systems such as water, gas, transport and waste treatment (The Royal Academy of Engineering 2011, DEFRA 2011, PCI 2011). For example, the Victorian heatwave in January 2009 resulted in rolling blackouts, cutting off power to over 500,000 people and disrupted public services such as health and telecommunications (NCCARF 2010). Similar affects have been experienced in many other countries. Both Klein (2005) and Hiete *et al.* (2011) reveal

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how electrical power outages are common around the world and how healthcare facilities are especially vulnerable to failures such as in lighting systems, communications technologies, computer systems, heating and cooling systems, water supply and filtration, food storage, refrigeration, operating theatres and alarm systems. Yet as Hiete (2011) also points out, there has been little research done in this area. Therefore, in this context, the aim of this paper is to report research that investigated the potential impact of extreme weather events including heatwaves on the effective management of healthcare facilities.

USING SYSTEM DYNAMICS TO ASSESS RISK

Loosemore *et al.*'s (2011) assessment of the facility-related risks posed to hospitals during extreme weather events uncovered a wide range of risks and opportunities. During a follow up study, the analysis of interdependencies related to these risks and opportunities demonstrated the limitations of traditional "tick-box" risk management methodologies to understand the problem and develop effective response strategies (McGeorge, *et al.* 2011). These, they argue, produce an artificially linear and static picture of hospital exposure, whereas the impact of an extreme weather event is in fact dependent on a dynamic network of time-related interdependencies within a complex array of human, organisational, technological and physical sub-systems. As Koubatis and Schonberger (2005) point out, traditional approaches to risk management were designed for simple linear systems in relatively stable environments and are inappropriate for complex, dynamic and interdependent systems (such as hospitals) in unpredictable environments.

Given the significant limitations of existing risk management approaches in understanding heatwave risks on hospital infrastructure and the predicted increase in heatwave events, there is an urgent need to employ new methods which can model these subsystem interdependencies in order to develop new evidence-based strategies to mitigate these risks. In this context, system dynamics (SD) holds significant potential. SD is a perspective and set of tools that allow us to better understand and model the structure and dynamics of complex systems (Sterman 2000). SD methods are able to represent and simulate, over time, the complexity, nonlinearity, time dependency and feedback loop structures that are inherent in complex systems such as hospitals.

Simulation models have previously been used to map hospital operations such as patient flows (Lane *et al.* 2000; Yi *et al.* 2010) and the provision of healthcare in a disaster situation (Fawcett and Oliveira 2000). Arboleda *et al.* (2007) used a system dynamics simulation model to assess the impact of an earthquake on the occupancy and patient flow of a health care facility in America, taking into consideration the disruption posed to the water, power and the road network.

The advantage of using a SD approach is not only its ability to model health system interdependencies during such events but the production of a simulation tool which will enable health system facility managers to experiment, in a virtual world, with different hospital risk control strategies to optimise health care outcomes. This "collaboration artefact" enables stakeholders to engage in group model building, policy design and testing which can help design more effective policies and organisations (Martinuzzi and Kopp 2011). Given the 24/7 operation of most hospitals and the criticality of services provided to the community, such experiments are extremely problematic if not impossible in the real world.

METHODOLOGY

A multiple case study approach was adopted for this study because case studies represent the best way to study complex, open systems such as healthcare (Yin 2009). Our case studies were chosen in close consultation with partner health services in Australia and New Zealand and are described in Table 1.

Table 1: Case studies

Case study	Description
1.	Coffs Harbour hospital is the largest hospital on the North Coast of NSW and is the area's major referral hospital.
2.	Ceduna hospital provides primary healthcare to the residents of Ceduna and surrounds in South Australia. Ceduna has a population of 3,500 people and 24% of the population are Aboriginal and Torres Strait Islanders.
3.	Whangarei district hospital is located 160km from Auckland, New Zealand, and is the largest urban centre in the Northland region, serving a population of about 75,000.

Case study data were collected using a proprietary system called Risk and Opportunities Management System (ROMS 2012). Using ROMS, focus group sessions were conducted at each case study hospital with key stakeholders such as facility managers, business managers, emergency staff, nurses, clinicians, hospital administrators and community health specialists. Transcripts of the workshops were then cross-referenced and analysed using content analysis to map the interplay of the many interdependent subsystems identified. This process represents the first stage (qualitative reflection) in employing a SD methodology (see Figure 1). The methodology consists of four main stages: Qualitative Reflection; Computer Model Formulation and Simulation; Simulation Testing & Evaluation; and Simulation Policy and Interaction Experiments (Zagonel 2002).

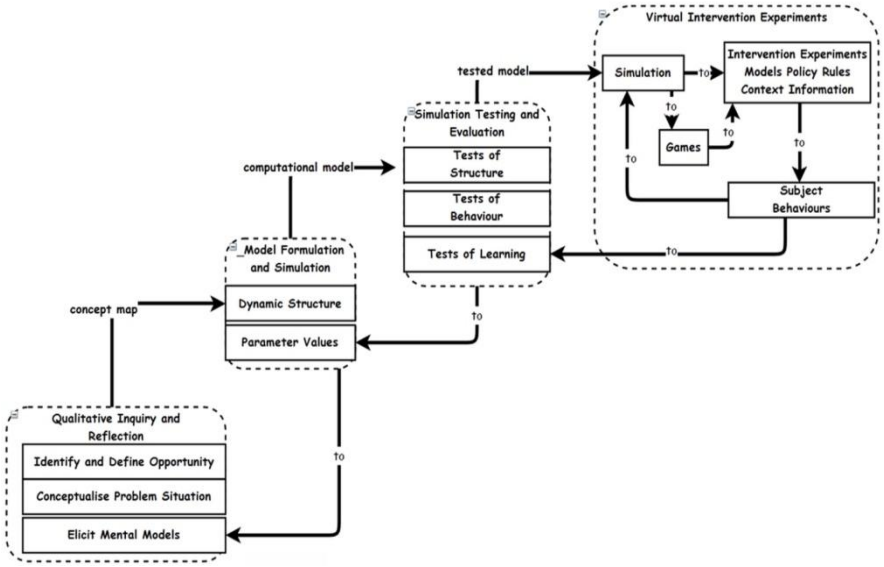

Figure 1 SD methodology (Source: adapted from Zagonel 2002)

Following the "Qualitative Reflection" stage described above, the "Computer Model Formulation and Simulation" stage involved creating an aggregated top down model

by producing rich picture diagrams (RPDs) of the three case studies using a pattern recognition technique developed by Guest and McLennan (2003). In essence, a RPD is a pictorial multi-layered representation of the real world using symbols to represent sub-systems and their relationships within a defined system boundary (Patching 1990). We then aggregated and synthesised the information into a single map of linked concepts, where relationships between main concepts are connected by "linking words" or "linking phrases" (Novak and Cañas 2008). The resulting concept map is presented in Figure 2.

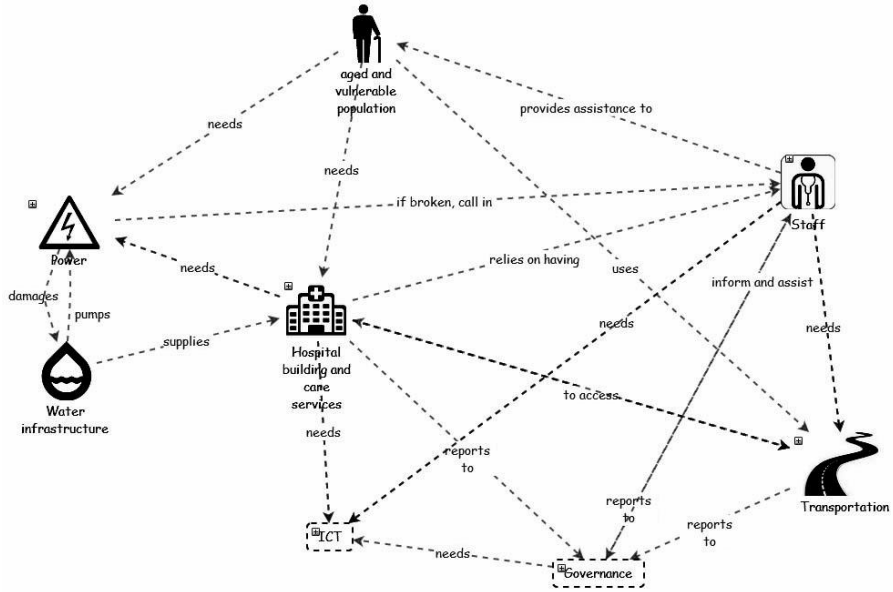

Figure 2 Aggregated map of linked concepts

The aggregated linked concept map shown in Figure 2 represents a generic model of the various components of the system which can be affected by an extreme weather event such as a heatwave. The effectiveness of the whole system in responding is therefore determined by how well these interdependencies are recognised and enabled through the various interacting management systems and through the informal actions of human actors who might be forced to move outside those systems (the invisible organisation). This concept map was then converted into a dynamic map of stocks, flows and interactions of key items of interest in the system using a process view, together with the relevant connecting information feedbacks and delays. While the RPD emphasised the interactions of the system, stock and flow diagrams represent their underlying physical and feedback control structure (Sterman 2000). In simple terms, stocks represent accumulations of money, materials and information in the system and flows represent the rate of increase or decrease in those stocks over time as the system operates. For example, as patients are admitted, treated and cured through health care services being delivered, the number of patients staying in the hospital rises and falls. In creating a stock and flow diagram, it is important to define an appropriate level of aggregation and a boundary for the stock and flow maps. The stock and flow diagram for our aggregate linked concept map is illustrated in Figure 3 and was produced using a program called Insight Maker (http://insightmaker.com/).

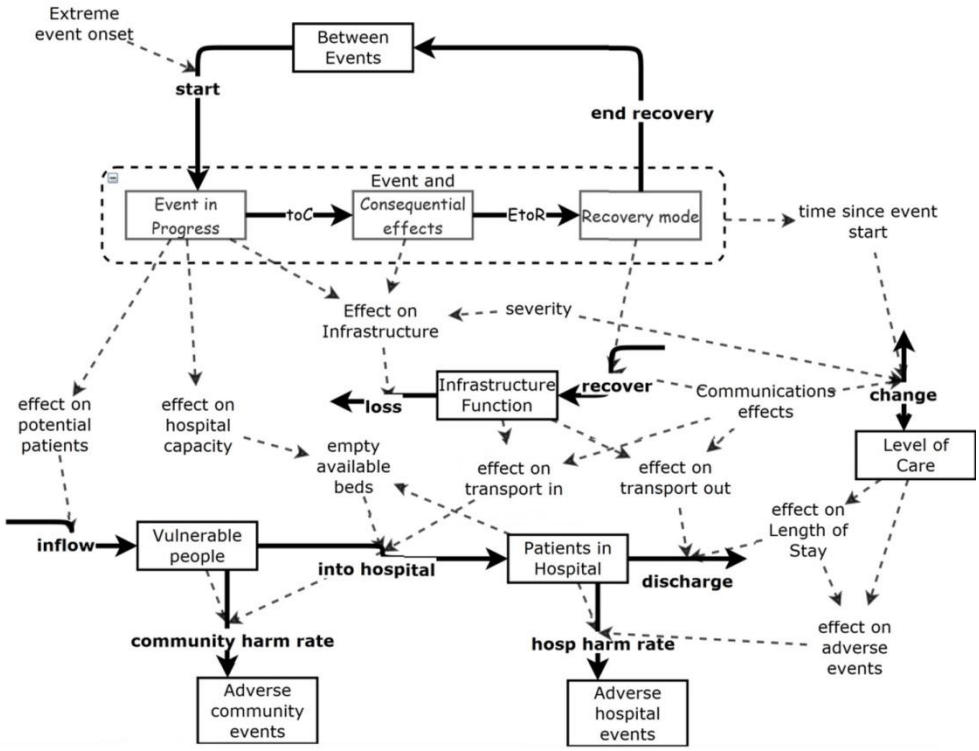

Figure 3 Stock and flow diagram created using Insight Maker

An extreme weather event directly affects the flow of patients and the level of care available from within the hospital. The top of the diagram shows the timing of the event and its consequences, the loss and recovery of community infrastructure, and the change in the level of care inside the hospital. The bottom of the diagram shows the flow of patients from the community to the hospital and the accumulation of adverse events suffered by the patients as a result of not receiving care in time.

During the third "Simulation and Testing" phase of Zagonel's SD method the stock and flow model was progressively refined over multiple iterations with experts and differences between the real world event patterns and the model outputs were detected and reconciled. Sterman (2000:852) describes modelling as "… a process of communication and persuasion among modellers, clients and other affected parties. The real test is whether the model helps make better decisions. Therefore it is important to test the overall suitability of the model for its purpose, its conformance to fundamental formulation principles, the sensitivity of results to uncertainty in assumptions, and the integrity of the modelling process."

The final stage of the SD method was to simulate the model which involved experimenting with parameter values to test the resilience of the system in the face of different scenarios. In our case this was a heatwave with and without an induced electrical outage scenario. These scenarios were constructed around the impact of the heatwave followed by an induced electrical outage on the model's key performance measures. The scenario fed into the model was generated out of our second ROMS workshop at Ceduna District Health Services. The hospital is located in a very isolated arid zone with hot dry summers and very high temperatures. Although extreme heat has been common historically in Ceduna, periods of prolonged temperatures in the mid 40 degrees Celsius range has increased in frequency and intensity in recent years. One of the scenarios envisaged in this workshop was that a heatwave could potentially stress or even knock-out electrical supply due to electrical grid and generator

overload. This would in turn reduce the capacity of the hospital to deliver appropriate levels of care to their area. Also, some supporting care agencies' occupational health and safety policies prevent their staff from road travel during heatwaves due to extreme heat and fire risks, which further limits the level of care that is delivered at the hospital and in the local community.

RESULTS

A proof-of-concept model was set up to first examine various parameters of the hospital healthcare system as identified in Figure 3. Key performance indicators which best represented the successful functionality of a hospital were selected. Some of these indicators and their descriptions are given in Table 2 below.

Table 2: Selected hospital key performance indicators

	Key performance indicators	Description
1.	Access functionality index	The extent to which the road infrastructure providing hospital access retains their functionality.
2.	Index of care	The ability for care to be provided to patients.
3.	Adverse non-admit events	Number of patients who will likely suffer an adverse impact due to the inability to access hospital treatment in time.
4.	Adverse hospital events	Number of patients who will likely suffer some sort of adverse impact while inside the hospital.
5.	Time under care	The total amount of time it takes for a patient to be treated, measured from when they fall ill/are injured, to when they are discharged from the hospital after receiving the treatment required.

Our base case scenario assumes a heatwave event that starts on day 5, lasts 14 days, and then takes a further 2 days to ease. A behaviour-over-time graph of this base scenario is generated to explore likely short to medium term effects the heatwave event may have on the hospital system. Figure 4 shows that the road access remains 100% functional during the first 6 days, before starting to decline to 75% between days 6 and 18.5. It recovers rapidly and is again fully functional by day 21. This takes into account the cumulative effect of a proportion of healthcare staff being prohibited from travelling by road, which abates abruptly once the event has past. The index of care, which is directly influenced by how well staff and patients can access the hospital, follows a similar pattern to road access functionality but then takes significantly longer to recover. The recovery rate depends on how severely care has been disrupted; how long the consequential effects of an event last; and how quickly the hospital is able to progress from "response" mode to "recovery" mode.

The two key performance indicators discussed above have a knock-on effect on the number of "adverse non-admit events" and "adverse hospital events" in the healthcare system. Both are influenced by the prevalence of vulnerable people in the hospital's catchment area, which increases during and immediately after a heatwave event. However, "adverse non-admit events" is also caused by the inability of patients to access the hospital due to unsafe road conditions; whereas "adverse hospital events" is exacerbated by prolonged waiting times at the hospital due to a reduced "index of care". Both will contribute to the total number of adverse events, but as they have different causes it is important to monitor them independently.

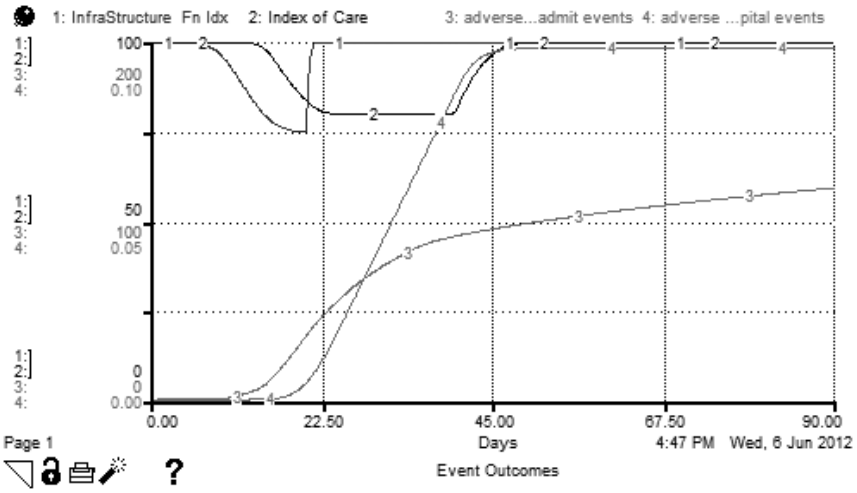

Figure 4 Behaviour-over-time graph showing the effects of a heatwave scenario without electricity outage on (1) access functionality index; (2) index of care; (3) adverse non-admit events; and (4) adverse hospital events

After establishing the base scenario, we then reconfigured the model parameters to simulate a power outage scenario, assuming that it will extend the heatwave crisis and delay the start of the recovery process by 4 days. The new behaviour-over-time graph (Figure 5) shows that in the event of a power outage during a heatwave, the "index of care" decreases significantly to 60% of its full capacity and takes slightly longer to recover afterwards. Cumulative "adverse non-admit events" increase from 109 to 158 events by day 90, and the "adverse hospital events" also increase from zero events to 0.5 events.

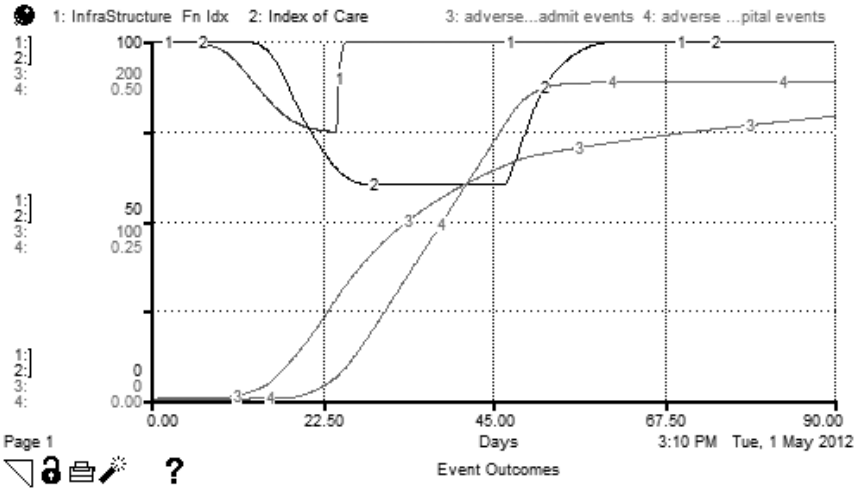

Figure 5 Behaviour-over-time graph showing the effects of a heatwave scenario without electricity outage on (1) access functionality index; (2) index of care; (3) adverse non-admit events; and (4) adverse hospital events

Figure 6 shows how an electrical outage scenario would negatively impact on the efficiency of the hospital system. In the base scenario, it has been assumed that the

average length of stay at this hospital is 8 days. In a heatwave scenario, due to a surge in patient demand, patient treatment is delayed, and the total length of stay peaks to 20 days on day 39 before slowly readjusting to 12 days by day 90. Where an electrical outage occurs as well, the problem is exacerbated and the total length of stay peaks to 23 days on day 46. The graph demonstrates the realities of feedbacks and delays raised earlier: that although the heatwave event last 14 days, it will affect the hospital system for a much longer period. The severity to which it affects the hospital system depends in part on how badly the system is hit, and how long the system takes to begin to recuperate from the event. This graph shows the accumulation of a range of competing factors affecting delivery of care in hospitals. It demonstrates a holistic understanding of admission rates and occupancy during and immediately after heatwave events, allowing hospital facility managers to more adequately address facilities and spatial requirements for hospitals throughout times of need.

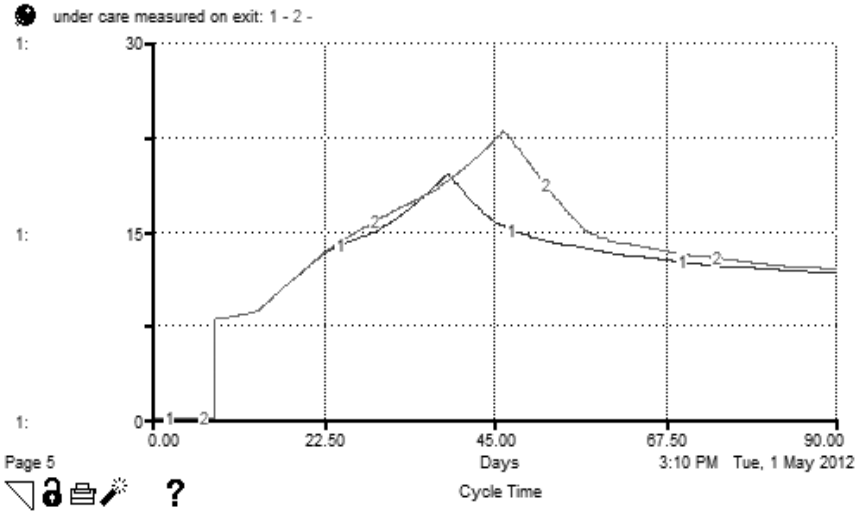

Figure 6 "Time under care" in the base heatwave scenario (1) compared with the generator failure scenario (2)

CONCLUSIONS

A proof-of-concept SD model of extreme weather events was used to replicate the history of a specific heatwave event, based on the known data from that event. Key performance indicators for the hospital system were selected and parameters were set to explore how the hospital system might cope first under the known heatwave scenario, and then when combined with a hypothetical outage scenario. A series of virtual experiments were conducted to test the extent to which vital functions, such as the "index of care", would be lost, and how long they would take to recover fully.

By examining the interactions and co-dependencies of various parameters, this study demonstrates the importance of understanding stocks, flows and delays in a complex system such as a hospital system. It allows the user to test how changing a particular parameter, such as the duration of event or recovery time, may impact on the system as a whole, enabling a holistic instead of a myopic approach to problem solving. This general model can be used to aggregate experiences of a variety of extreme weather events. By focusing future data collection for extreme weather events on test strategies to improve resilience to a wide range of events and their consequences, this model can improve the rate of learning from past events. It can also safely test, in a virtual world,

specific intervention methods to determine their effectiveness in mitigating the loss of function in such events in the future.

Systems thinking and SD challenges existing linear and reductionist ways of approaching risk management, in the field of facilities and construction management. This paper has shown that it has significant potential to be used effectively to supplement existing risk management strategies for facility managers, who by necessity often view their facility in isolation from the surrounding infrastructure in which it is imbedded. Taking the systems view allows policy makers and managers to consider the connectivity and interdependency of their asset in the wider policy and strategic environment.

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RESOLVING THE METHODOLOGICAL CONUNDRUM: BOLSTERING THE RESEARCH ACHILLES HEEL IN SOUTH AFRICA

F.A Emuze[1] and W.M Shakantu[2]

[1]*Built Environment Research Centre (BERC), School of the Built Environment, Nelson Mandela Metropolitan University, PO Box 77000, Port Elizabeth, South Africa, 6031*

[2]*Department of Construction Management, School of the Built Environment, Nelson Mandela Metropolitan University, PO Box 77000, Port Elizabeth, South Africa, 6031*

Determining, understanding, writing and applying research methodology to treatises, dissertations and theses has been and continues to be a major challenge for students and supervisors alike. This research was thus conducted in order to chart a pathway out of the methodological conundrum. The method used is an expository review of the methodology chapters of existing honours treatises, masters treatises and dissertations, and doctoral theses archived in a South African university. The critical literature examination was however limited to construction management research (CMR) outputs. The findings reveal that the research planning, locating the related literature, balancing between describing the problem qualitatively and quantitatively, establishing the number of parameters that need to be measured / observed, and determining the nature of the research problem are the weak points in the establishment of an appropriate philosophical position and associated selection of method. Moreover, there are instances where instead of letting the nature of a particular research problem dictate its means of solution, favourite methodological frameworks and methods were employed without a reflection about the features of the problem. The implication for this research is that it is necessary to situate the research background in the relevant research paradigm. In other words, resolving the methodological conundrum could bolster the research Achilles heel that has hitherto bogged down research productivity and completion.

Keywords: education, philosophical position, research methodology, South Africa

BACKGROUND

Fellows (2010) noted that paradigms concern ontology and epistemology and so, relate directly to methodology and, then, proceed to data collection and analyses. He further suggests that it is essential to understand the terms clearly and to express the position adopted based on justifiable theoretical and / or pragmatic considerations. Pragmatic considerations in turn brush aside the quantitative / qualitative divide by contending that the key question is whether the research has assisted investigators to find out what they want to know (Feilzer, 2010). Although it is not rigidly fixed on

[1] Fidelis.Emuze2@nmmu.ac.za

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methods used as long as the methods used have the potential of providing answers to what the researcher want to know, pragmatism requires a rigorous understanding of both quantitative and qualitative method that is transparent and replicable as much as possible (Feilzer, 2010).

Fellows (2010) equally observed that for some time now, researchers have been required to adopt, articulate and justify their ontological and epistemological position and, thus the paradigm adopted, so that the research method / methods, and findings can be examined in context. Within the construction and built environment research domain, Fellows (2010) noted that the dominant paradigm has manifestly been positivistic and quantitative, followed by the qualitative / or constructivist paradigm that has gained ascendancy by employing interpretivism, grounded theory and other research strategies. The emergent paradigm based on the triangulation debate involve the integration of previously individual paradigms, and their adopted methods of investigation, into a more complex, and perhaps, realistic view (Fellows, 2010).

Given the number of paradigms and research strategies available to a researcher in the multi-disciplinary construction management subject area, the choice of methodology to be used for an enquiry can be worrisome to students and supervisors. Therefore, this paper addresses the challenge by conducting a research so as to chart a pathway out of the methodological conundrum.

SYNOPSIS OF THE RESEARCH PARADIGM DEBATE

Almost all research studies in social and behavioural sciences, regardless of disciplines / programmes, require a rationale before it can proceed. The rationale / basis are often called the theoretical framework, which indicates the big research picture, identifies the literature reviewed and then, directs the research objectives (Radhakrishna, Yoder & Ewing, 2007). Thus, the decision to select a research design depends on the goals of the study and the review of related literature that provide a solid foundation for developing the theoretical framework.

Developing knowledge when conducting research could be made easier when a structured approach that will aid the tackling of the project in sequential and manageable way is followed. Layers of research could start at the paradigm layer and then move to strategies, choices, approaches, and time horizons until a method or methods are chosen (Collins, 2010). In this context, a research project can begin by choosing paradigms such as positivism, realism, interpretivism, objectivism, subjectivism, pragmatism, functionalism, radical humanist and radical structuralist. It can then proceed with strategies that are not limited to experiment, survey, case study, action research, grounded theory, ethnography and archival research. Whatever paradigm or strategy that is used, project participants need to clearly understand it, and the choice should aid the realisation of stated objectives.

The complexities of the industry in terms of its dominant project nature and the need to proffer solutions to old and new problems by researcher have encouraged debates about how knowledge is created in the domain. The methodological debate related to construction management research began when Seymour and Rooke (1995) suggested that the dominant rationalist paradigm is used within the research domain (Edwards & Holt, 2010). While proposing different perspectives, the debate by several researchers (see Edwards & Holt, 2010) went on to call for an examination of construction management research paradigms.

The construction management research methodological debate then led to the investigation of the objective / subjective or quantitative / qualitative divide. For example, Dainty (2008) examined methodological positions and research methods used by a sample of the construction management research community and raised questions related to its constricted ontological and epistemological position. The article that discussed the implications of the apparent narrowness of the construction management research community's methodological outlook and the implications for understanding the practice of construction concluded that the field appears to be firmly rooted within the positivist tradition (Dainty, 2008).

RESEARCH STRATEGY & RESULTS

The method used for generating the primary data is an expository review of the methodology chapters of existing honours treatises, masters treatises and dissertations, and doctoral theses archived in a South African university. The examined research outputs were submitted between 2008 and 2012. In total, 64 research reports were reviewed. The critical literature examination was however limited to construction management research outputs.

Table 1 indicates the methodological approaches denoted by the BSc (honours) treatises that were reviewed. Out of a total number of 42 treatises, 5 were submitted in 2009, 12 were submitted in 2011, and 25 were submitted in 2012. The review of the treatises submitted in 2009 show that the results of 4 were based on quantitative survey method and 1 was conducted with a mixed methods approach. The 2011 treatises that were reviewed indicate that 10 students utilised the quantitative method, while 2 of them used mixed methods. In addition, in 2012 that 25 treatises were submitted, the quantitative method account for 21 treatises, while the qualitative method and the mixed methods were used by 4 students. A closer look at the treatises also show that in terms of unit of analysis, 31 focussed on projects, while 11 addressed industry issues. With titles such as "planning and control of construction projects", all the 2009 BSc (honours) graduates addressed project management related issues.

The treatises show that topics such as defects, non-conformances, quality, communication on site, delays, management information systems, rework, productivity, risks, health and safety (H&S), the environment, construction and demolition (C&D) wastes, and labour intensive construction were addressed by the students with regard to project management. Although treatises that addressed industry issues were few, they nevertheless examined the intricacies surrounding corruption and ethics in the industry. The impact of the recent global financial meltdown on the industry as a whole, and the residential property sector in particular in terms of profitability and organisational sustainability were also researched..

While a sizeable number of the sample strata were compiled by a random sampling method, some of the 2012 treatises relied on the purposive sampling method.

Purposive sampling is a procedure in which the researcher samples those that are deemed to be representative of a given population (Springer, 2010). The difference between purposive sampling and probability sampling methods is that purposive sampling is based on the researcher's informal ideas about representativeness.

Furthermore, the entire BSc (honours) treatises featured the survey or interview of general contractors (GCs) in the Southern Africa region. With the exception of 4 treatises that featured primary data that were generated in Botswana (I), Swaziland

(1), and Lesotho (2), the other BSc (honours) treatises addressed project issues in South African construction.

Table 1 The methodological approaches denoted by BSc (honours) treatises

Year	Submitted	Research Method			Unit of Analysis	
		Quantitative	Qualitative	Mixed Method	Project	Industry
2009	5	4	0	1	5	0
2011	12	10	0	2	7	5
2012	25	21	2	2	19	6
Total	42	35	2	5	31	11

Table 2 indicates the methodological approaches denoted by the MSc treatises and dissertations that were reviewed. Although the numbers of reviewed MSc research outputs were fewer than the BSc (honours) treatises, the quantitative method seems to dominate. Of the 13 MSc treatises / dissertations that were examined, 8 used the quantitative method, 2 used the qualitative method, and 3 used the mixed method for generating primary data for the empirical studies. The 2 treatises that utilised the qualitative method examined industry phenomena through a multi case study approach, while the 3 studies based on mixed methods used interviews to validate / or support findings from an initial quantitative survey.

However, most of the research reports addressed industry issues. This is a steady departure from the BSc (honours) treatises. The industry issues that were addressed include the training of artisans; corruption and its effects on the industry; hyperinflation and its effect on the industry; service delivery in the public sector; sustainable development; and the constraints faced by small, medium and micro enterprises (SMEs) in the industry. Concerning project as a unit of analysis, topics such as supply chain management were addressed.

In addition, GCs, clients, subcontractors, suppliers and other concerned parties were either surveyed or interviewed by the MSc students. The scope of the studies ranged from a single country to 2 countries in the form of comparative studies in the Southern African region. However, most of the purposive surveys were conducted in South Africa among GCs and designers.

Table 2 The methodological approaches denoted by MSc treatises and dissertations

Year	Submitted	Research Method			Unit of Analysis	
		Quantitative	Qualitative	Mixed Method	Project	Industry
2009	2	1	0	1	0	2
2010	5	4	0	1	1	4
2011	2	2	0	0	0	2
2012	4	1	2	1	2	2
Total	13	8	2	3	3	10

Table 3 indicates that between 2008 and 2012, 9 PhD in construction management studies were completed in the university. Of this number, 5 primarily utilised the quantitative method for the generation of the primary data that led to the development of proposed models. 3 used qualitative method that embraced multiple case study

approach and 1 mixed method study was recorded. It is notable that some of the studies involved the compilation of primary data from other regions of the continent of Africa.

While viewing the theses in order to decipher the unit of analysis adopted by the candidates, it was discovered that most of the studies focussed on industry issues. In particular, the 6 doctoral studies that addressed industry issues examined topics that were not limited to H&S inspectorate functions in South Africa; the impact of public private partnership (PPP) projects in South Africa; and the competitiveness and development of construction SMEs in South Africa.

Unlike the BSc (honours) and MSc treatise, the PhD theses stated the philosophical position that each research adopts after presenting a range of options. The different methodological approaches available were also often discussed before proceeding to present the population and sample strata for the study.

Table 3 The methodological approaches denoted by PhD theses

Year	Submitted	Research Method			Unit of Analysis	
		Quantitative	Qualitative	Mixed Method	Project	Industry
2008	3	2	1	0	1	2
2011	2	1	1	0	1	1
2012	4	2	1	1	1	3
Total	9	5	3	1	3	6

DISCUSSION

In general, it was observed that at each level of research project execution, the quantitative method seems to be the preferred method that was utilised by the students. This corroborate the perception that the construction management research may be firmly rooted in the positivist approach that adopts an objective orientation, where the purpose is about the discovery of factual findings pertaining to a phenomenon (Dainty, 2008). The positivist approach that emphasise causality and generalisation is in accordance with the empiricist view that knowledge stems from human experience, which portrays the ontological perception of the world comprising of discrete and observable elements and events that interact in a determined and regular manner (Collins, 2010).

Although the built environment research is reportedly project based (Segal, 2011), it is incumbent on supervisor to chart appropriate research course for students, especially at the undergraduate level. While not exhaustive because of it limited sample size, a recent research findings suggest that the nature of investigation and research problems constitute the primary factors that contribute to the choice of methodological approach adopted by a doctoral construction management researcher in a South Africa university (Emuze and Smallwood, 2011). Emuze and Smallwood (2011) further noted that it is imperative that methods and factors that are associated with research methodology should be thoroughly investigated and contextualised through their ability to provide useful avenues for achieving stated objectives.

Granted that research at the doctoral level has been defined as seeking a scholarly approach towards creating original knowledge; at the masters level, it is more focused on developing research skills; and at the undergraduate level, it is often about encouraging constructivism and enquiry-led learning (Lee, 2012), it can be argued that

the spirit of research and enquiry should run through the experience of all students in higher educational institutions (Brew, 2006). In effect, it is necessary to situate the research background in the relevant research paradigm rather than adopting a research method out of convenience.

This is important since built environment research should seek to quantify performance of an isolated circumstance as a means of assisting with the prediction of performance in another (Segal, 2011). In other words, if academic knowledge is to merit application in practice, its means of generation should be robust enough to achieve desired objectives (Segal, 2011). The import of the discourse is centred on the need to focus on how graduate or postgraduate students are educated in terms of research methodology. According to Lee (2012), a globally competent postgraduate should possess research skills that include research design and methods; methods of analysis; academic writing; literature searches; project management; ethical issues; and oral as well as written presentation of findings. Lee (2012) equally posits that it is important for a researcher to imbibe the philosophy of knowledge in terms of how knowledge emerges; sociology and politics of knowledge creation; philosophical approaches to ethical issues; disciplinary and interdisciplinary ways of thinking; and enculturation in different cultures / disciplines.

CONCLUSIONS

The study was embarked upon based on the premise that determining, understanding, writing and applying research methodology to treatises, dissertations and theses has been and continues to be a major challenge for students and supervisors alike. The research was thus conducted in order to chart a pathway out of the methodological conundrum.

The methodological debate in the construction management research area has highlighted salient issues related to the objective / subjective or quantitative / qualitative divide. A major highlight of the debate was the perceived dominance of the quantitative approach in the subject area, a situation that was corroborated in this study. As indicated in the treatises, dissertations and theses that were examined, the quantitative research method seems to dominate, especially among the BSc (honours) and MSc treatises. This invariably suggests the projection of the positivist approach to most of the empirical studies that were undertaken at the university. However, given the complexities of project environments and the industry at large, it can be argued that it is necessary to situate the research background in the relevant research paradigm. If this is the case, perhaps the number of research outputs based on the quantitative approach may be minimal among the examined treatises, dissertations and theses.

In effect, resolving the methodological conundrum could bolster the research Achilles heel that has hitherto bogged down research productivity and project completion. When the quality of supervision among BSc and MSc students is improved and researchers are made aware, and then, encouraged to examine a wide range of paradigms and strategies when making methodology related decisions, the challenge may be surmounted. Because most quantitative surveys are based on the perceptions of respondents that may be far from the reality, it is incumbent on supervisors of research projects to encourage critical reflections before a field work is embarked upon by students. More so, the limited responses rates recorded in quantitative surveys in South Africa as exemplified in the examined outputs (less than 50%) necessitate the

use of other methods for research enquiries because of issues related to generalizability, reliability, and validity of findings.

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CONTEXTUALISING INNOVATION IN CONSTRUCTION FIRMS IN REGIONAL AREAS

Graham Brewer, Thayaparan Gajendran and Raichel Le Goff

School of Architecture and Built Environment, University of Newcastle, Australia

Construction firms based in regional contexts face different challenges to their metropolitan counterparts in terms of access to markets and resources, scale of operations, and the nature of their competition. This potentially provides both business opportunities and challenges particularly in relation to innovation activities. A large scale research project investigating innovation processes in an Australian regional construction industry is being contemplated and a research mechanism has been piloted. Accordingly the case of a successful regional New South Wales small-medium-sized enterprise's (SME) quest for sustainable competitive advantage is presented through the lens of a dynamic capabilities framework. It reveals four capabilities that deliver innovation, one of which is regional in flavour, indicating that a regional location need be no impediment to innovation and indeed may hold some advantages

Keywords: construction firm, dynamic capabilities, innovation, SME.

INTRODUCTION

It is overwhelmingly the case that construction firms in regional areas of Australia will be small or medium-sized enterprises (SMEs). Regional SMEs may be compelled to innovate in order to generate sustainable competitive (though not necessarily monopolistic) advantage (Todtling & Kaufmann, 2002), developing responsive internal processes and networking with trading partners (Dosi, 1988). Whilst much of the innovation literature concentrates on technology-driven initiatives leading to substantive products, innovation has also been identified in relation to service-based products (Gallouj & Weinstein, 1997). Most construction-based enterprises can be thought of in a hybrid way, delivering physical artifacts using non-physical services (procurement and management), where innovations are found at their interface: this is where a firm's "dynamic capabilities" reside.

The dynamic capabilities literature is congruent with such a technological/non-technological view of innovation. It seeks to understand a firm's tangible and intangible assets, history and path dependency (Teece, Pisano & Shuen, 1997). On this basis a qualitative dynamic capabilities research mechanism has been designed for use in a large scale study of innovation capacity in the construction sector when located in regional Australia. Three pilot case studies of firms with known innovation capability have been planned; one is now presented. Thematic analysis of five interviews and supporting evidential material reveals both the dynamic capabilities that have delivered the firm's success, and the influence of its regionality on its response to

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competitive challenge. By doing so it provides preliminary support for the suitability of a dynamic capabilities perspective to investigate the innovation performance of SMEs in a regional context.

LITERATURE REVIEW

Innovation in small firms within the construction sector has been reviewed in the past in terms of both the market-based and resource-based perspectives (Sexton & Barrett, 2003). The highly project-centric and fragmented nature of the construction industry, together with its "precipitating events" triggering or hindering innovation activities are identified as presenting a unique context within which innovation has to occur. Conversely both the market-based and resource-based perspectives have been criticised for providing an inadequate framework within which to explain the complex interplay between internalities and externalities (Teece, Pisano & Shuen, 1997; p 509).

Lundvall (1992) conceptualised the integration of internal and external processes undertaken with the intention of innovating as "innovation systems", defining them as being “constituted by a number of elements and by the relationships between these .... which interact in the production, diffusion and use of new, and economically useful, knowledge.”

Gallouj & Weinstein (1997) highlight the emphasis innovation literature places on the development of technological innovation in manufacturing activities, suggesting that service industries have largely escaped the gaze of researchers. Where innovation in service industries has been analysed they suggest that two bodies of literature exist. The first deals with the adoption of ICT for a service activity, leading to incremental process innovations that result in efficiency gains, process redesign, and ultimately new service products: in construction the adoption of web-based project document repositories or Building Information Modelling are contemporary examples. The second body of studies acknowledges the existence of non-technological forms of innovation e.g. new and novel consultancy services. These are frequently ad hoc forms of innovation that defy easy imitation or reproduction, and are not suited to widespread formalisation (Gallouj, 1991 in Gallouj & Weinstein, 1997; p 539). Collaborative approaches to building design, project procurement or project supply chain management are examples of this form of innovation. In order to understand both technological product and service innovation in the same terms it is necessary to characterise both in terms of a set of interrelated product/service characteristics (i.e. specifications) and competencies (provided by the innovating firm), which deliver the final characteristics of either the product or service (Gallouj & Weinstein, 1997; p 544). Conceivably it may involve a combination of both.

Dynamic capabilities (Teece, 2009) provides an appropriate lens through which to examine the complex interplay between the technical characteristics of a product or service, the competencies of the firm providing it, and the multitude of environmental factors influencing the firm's behaviour. It was initially conceived to explain innovation in private enterprise firms operating in dynamic technological environments, and sought to explain competitive advantage as arising from a firm's specific inventory of assets, knowledge, and history. However it has since been extended to include non-technological products, and services (e.g. Zahra *et al.* 2006).

In essence project management and construction capabilities, which can be valuable to firms at one point in time, do not necessarily remain valuable when technology conditions change: often firms must reconfigure their capabilities to survive. The

capacity to do so is linked to their dynamic capabilities that represent a "set of … [managerial and organizational] processes" (Eisenhardt and Martin 2003, p. 342). They are different from substantive capabilities (e.g. the capacity to construct a building) in that they modify resources and substantive capabilities (e.g. a dynamic capability can represent a capacity to change the way the organization builds bridges) (Zahra *et al.* 2006).

Key processes that are embedded in an organization's dynamic capabilities concern the identification of opportunities and reconfiguration of substantive capabilities (Eisenhardt and Martin 2000; Teece 2009; Zahra *et al.* 2006).

- Opportunity identification involves scanning, search and exploration across technologies and markets (Teece 2009).
- Opportunity identification provides the firm with insights such as technological information (Damanpour 1991). In order to seize identified opportunities, new business models, processes, complementary resources and methods are needed and require evaluation. Thus, once opportunities have been identified and new business models have been evaluated and selected, the organization's capacity to reconfigure its resource base becomes crucial if it is to align with changed conditions (Teece 2009).
- Reconfiguring, as the third process, reflects extending, modifying and/or changing the resource base and substantive capabilities (Teece 2009).

Further, a construction company's decision to expand into international markets must be based on a good understanding of the opportunities and threats associated with international business, as well as the development of company strengths relative to international activities (Teece, 2009). Ultimately "dynamic capabilities should be laid at the core of strategic management processes" (Shera and Lee 2004: p 935), wherein dynamic capabilities are tangible and intangible capabilities using resources effectively to deliver products and services.

METHODOLOGY

Philosophically the nature of innovation processes at play in a firm are influenced by the perceptions of its members – particularly senior members making critical decisions – of its product or service offerings, its capabilities and its technological/corporate knowledge gained during its history. The consequent estimation and quantification of the risks and benefits of innovating will have a considerable impact on its commercial decisions. Such decisions are made on the basis of both rational and boundedly rational criteria (Simon, 1991), which embody formal and informal dimensions (Bresnen and Marshall, 2002). The phenomenon of decision-making in such an environment is best revealed using qualitative post-positivist approaches (Gajendran *et al.* 2011).

Methodologically this research was thus designed from a constructivist perspective that addressed multiple stakeholder realities (Creswell & Clark, 2007). This was actioned through a detailed single case study utilising ethnographic research methods, so as to capture both phenomenon and context (Yin, 2009), allowing context-specific generalisation. The choice of a single case was considered both methodologically appropriate as an "instrumental" case (Stake, 1995) and opportunistic given the researchers' access to key stakeholder organisations in an innovative regional Australian SME. In the event five interviews were conducted with the managing director/proprietor, design manager, general manager (Australia), general manager (UAE) and engineering manager.

CASE STUDY FIRM

The focal company for this case study was founded in 1990 specifically to develop and construct property. Through its development and construction arm the group has undertaken property development throughout the Newcastle and Hunter region in New South Wales, Australia. Projects have included Commercial, Industrial and Land Subdivisions. Soon after the firm was set up its proprietor (an engineer by profession) established an architectural facade engineering division, which now forms the major part of its business. Whilst it is headquartered in Newcastle it has expanded to have an international branch office in Dubai. The firm claims to have completed projects worth in excess of A$0.5B during its life.

RESULTS

Operationally, interviews were conducted using a semi-structured script intended to probe the issues of innovation, regionality, and the firm's dynamic capabilities. These were recorded, transcribed, and subjected to a rigourous multi-round process of open and axial thematic coding. Each transcript was coded independently by two researchers, the results of which were compared at coding meetings, where similarities and differences in coding were discussed and consensus on coding achieved. Figure 1 is an extract from the consolidated code table, which was constructed from the coding summaries for all five interviews. In total 27 open codes were generated, each developing between 0-5 axial codes.

These codes were subjected to a process of abstraction to derive synthesised themes. These themes were then cross-referenced back to the literature, enabling the researchers to provide detailed explanations of the relationships between the six generic capabilities found in the firm, and how they combined to form it's dynamic capabilities.

Main code	Axial code 1	Axial code 2	Axial code 3	Axial code 4	Axial code 5
Product (facade)	Evolutionary design	Cable stayed	Materials reduction	Added value to clients	Competitive advantage
	Quirky design	Cost efficiency	Reduced manufacturing costs	Added value to clients	Competitive advantage
	High reputation	With consultants	Relationship-based	Long-term/strategic	Competitive advantage
		With major clients	Consultant recommendation	Relationship-based	
Product (property)	Investment	Infrequent	Opportunistic		
	In-house design	Infrequent	Opportunistic		
Proprietor	Strong leader	Eclectic engineer	Quirky design		
		Strategic direction	Sustainable growth	Stability not profit maximisation	
		Hands-on	Problem-solving	Intervention	
		Hands-off			
Service (contracting)	Contract management	Transactional relationship			
	Project management	Transactional relationship			
Site visits	Facilitation	Increased understanding			
		Better design			
		Dubai			
Practical skills	Trade background	Good understanding			
	Non-trade background	Lack of understanding			

Figure 1. Extract from coding summary: quirky engineering perspective

ANALYSIS

Zahra *et al.* (2006; figs 1 & 2) describe and elaborate an appropriate framework of capabilities within which to situate and thereafter explain the synthesised themes obtained from Figure 1, using a dynamic capabilities lens. Table 1 summarises the themes, assigning them to one or more of the generic capabilities held to contribute towards dynamic capability formation. By way of example it can be seen that the thematic attribute "quirky engineering perspective" was synthesised in part from the open code "proprietor" (Figure 1: cells 61C and 61D) and open code "product

(facade)" (Figure 1: cells 56B-F). This thematic attribute was then in turn coded to the generic dynamic capabilities "entrepreneurial", "internal resources", and "internal culture". Lastly, the thematic attributes of the firm were synthetically distilled to derive dynamic capabilities specific to the case study firm. It can be seen that four dynamic capabilities were identified (A-D) and that each was derived from a combination of the attributes of the firm that had been identified thematically. On occasion these attributes were used more than once. There follows a detailed explanation of each dynamic capability.

Capability A is cultural in nature, reflecting the ability of the firm and its employees to exercise local sensitivity in its dealings with clients and supply chain partners: "Our supply chain relationships, I mean, that's 80 per cent of what we do. The other 20 per cent being the actual design and the project management." (Proprietor)

In essence the firm is able to tailor its appearance to its trading partners in ways that suit its own objectives: " A lot of supply chain relationships are very brief […]you don't have that ongoing relationship [but when you do] over several projects, you can end up with what we literally call, what the Japanese certainly think of as a lifetime relationship." (General Manager, Australia).

This causes it to engage in relational transactions where local trading conditions dictate that this is desirable or normal, or where the trading relationship with a particular supplier is particularly valued " There's a concept called lifetime value of a client […] that becomes the value of the goodwill on a balance sheet." (Proprietor), switching to a strictly contractually transactional mode in domestic markets "[…] we don't really pretend to put up a nice as nice, mothering, nurturing approach with our [trade] sub-contractors (General Manager, Australia).

Capability B also has an organisational culture dimension but finds its roots in the personality and leadership of the firm's proprietor and his technical perspective. It is derived from his particular approach to engineering design: "It started with my own personal experience in light-weight structures […] design engineers had a very impractical way of addressing the nuts and bolts of the design […] they were astounded when [our redesign] had perimeter failure rather than [component] failure, at three or four times the design load." (Proprietor)

It has found its expression in a succession of major projects where his innovations and those of his design team have evolved to deliver successful outcomes: "We've done a lot of things that aren't standard, we've been recognised for that […] We look outside the box a lot." (Design Manager).

These have embodied successive reductions in the quantities of materials used, a reduction in the level of skill required to assemble the facades on-site, and other "lean" principles: "Yes, lean and mean, but this requires designing the skill out of on-site assembly […] and low or zero defects in product." (Design Manager).

Table 1. Thematic analysis/dynamic capabilities results

Capabilities / Thematic attributes of firm	Entrepreneurial	Internal resources/skills	Internal culture	Organisational learning	Organisational knowledge	Substantive capabilities	Dynamic capabilities	Performance
Ability to adapt to cultural mores of local markets			x				A	x
Ability to conceptualise and then action new manufacturing processes		x			x		B	x
Ability to work in new markets irrespective of geographical location		x			x		A	x
Advanced document sharing between offices		x					BCD	x
Attractive lifestyle in Hunter region		x					D	x
"Australian" lean perspective on procurement and manufacturing		x			x		B	x
Evolutionary engineering perspective				x			B	x
Flexible, highly skilled workforce		x				x	D	x
"Hard to imitate" designs and products		x		x	x	x	B	x
High-level computational analysis		x					BC	x
Investment in supply chain relationships				x			E	x
Investment in workforce				x	x		D	x
Low "churn" of staff		x			x		D	x
Connecting design, manufacture and construction site practice				x			B	x
Product conceptualised in terms of information rather than artefacts	x	x		x	x		C	x
Quirky engineering perspective	x	x	x				B	x
Reconceptualising design problems	x	x	x		x		B	x
Strong organisational culture			x				A-D	x
Supply chain relationship management		x	x	x	x		AC	x

This has also required an ongoing process of staff development intended to sensitise everyone connected with the design process to the consequences of their decisions, through manufacture and onward in the construction phase, with the intention of continually improving product outcomes: "Guys don't come from a trade background these days […] so we try to send them to our suppliers factories and on sites, so they see the consequences of their designs […] knowing how difficult they are to build." (General Manager, Australia).

Capability C is an abiding recognition that the firm's product is first and foremost a flow of information: "These days, with all of our major clients all using web-based document control systems, it doesn’t really matter where we are. With a good supply chain, no one cares whether a purchase order comes from Sydney, Melbourne or Beijing." (Design Manager).

To be profitable it must optimise that information flow both in terms of accuracy and speed, internally and with its trading partners: "I can liaise with the General Manager in Dubai, find out what spare capacity exists and send them an FTP work package at 2.30pm. With the time difference it is waiting for me the next morning and it works the other way round as well […] We can do Revit compatible stuff but our AutoCAD drawings contain more detail, so we ensure that our stuff can match the client's BIM requirements." (Design Manager).

Major investment has been made both in infrastructure (hardware/software/ extranet) and in relationship management of key supply chain trading partners: "We regularly embed staff in our suppliers to make sure they can match our ISO9001 requirements

[…] we worked hard to get this and we aren't going to let anyone jeopardise it through bad documentation or information [transfer]." (Engineering Manager).

Capability D is its workforce, which it recognises is highly skilled, flexible, and committed; " …it either works well for you in [firm's name] or it doesn't work at all. We're quite hard on ourselves from the point of view of performance and quality." (Proprietor).

This capability is founded upon the firm's remoteness from major markets for the specialised, skilled labour it employs: "People I think are a lot less transient when they find their roots in Newcastle […] they love the lifestyle, they like the job, competition for them is less […] so it takes a big iron lever to move them." (Engineering Manager).

A combination of distance and the attractiveness of the lifestyle in the Hunter region have reduced poaching by competitors, and the desire amongst its workforce to move, leading to both a high level of corporate memory and a low level of intellectual property seepage: "Most of our guys wouldn't move to a competitor for twice the money - it's a lifestyle thing and they are [firm's name] people.

The commitment of the workforce to the firm is mirrored: the establishment of a Dubai branch has allowed the transfer of staff from there to the Newcastle office and vice versa according to workload, thereby minimising staff layoffs during slack periods: " All the guys that run the office there [Dubai] have been in that office [Newcastle] or long term JML people who are in the JML mode." (General Manager, Dubai).

DISCUSSION

It is seductive to explain the performance of SMEs in terms of the heroic actions of a small number of individuals, and undoubtedly the influence of this firm's proprietor is writ large across all of the data collected. His particular view of engineering design pervades all levels of the firm, as to his beliefs in connection with trading partner relationships: "Yes, a particular perspective on materials reduction and on short production runs – our guys have to understand manufacturing constraints – and on procuring just what we need for the job." (Proprietor). However this firm demonstrably has a learning culture (Sapienza, DeClerq and Snadberg, 2005) that was established from the outset (Autio, Sapienza & Almeida, 2000): "Michael and John have been around from the start, but new staff have to be brought up to speed with the kit of bits that we typically use, and think about better ways they can be made and used." (Engineering manager).

The firm's history begins with a "quirky" approach to engineering, minimal research effort, but a strong record of evolutionary development, which appears to be at odds with much of the innovation literature that indicates a firm's propensity to atrophy if substantive capabilities are not exercised and renewed (e.g. Zahra *et al.* 2006; p 20). On the other hand it is evident that design agility, which reuses and refines concepts used on previous projects is quite normal practice. Nevertheless, this approach is indicative of a high level of path dependency, where current activity is substantially dictated by the firm's history.

Theory indicates that a firm's drive for competitive advantage through innovation may be achieved delivering substantive or service products (Gallouj & Weinstein, 1997; p 538), however the case study firm conceptualises its product in terms of information flows, which subsequently find physical form through manufacturing and construction

activities. Moreover the firm's designers are happy to act in a consultative role for a fee during the early stages of the project, indicating that their competitive advantage is derived from both substantive and service product offerings, blurring the boundary between each.

Their awareness of opportunities presented by the environment is acute (Eisenhardt & Martin, 2000) neither being confined to business leads or technological advances alone. However consideration of expansion into new products such as curtain walls have traditionally been regarded as high-risk ventures in the absence of high-quality components available in Southeast Asia or Australasia: this perception is changing with the advent of cost-effective alternatives becoming available in Europe.

The perception of risk and the way in which it has been accommodated by the firm's leadership is undoubtedly risk-averse, often choosing not to utilise its dynamic capabilities in pursuit of business opportunities. This could be characterised as non-rational economic decision-making, ignoring maximisation of economic return (Zahra *et al.* 2006; p 21). Such boundedly rational behaviour (Simon, 1991) has been exercised in pursuit of business survival over the long-term, and has nevertheless resulted in significant business growth over a protracted period.

Ultimately the case study firm produces a hard-to-imitate substantive product (Teece, 2009) and service offering (Gallouj & Weinstein, 2007) through consultancy that is offered by few firms globally. The extent to which a) the market for its product continues to exist and b) it retains the ability to be competitive will depend upon its continued innovative activity. This in turn will depend upon the mix and development of tangible and intangible competences that define its dynamic capabilities.

CONCLUSIONS

The research presented in this paper was the preliminary findings from part of a study that was exploratory in nature. It was intended to determine the extent to which a dynamic capabilities lens would be an appropriate mechanism for revealing the innovation practices of construction firms operating in regional areas of Australia. As such it revealed the approach to be a useful, integrative mechanism: issues of regional influence had to be specifically prompted, since they did not appear to figure highly in the conscious decision making of those interviewed.

The case study firm clearly displayed a number of dynamic capabilities which made it globally competitive in a niche market. However the perils of path dependency could be detected, triggering the need to consider alternative products in order to continue this success into the future. Further, this firm could be considered atypical of regional SMEs in the construction industry and thus their point of departure, and the dynamic capabilities developed over more than two decades could be considered unusual. Certainly both the desire and ability for a regionally based SME to be globally competitive would be a rarity in the construction sector, and this case study must be understood in those terms.

The value of this case study to the researchers was as the initial step towards validating a robust and appropriate research methodology with which to investigate innovation in regionally based construction SMEs. Moreover, as a single case study generalisation of its findings cannot be made beyond the firm's boundaries: however it does raise a number of critical questions for future research:

- To what extent are the regional benefits experienced by the case study firm mirrored by others in the local industry?

- To what extent is the boundedly rational decision to limit growth in favour of stability through risk minimisation mirrored by other SMEs in the local industry?
- How does a strong business proprietor influence the culture of a firm as it matures?

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RISK MANAGEMENT

INCORPORATING SECURITY MEASURES INTO THE BUILT ENVIRONMENT

Steven Harre-Young[1], Lee Bosher[2], Andrew Dainty and Jacqueline Glass

School of Civil and Building Engineering, Loughborough University, Loughborough, LE11 3TU, UK

The protection of the built environment has been given increasing attention over recent years, with physical interventions being integrated into the built environment itself and an impetus on the role of those who are responsible for its design, construction and operation. Of particular note has been debate and behaviour surrounding the incorporation of security measures to specifically mitigate terrorist threats, as varying perceptions regarding obligations and incentives to do so have resulted in vulnerable places remaining unprotected. As part of on-going research into the security of the built environment, a three-year study into the protection of crowded places from terrorism has determined the factors that influence whether such measures are incorporated into built assets, in order to further understanding of the perceptions and reality behind decision making. Drawing on data obtained from interviews with 47 construction management and security professionals in the UK and USA, as well as observations during site visits and document analysis, a framework is put forward that presents the factors that influence whether security measures are incorporated, as well as the factors that influence the value of the measures themselves. The framework highlights the need to consider the incorporation of physical measures during the early design stages whilst also reconciling the requirements of such measures against those of other design criteria; to understand the intricacies surrounding risk mitigation within time and cost constraints, and to accrue maximum value. Such a framework, it is argued, would aid policy and key decision makers in co-ordinating their efforts and effectively protecting vulnerable places from the range of risks that the UK faces, thereby mitigating a range of natural hazards and major accidents, not just specific threats.

Keywords: counter-terrorism, design, risk, safety, security

INTRODUCTION

The design, construction and operation of the built environment is influenced by a vast array of legislated and non-legislated considerations. Most notably however, a plethora of hazards, threats and major accidents pose significant risks to the built environment itself (Cabinet Office 2012; Harre-Young 2012; HM Government 2010; Edwards 2009). Whilst it has been acknowledged that the identification of every risk may not be achievable, it has been noted that the vulnerability and protection of the built environment affects everyone, as everyone interacts with it (Bosher and Dainty

[1] S.N.Harre-Young@lboro.ac.uk

[2] L.Bosher@lboro.ac.uk

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2011: 2). Over recent decades, the growing investigation of the aforementioned risks has resulted in a range of research into notions of resilience, safety, security, and counter-terrorism, most notably in relation to integrating physical interventions into the built environment to protect those who use it. Despite riverine, pluvial and coastal flooding, and severe windstorms, posing the greatest risk to the built environment, and that their occurrence and severity is likely to increase due to changing climatic conditions (Bosher and Dainty 2011; Crichton 2008), of significant concern has been the threat of terrorism faced within the UK through the intentional targeting of crowded places. Concern has been raised regarding how the built environment has been designed and retrofitted to reduce its vulnerability to, and mitigate the impacts of, terrorist attacks (Coaffee 2010). Building on a three-year study into the protection of crowded places from terrorism in which a theoretical framework was developed to understand the factors that influenced whether crowded places were protected, as well as the value of counter-terrorism measures (CTMs) themselves, the research questions whether such a framework can be used to understand the protection of places that are vulnerable to not just the threat of terrorism, but also the plethora of other threats, hazards, and major accidents that pose risks to the built environment. The research also highlights the need to consider the incorporation of physical interventions into the built environment whilst reconciling their needs with those of other design considerations, to understand the intricacies of mitigation within time and cost constraints, and to accrue maximum value from incorporating measures. In doing so, it is anticipated that further debate and guidance will be encouraged on whether, and how, principles of security should be further aligned with the design, construction and operation of the built environment.

SECURITY AND THE BUILT ENVIRONMENT

The built environment is the substantive physical framework that enables society to function in its social, political, economic and institutional aspects (Geis 2000). In its design, construction and operation, a vast number of considerations need to be made, some of which are legislated for, some of which are not; political, social, economic, technological, environmental and ethical, legal, system-focused, structural, and strategic factors are all inherent in the design and retro-fitting of the built environment (Allan and Davis 2006). System considerations include security, and taking the risk of natural hazards as an example, a vast array of natural hazards pose a risk to the built environment and each require an in-depth understanding of their nature and mitigation in order to reduce their likelihood and lessen their impacts effectively and proportionately. Whilst the identification of every risk may not be achievable, it has been acknowledged that the vulnerability and protection of the built environment affects everyone, as everyone interacts with it (Bosher and Dainty 2011). The reduction in vulnerability of the built environment to such risks is, therefore, of significant importance.

In response to this there has been a growing trend towards the incorporation of physical interventions into the built environment so that the potential impacts of hazards, threats and major accidents occurring are avoided or reduced. Whilst the aim of the paper is not to critically examine or gain intricate knowledge regarding the mitigation of all hazards, threats and major accidents, there is clearly a need to anticipate, prevent and prepare for, and respond to and recover from, their potential impacts as far as is reasonably practicable. The anticipation of irregularity and change in the nature of such risks has also been an emerging appreciation, evident in a

growing body of literature, and has in part led to the concept of resilience, in which its Latin roots of 'resilio' mean to 'jump back' (Sapountzaki 2007).

However, it has been recognised that in most cases it will not be sufficient for a system to simply 'jump back' or return to its original state, as its original state contributed to the disaster or disruption occurring (Bosher 2008). Therefore, the 'resilience' (and security) of a system is its ability to avoid, or at least absorb, disruption, and thereby draw on anticipation, preparation and preparedness, and response and recovery (Institute for Public Policy and Research 2009). The resilience and security of systems are therefore influenced by both human understanding and action, as outlined above; paradoxically, the built environment and its related planning practices are not only affected by disasters, but they can also constitute their causes (Wamsler 2008: 350). Or, in the words of Mileti (1999: 12) "human beings - not nature - are the cause of disaster losses". The way in which the built environment has expanded over the past 30 years has, arguably, had little regard for such influences and has not only caused disasters, but exacerbated their impacts (Dainty and Bosher 2008). Therefore, those who design, construct and operate the built environment have a significant role to play in the avoidance and reduction of disasters and their impacts, and greater debate and understanding regarding the protection of the built environment from the plethora of hazards, threats and major accidents that pose a risk to it is needed. Such an understanding has been developed specifically in relation to the aforementioned threat of terrorism, as recent research (see Harre-Young 2012) has explored the terrorist threat itself, and whether and how the design, construction and operation of the built environment can be used to protect it.

TERRORISM AND COUNTER-TERRORISM

Terrorism has a long established history in the UK, which is evident from a range of literature (Silke 2011; Richards 2011; HM Government 2010) and can be categorised as emanating from three areas, those being international terrorism, Northern Ireland-related terrorism, and domestic extremism. The threat from international terrorism, and more specifically Al Qaeda and their affiliates and supporters, despite being significantly weakened in recent years, is still faced (Cabinet Office 2012), and are seen as highly dangerous and a continuing threat due to their absolutist religio-political beliefs that result in a commitment to mass killing and economic destruction and disruption (Wilkinson 2007a). The threat from Northern Ireland-related terrorism has manifested itself in the form of varied methods of attack, including assassinations, vehicle-borne improvised explosive devices (VBIEDs), and mortar attacks (Wilkinson 2007b), yet it was arguably the 1996 VBIED attack in Manchester City Centre that is most prominent (Harre-Young *et al.* 2009). More recently, there have been consistent attacks in Northern Ireland, resulting in not just a continuing threat (Centre for the Protection of National Infrastructure (CPNI) 2010), but a growing concern (HM Government 2011). In relation to domestic extremism, protests that have resulted in public disorder and criminal damage have been evident more recently, including widespread rioting that occurred in UK cities in August 2011 (BBC 2011). Notwithstanding the targeting of individuals (as above), critical national infrastructure and government buildings that has taken place to date (Andrew 2009), Clarke and Soria (2009) and Harre-Young *et al.* (2009) have highlighted that of all the publicly known cases of terrorist plots and attempted attacks that have come to light since 2000, all have involved attacks on crowded public places and/or transport networks, and evident too has been the prominent use of VBIEDs.

Protecting from terrorism

Incorporating physical measures into the built environment to deter and mitigate the impacts of such attacks and other forms of crime has been undertaken throughout history (Briggs 2005: 68), yet it has been the use of such measures in relation to the aforementioned terrorist threats that has been increasingly prevalent in debates between, and within the realms of, practitioners and academics, as 'fortress architecture' and 'defensible space' became synonymous with such protection (Coaffee 2010). However, it was arguably the onset of Crime Prevention Through Environmental Design (CPTED) that was the basis from which other frameworks and typologies of protective measures emerged, with CPTED encompassing access control, natural (informal) surveillance, organised (formal) surveillance, territoriality, defensible space, and target hardening (Cozens *et al.* 2001; Moffat 1983). More recently, Harre-Young (2012) has developed a typology of CTMs that can be used to protect such places, which categorises the measures into three groups, those being Hostile Vehicle Mitigation (HVM), protective construction, and planning, detection and procedures. As part of the same study, a further output was made in the form of a theoretical framework that encompassed the factors that influence whether places are protected, and the factors that influence the value of CTMs themselves (ibid.).

PROTECTING THE BUILT ENVIRONMENT

The framework presented in Figure 1, derived from a three-year study into the protection of crowded places involving interviews with 47 construction management and security professionals (the methodology for which is detailed below), highlights eight factors that influenced whether crowded places were protected. Two of those factors (threat and risk assessments (TARAs), and stakeholder understanding and engagement) also influenced the value of CTMs themselves, as did auditing.

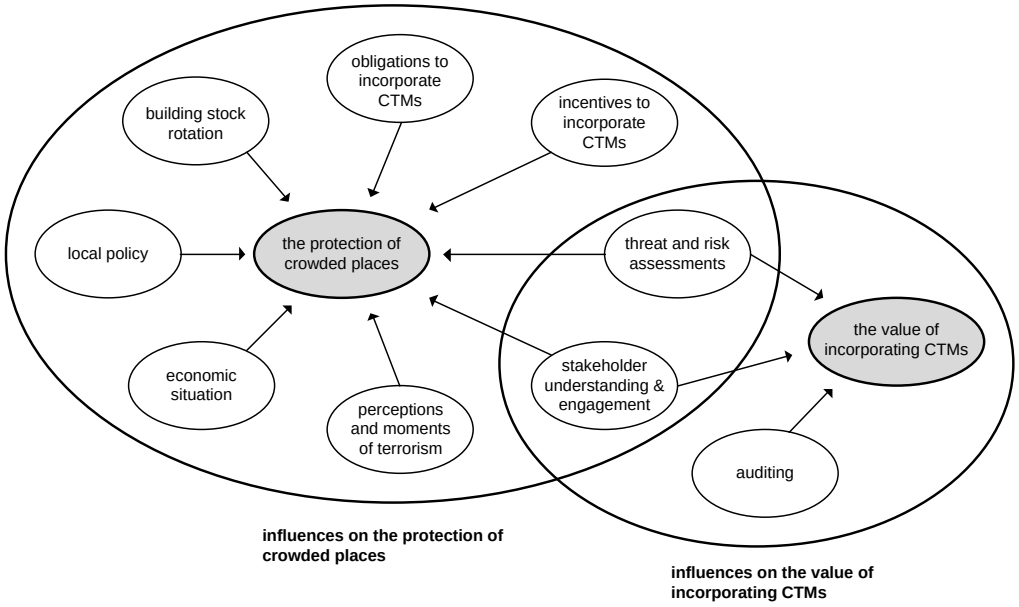

Figure 1: A framework of the protection of crowded places (Harre-Young 2012: 41)

METHODOLOGY

The aim of the research was to understand (and therefore change or influence) the social world through the identification of the ‘structures at work’, so an interpretivist epistemological position was adopted, as was a critical realism position in relation to

ontology (Bryman and Bell 2007: 18). In explaining the reality of the situation, creating theory as a result of that understanding, and then testing the developed theory, the research was iterative in nature due to it being inherently inductive and deductive, and required the adoption of a reconciliatory approach to examine and understand the 'structures at work' whilst recognising that such understanding was subjective and required interpretation (Robson 2011: 31; Walliman 2006: 20). In order to capture the subjective nature of the research, a qualitative research strategy and respective research methods were used that included interviews, site visits and document analysis, all of which were carried out in both the UK and the USA. The analysis of data was carried out through analytic induction, in which the universal explanation of the phenomenon being studied was sought, through the collection of data until no identified cases were found to be inconsistent with the developed explanation (Bryman and Bell 2007: 583). Thematic coding was used, with emergent themes forming the basis of the theoretical framework, which then became a coding frame upon which data was labelled, reflected on, and informed the collection of further data (Robson 2011). A total of 47 participants were recruited for the research, with the collection of data spanning 16 months.

THE NEED FOR A BROADER UNDERSTANDING

Whilst the research furthered understanding in relation to the design, construction and operation of the built environment in relation to countering the threat of terrorism, it can be questioned whether the development of a theoretical framework in relation to the above could be used to understand the mitigation of more than just terrorist threats. A range of natural hazards are both more likely and of higher consequence than terrorism-related risks (Cabinet Office 2012), so an in-depth understanding of the incorporation of protective measures more broadly, as well as their value, seems of use practically to those who are responsible for the design, construction and operation of the built environment, and pertinent in furthering academic debate and knowledge in the area. The previous theoretical framework (Figure 1) is therefore built on in order to develop a theoretical framework that could be used to understand the incorporation of protective measures to mitigate the plethora of risks that the built environment faces, as presented in Figure 2.

INFLUENCES ON PROTECTING VULNERABLE PLACES

The eight factors influencing the protection of vulnerable places (obligations, incentives, risk assessment, stakeholder understanding and engagement, perceptions and occurrences of risks, the economic situation, local planning policy, and building stock rotation) are explored below.

Obligations and incentives

Legislative, insurance-based and moral obligations determined whether crowded places were protected and whether CTMs were incorporated (Harre-Young 2012), and literature is clear in stating that interpretations of existing legislation are such that 'duties of care' do encompass terrorist acts (Harre-Young 2012; Fussey 2011; CPNI 2010) and that such legislation has been used to prosecute where counter-terrorism advice had been received but not acted on (Veale 2009: 291).

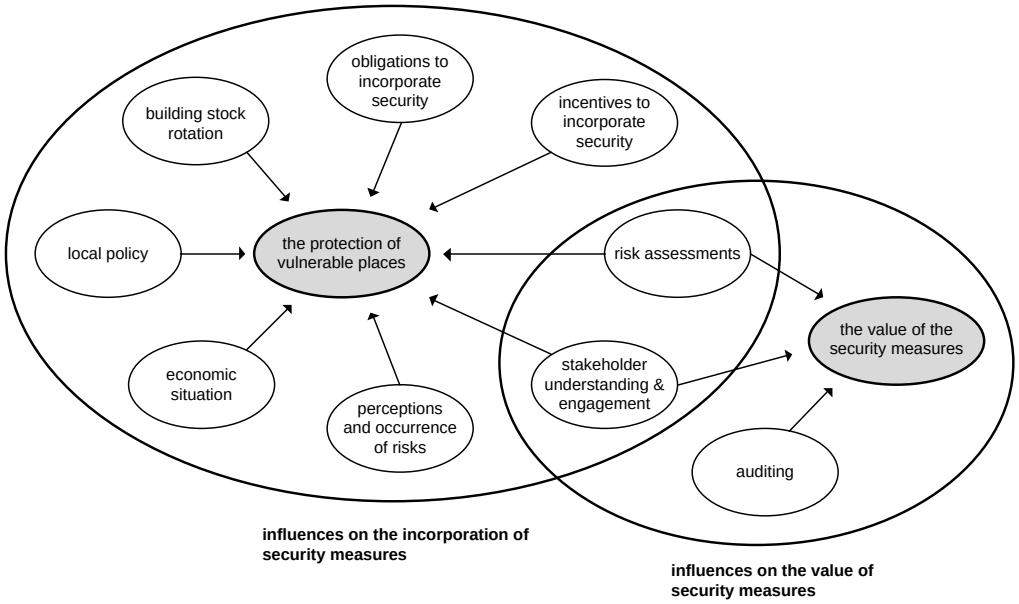

Figure 2: A theoretical framework for influences determining the incorporation of security measures

Such 'duties of care' apply to all hazards, threats and major accidents that pose a risk to places and spaces, and are therefore highly pertinent when designing new places or spaces, or renovating/refurbishing existing ones. A range of incentives influenced whether CTMs were incorporated, those being reductions in risk and loss of/damage to life, property and reputation; accruement of competitive advantages; generation of revenue; conduciveness with the agendas of pedestrianisation, regeneration and master-planning; and insurance incentives in the form of competitive policies and possible reduced excesses (Harre-Young 2012). Incentives to incorporate security measures would also remain highly influential, as reductions in risk and loss of/damage to life, property and reputation are significant factors upon which the incorporation of protection can be based. Harre-Young (ibid.) found that no CTMs were explicit to counter-terrorism (every CTM identified had additional benefits), and that the minimum additional benefits accrued through incorporating protection was the mitigation of other forms of criminal damage and public disorder.

Rouse (2004: 64) argues that "to account for value of architecture to companies, what you actually talk about is value to business" and therefore, in identifying incentives to incorporate security measures into architecture (and other built assets), the value of doing so to business must be identified, which has been done so in terms of revenue generation, the accruing of competitive advantages, the conduciveness of other agendas, and gaining insurance incentives (Harre-Young 2012). It could be argued that security measures, by reducing the likelihood of and mitigating the impacts of, a range of hazards, threats and major accidents, would accrue more significant incentives than CTMs alone, benefitting end-users and other stakeholders relatively more than if CTMs had only been incorporated. Whilst questions remain regarding obligations to incorporate security measures and how such practices are aligned with the design, construction and operation of the built environment, it raises whether there are in fact a range of incentives that could compel stakeholders to do so, regardless of perceived obligations.

Assessment, perceptions and occurrences of risk

The undertaking and contents of TARAs influenced whether crowded places were protected as the outcome of such an assessment could be to protect (the extent to which would vary in relation to the type and scale of the terrorist threats faced), or to not protect/incorporate CTMs. TARAs are, as a result of the above, inherently sensitive and confidential, and should only be conducted by trained people, such as Counter Terrorism Security Advisers. The undertaking and contents of risk assessments would remain highly influential in understanding the needs of broader protection, as they would influence both the incorporation of security measures and their value. Arguably, their influence would be exacerbated due to the increased complexity in not only determining what hazards, threats and major accidents the assessed place or space is vulnerable to, but how each would be reduced and mitigated whilst trying to achieve a joined up or 'holistic' approach. Whether any unintended consequences of security measures would impact others would also need to be understood and identified. Perceptions and occurrences of the risks remain a consideration, as peoples' views of risk and of the risks faced will vary, and will continue to be influenced by the occurrence or manifestation of them, such as flooding events.

Stakeholder understanding and engagement

Engagement between, and understanding of, stakeholders was also found to influence the protection of crowded places, and would remain pertinent, especially considering the aforementioned increased complexity. A solution towards the adequate and effective engagement between stakeholders in which security measures and solutions could be identified and examined is through the use of charette-type meetings whereby architects (and other design professionals) could invite required stakeholders to work through such issues, thereby enhancing the quality of the design produced, as well as enhance their own understanding (Glass 2008: 180).

Economic situations, local policy and building stock rotation

Economic influences are both pertinent to the current situation both nationally and internationally, and have been noted as influencing the incorporation of security measures through the prioritisation of other agendas over those of security (HM Government 2010: 21). This furthers the potential significance of incentives to incorporate security measures and therefore highlights a need for research into the incentives that are inherent in the incorporation of them. Local policy was proven to influence the incorporation of CTMs as different local authorities had different stances regarding what CTMs they deemed as appropriate or not (Harre-Young 2012) and so it can also be assumed that such influences would remain when considering the incorporation of security measures more broadly. This reinforces the need for stakeholders to effectively engage and further highlights the need for a platform from which this can occur, such as charette-type meetings (Glass 2008), in order to understand local policies and produce appropriate and compliant solutions. The influence of building stock rotation remains pertinent to the incorporation of security measures, as the vast majority of vulnerable places already exist, so the retro-fitting of them remains the most likely scenario considering their incorporation. Impetus would still need to be put on engaging as early as possible during the design process though, as retrofitted measures can cost more and be less effective (Harre-Young 2012).

INFLUENCES ON THE VALUE OF SECURITY MEASURES

Whilst TARAs and stakeholder understanding and engagement evidently influenced the protection of crowded places and whether CTMs were incorporated, they also influenced the value of CTMs themselves, as did auditing. The contents of the TARA itself, the situational context in which the focus of the assessment resides, the terrorist threats faced, and the understanding and incorporation of proportionality all influence the value of CTMs, as they can determine whether the proposed or incorporated protection is under-engineered and vulnerable, or over-engineered and obtrusive (ibid.), and the same can be assumed for protecting against other threats, hazards and major accidents given the need for an accurate risk assessment. Stakeholder understanding and engagement influences the incorporation and value of security measures due to it encompassing, amongst other factors, understanding of the requirements, performance and consequences of the measures themselves, a matter which if misunderstood could leave places and spaces vulnerable to attack. Auditing influenced the value of security measures a lack of, or insufficient, auditing could lead to inappropriate and ineffective measures that leave 'protected' places vulnerable to attack, that could potentially exacerbate the impacts of an attack, and could therefore result in additional capital outlay to remove, make safe, and replace inappropriate measures with correct/appropriate ones. The implication here for stakeholders is the over-engineering and potential obtrusiveness, or under-engineering and vulnerability of the places and spaces planned for and designed, coupled with the potential for mistakes in incorporating security measures to exacerbate the impacts of an attack, should one occur.

CONCLUSIONS

There is a need for further debate within the construction industry as to the alignment of protecting the built environment and any means through which the likelihood and impact of disasters are reduced, and the design, construction and operation process. Whilst questions remain regarding obligations to incorporate security measures, incentives to do so have been highlighted that could compel stakeholders to incorporate them, regardless of perceived obligations. A framework has been put forward that presents the factors that influence whether security measures could be incorporated, as well as the factors that could influence the value of the measures themselves. The framework provides a strategic overview of the issues that are of relevance to construction managers, inherent in the protection of vulnerable places, as obligations exist under legislated duties of care; a range of incentives are evident; risk assessments and stakeholder understanding and engagement are highly influential; perceptions and occurrences of risks also influence protection; economic influences remain highly topical and influential and highlight a need for research into security measures and their incentives and value to business; local policy variations influence the incorporation and choice of security measures; and building stock rotation also influences the incorporation of security measures due to the vast majority of built assets already existing and therefore require retro-fitting (Harre-Young 2012). The research also highlights the need to consider the incorporation of physical interventions into the built environment whilst reconciling their needs with those of other design considerations, to understand the intricacies of mitigation within time and cost constraints, and to accrue maximum value from incorporating measures, which can be achieved through such a framework. Such a framework, it is argued, therefore aids those responsible for the design, construction, operation and importantly, the protection, of vulnerable places in proportionately protecting built assets that are or

could be vulnerable to the plethora of hazards, threats and major accidents that the built environment is at risk from, and ensure that they are neither over-engineered and obtrusive or under-engineered and vulnerable, or incorporated in such a way that could exacerbate the impacts should those risks manifest themselves.

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PERCEPTIONS OF FUZZY SET THEORY IN CONSTRUCTION RISK ANALYSIS

Olubukola Tokede[a] and Sam Wamuziri[b,1]

[a] *School of Engineering and the Built Environment, Edinburgh Napier University, Edinburgh, EH10 5DT, UK*

[b] *University Management Research Centre, Glyndŵr University, Wrexham, LL11 2AW, UK*

Over the last three decades, organizations have increasingly been taking account of risk and uncertainty in their decision-making processes. The traditional methodology for risk management involves risk identification, risk analysis and management response to risk. Common risk analysis techniques in the construction industry include sensitivity analysis, probability analysis, Monte Carlo simulation, beta analysis etc. In this regard, Monte-Carlo simulation has been a touchstone of simulation efficiency across contemporary literature on risk analysis. However, a number of concerns have been raised about the intractability and construct validity of Monte Carlo representations for construction risks. The use of Monte Carlo simulation is based on the premise that the uncertain or risk event can be defined by a known probability distribution function. Unfortunately, this is not the case as far as risk is concerned in construction projects. It is in situations such as these where precise probability density functions cannot be ascribed to uncertain events that fuzzy set analysis becomes helpful. This research investigates the perceptions of fuzzy set theory and its influence on the practice of construction risk analysis. This work is part of a larger study that aims to investigate the specific insights that fuzzy set theory could bring into the construction risk analysis discipline. Purposive sampling was employed in selection of participants for the investigation. Structured interviews were conducted with highly experienced construction professionals in the United Kingdom. The results of these studies reveal that fuzzy set theory can enhance reasoning in analysing construction risks. However, fuzzy set theory as a stand-alone mathematical tool is not sufficient to complete the risk analysis process. Furthermore, the study indicates the vulnerability, volatility and computational intensiveness of fuzzy set theory may discourage construction practitioners from embracing the principles and applications of fuzzy set theory

Keywords: decision analysis, fuzzy set theory, risk analysis, risk modelling.

INTRODUCTION

In recent years, poor performance of construction projects has provoked an increased interest into the nature and mechanism of risk analysis and management (Smith 2006). Construction risks have been mostly found to exhibit dynamism and continuity across a project's lifecycle (Chan *et al.* 2009; Nieto-morote & Ruz-vila 2010). This

[1] s.wamuziri@glyndŵr.ac.uk

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conceptual framework has buttressed the need to improve the thoroughness and accuracy in the calculus of risk modelling procedures.

It has previously been considered that dynamism and continuity are attributes pragmatically suited for random and iterative manipulations (Sadeghi *et al.* 2010). This approach to risk evaluation derives its conception from probabilistic techniques. It is equally instructive that Monte Carlo simulation, a widely-known probabilistic technique is commonly employed for risk analysis procedures in the construction industry (Ayyub 2003). In many instances, Monte Carlo simulation has been found useful in evaluating outcome variance in a manner that produces the fairest summary. Of primary importance is the recognition that Monte Carlo simulation has exhibited great potential and use in many industrial risk analysis procedures. The initiative of treating every uncertainty as variability however constitutes a fatal presumption (Boussabaine & Kirkham 2004). Ayyub (1999) had reckoned that project uncertainty could result from a variety of situations among which are ambiguity and vagueness. Consequently, it is still commonly emphasized that the information potential of construction projects is not being fully harnessed (Shaopei 1998). Molenaar (2005) classified information on construction projects as "Known/Knowns", "Known/Unknowns" and "Unknown/Unknowns". Each of these categories of information requires different approaches to define and analyse at any particular time. Traditional methods usually adopt a deterministic and conservative approach which often proves insufficient in contemporary analysis and management of uncertainty. Therefore, it is considered that the utility of many risk models in fulfilling the risk analysis function is limited. In this respect, fuzzy set theory provides a useful framework for better representing the information about construction projects (Long & Ohsato 2008). Another explicit benefit in risk modelling is that fuzzy sets can better depict situational reality which ultimately assists the efficiency of decision-support for construction projects (Fayek & Oduba 2005).

Despite this crucial acknowledgement in the potential of fuzzy set theory to augment the process of risk analysis, many construction practitioners have doubts on the efficacy of fuzzy sets. Previous work carried out by Kangari (1986) was tailored at developing a conceptual model for fuzzy set theory in construction risk analysis. More recent work has advanced the mathematical rigour of risk events in established phases of construction projects (Chen & Huang 2007; Long & Ohsato 2008). Considerably, most research efforts on fuzzy set theory in construction risk analysis have focused on the development of its mathematical axioms and syntaxes. Little interest has been shown in relation to construction practitioners and the influence the attitudes in the construction sector might imply for applying fuzzy set theory to risk analysis. This study explores the perceptions of the principles of fuzzy set theory and its practical implication for construction risk analysis and management.

RESEARCH AIMS

The aim of this research exercise is to investigate the perceptions of fuzzy set theory within the context of the attitudes prevalent in the construction sector. The research questions were structured in open-ended forms. To this end, the questions were electronically sent to the interviewees ahead of the actual interview. The questions were intended to provide a basis for interaction on specific and general concerns in construction risk analysis. It also aimed to capture the informed opinions of construction experts. In effect, the research questions are stated below.

1. Does fuzzy set theory represent a valid mathematical modelling technique for analysing risk in construction projects?
2. If positive response is given to question 1(above), in what aspect(s) of the construction project lifecycle does fuzzy set theory have validity and utility?
3. Are there any peculiarities that limit the application of fuzzy set theory in the construction sector?
4. What comparative significance exists between fuzzy set theory and other established risk analysis tools and techniques in the construction sector?
5. Are construction professionals adequately trained to apply the concepts of fuzzy set theory?
6. Does adoption of fuzzy set theory by construction organizations translate into any major advantage in the competitiveness of construction products?
7. Does fuzzy set theory provide sufficient guidance to support robust decision-making functions?

PRINCIPLES OF FUZZY SET THEORY

Fuzzy set theory was formally introduced by Zadeh (1965) as a calculus that can be used in formalizing our intuitions about composition of graded categories (Kim *et al.* 2006; Chan *et al.* 2009). Fuzzy set theory is a branch of modern mathematics and belongs to the wider family of concepts termed “fuzzy logic” (Belohlavek *et al.* 2009). In other words, fuzzy set theory encompasses the classical set theory – where degree of belonging is either complete or null as well as other sets whose degree of membership is partial and not well defined (Zadeh 2008). It equally follows that fuzzy set theory is a superset of the classical binary or Boolean conventional logic. Fuzzy set theory is not a theory of concept in itself; rather it is a mathematical approach that can be used to build models for different applications (Belohlavek *et al.* 2009). Fuzzy set theory cuts across the entire spectrum of mathematical modelling languages. Zadeh (2008) posits that mathematical modelling languages include probability theory, differential equations, difference equations and functional analysis. All of these are based on bivalent logic. Fuzzy set theory is however not restricted to this bivalence (Zadeh 2008). It does not have a uniquely defined mathematical form (Zimmerman 2001) but an entire range of multi-valued logic (Chan *et al.* 2009).

Zadeh (1965) postulated that fuzzy set theory was developed to model the vagueness existent in human cognitive processes. Unarguably, fuzziness is prevalent in all areas in which human judgment, evaluation and decision-making is required (Zimmerman 2001). Kosko (1990) indicates that fuzziness has both physical and sociological consequences. In the physical realm, fuzziness connotes a gradual transition between possible states. Sociologically, fuzziness implies the possibility of an infinite degree of relationship between elements of a set as opposed to just being “completely related” or "non-related". In recent years, fuzzy set theory has been found remarkable in explicitly evaluating the fuzziness in dynamic systems. More recently, this conceptual setting has also been embraced to enhance risk and uncertainty analysis in construction projects. Some of the crucial features of fuzzy set theory are discussed.

Fuzzy set operations.

Set operations are logical mathematical formulations that guide the interaction between elements of a set (Nieto-morote & Ruz-vila 2010).Since the concept of fuzzy

set theory espouses gradual transition between elements of a set; the operations are interpreted as the interactions between membership functions of the sets rather than just the single elements within the sets. The fuzzy set operations applicable for two hypothetical sets, A and B on the universe, X with a given element, *x* is shown below.

The *UNION* of two sets is the maximum value of the membership function of the particular element(s) in either of both sets.

According to Ross (2004), the union of two sets using its corresponding membership functions, $\mu_{\tilde{A}}(x)$ and $\mu_{\tilde{B}}(x)$ are given below as:

$$\mu_{\tilde{A} \cup \tilde{B}}(x) = \max\,[\mu_{\tilde{A}}(x), \mu_{\tilde{B}}(x)]$$

The *INTERSECTION* of two sets is the minimum value of the membership function of the particular element(s) in either of both sets.

According to Ross (2004), the intersection of two sets using its corresponding membership functions, $\mu_{\tilde{A}}(x)$ and $\mu_{\tilde{B}}(x)$ are given below as:

$$\mu_{\tilde{A} \cap \tilde{B}}(x) = \min\,[\mu_{\tilde{A}}(x), \mu_{\tilde{B}}(x)]$$

Mathematically, the *COMPLEMENT* of a set, A, with a given element, *x* is shown as:

$$\mu_{\bar{\tilde{A}}}(x) = 1 - \mu_{\tilde{A}}(x)$$

The elements of a fuzzy set can also undergo fuzzy arithmetic operations if the elements in the fuzzy set are represented by fuzzy numbers. Fuzzy numbers are approximate numerical values which lack clearly defined boundaries (Ayyub 2001).

Membership Functions.

The concept of a membership function is not unique to fuzzy set theory. A membership function is equally not restricted to numerical values (Ayyub 1999). Membership functions embody the description of a set (Ross 2004). The purpose of a membership function is basically to express the degree of belonging of an element in a particular set (Long & Ohsato 2008). A membership function equally provides an effective way to translate subjective terms into mathematical measure (Kim *et al.* 2006). In a more practical sense, a membership function basically represents the degree of similarity of different objectives of a defined parameter (Shaopei 1998).

The most common shapes of the membership functions of fuzzy sets in the literature of construction management are triangular and trapezoidal shapes (Fayek & Oduba 2005). Other shapes that could suffice in contemporary literature include camel-back, tent, spire or steeple (Byrne 1997). The shape of a membership function is however a graphical approximation of the membership values. Real-life problems might have more complex patterns that may be more difficult to represent in simplified diagrammatic forms (Fetz *et al.* 2005).It is noteworthy that the operational essence of a fuzzy set lies in the descriptive precision of its membership function. Hence enormous attention and commitment must be devolved into configuring the membership functions of fuzzy sets.

APPLICATION OF FUZZY SET THEORY IN RISK ANALYSIS

Risk analysis has been found useful in focusing managerial attention to critical areas of construction projects. Established methods for risk analysis include expectation variance criterion, probability analysis, Monte Carlo simulation and beta analysis. All the afore-stated methods provide useful insights in instances where the probability density function can be precisely defined. However, situations exist in the

construction industry where such assumptions are inadequate or inappropriate for describing events. In construction risk analysis, fuzziness is considered an attribute inherent in the mechanics of uncertain events (Ayyub 2001). It is envisaged that recognition of fuzziness could enhance structural explicitness in construction risk models (Ross 2004). In canvassing for explicitness in the depiction of uncertain events, Hirota (1980) constructs the graphs of membership functions representing the probabilistic and fuzzy sets over a possible range of values. As seen in *Figure 1*, below, Hirota (1980) posits that if the membership function of a fuzzy set is well-defined, it can clearly represent the mechanics of uncertain situations. Hirota (1980) also concludes that probabilistic sets only consider the "rough tendency" of mean values and variances which are derivatives of its nth moment analysis leading to the lack of clear distinction seen in the profile graph of the probabilistic sets in *Figure 2.*

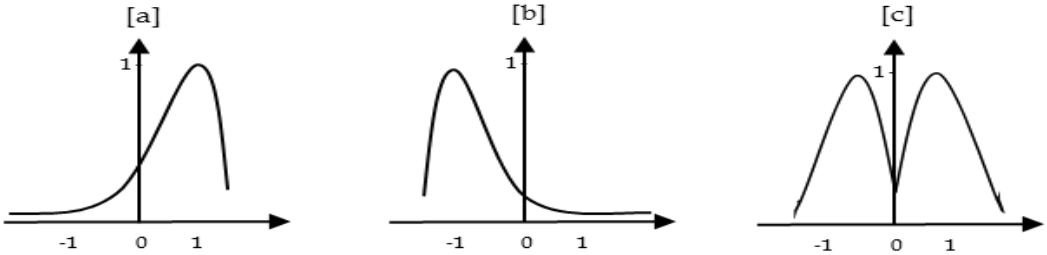

Figure 1: Fuzzy sets [a] numbers nearly early equal one [b] numbers nearly equal minus one [c] the union of [a] and [b] above. (Source: Hirota 1980)

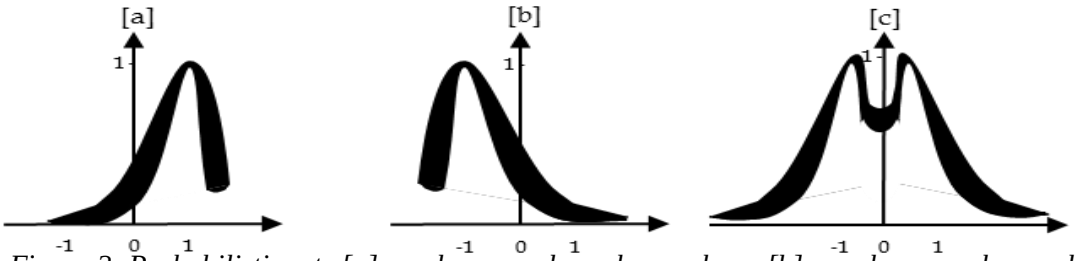

Figure 2: Probabilistic sets [a] numbers nearly early equal one [b] numbers nearly equal minus one [c] the union of [a] and [b] above. (Source: Hirota 1980)

In many of such situation where there is a lack of clear distinction in construction events, fuzzy set analysis has been found useful in modelling the inherent risks and uncertainties. An illustrative review of the application of fuzzy set theory across certain areas of the construction project lifecycle is outlined below.

Investment appraisal

Investment appraisal is considered the most important stage of a project (Shaopei 1998). At the investment appraisal stage of a construction project, fuzzy set theory has been used in event forecasting, cost estimation and overall project evaluation. One crucial challenge in the investment appraisals of construction projects is the virtual indeterminacy in the directions and movements of construction markets. In applying fuzzy set theory, single figures-of-merit say for NPV, IRR or any other numerical profitability indicator could be fuzzified through any of the appropriate value assignment methods. For example, Byrne (1997) applied fuzzy set theory to real estate investment situations by assuming a ±10% cost contingency to crisp values of discounted cash flow figures. Other portfolio studies have utilized subjective values obtained as linguistic variables to represent the lack of distinction in the estimates of uncertain events. It was hinted by Dikmen *et al.* (2007) that fuzzy set theory has been increasingly significant in investment appraisal situations. However, Rebiasz (2007)

has raised concerns on the economy of using fuzzy set theory in providing a rich picture in the early stages of a construction project. It was considered that the sparse information available at this stage of a construction project might not be well suited for enhancing robust analysis in evaluating the fuzziness in risk and uncertain events.

Network Scheduling

The critical path method (CPM) and the program evaluation and review technique (PERT) are two common techniques for scheduling networks in construction projects. The assessment of criticality of a project network provides information for project control. In classical set computations, a project network of zero float is judged critical (Long & Ohsato 2008). While fuzzy set theory acknowledges this proposition, fuzzy set theory adds that every project path has a degree of criticality (called critical-potential) which can be defined as the possibility degree of zero range of uncertainty (Fetz *et al.* 2005). In classical risk analysis, the critical path of a project network can be identified and adjusted by backward and forward recursion of activity times (Fetz *et al.* 2005). One approach to the fuzzification of crisp activity duration values is the corresponding alteration of forward and backward passes based on the modification in fuzzy arithmetic. A distinct feature in fuzzy arithmetic is that fuzzy subtraction is not the inverse of fuzzy addition (Lorterpong & Moselhi 1996). Chen and Huang (2007) further discovered that criticality of a path rises as the fuzzy float time decreases. Shih-pen (2007) developed a method to estimate the relative degree of criticality of activities on a project network. This calculus provides a comparative assessment in the criticality of project paths on a scheduled network. Extensive work has been done in analysing risks in scheduled networks using fuzzy set theory. However, the extent to which fuzziness is conserved is still an arbitrary procedure.

Project monitoring and Control

Monitoring and control are dynamic initiatives to guide the execution of construction projects. Monitoring and control might involve processes that range from changing overall method of construction, adjustment of internal structure, alteration of temporal and causal dependencies of activities as well as resource modification. In construction projects, monitoring and control is often carried out in order to achieve cost-time optimization and quality assurance. Whilst quality assurance is usually a more subjective and routine exercise, cost-time optimization is a crucial risk analysis function that generally involves a broad range of initiatives. In classical risk analysis, cost-optimization is usually achieved by time-cost trade off, resource allocation and resource levelling. The principles of fuzzy set theory can also be useful in providing instructive guidance for project monitoring and control. In respect of network scheduling, the strategic initiative explicitly steered by fuzzy set theory is that activity durations with lower degree of criticality should be minimized before activities with higher degree of criticality (Chen and Huang 2007). The caveat expressed in situations where equal degree of criticality occurs, is that resource constraints should dictate the optimization initiative. Long and Ohsato (2008) specify that fuzzy set theory could assist dynamic control of projects by enhancing proactive and periodical updates as the project progress. In a general sense, this suggests that adopting an “as soon as possible” implementation approach can help in curtailing construction project risks.

RESEARCH METHOD

This research constitutes part of a larger study that aims to investigate the specific insights that fuzzy set theory could bring into the construction risk analysis discipline.

The participants were chosen through purposive sampling due to the difficulty in finding construction professionals familiar with the principles of fuzzy set theory. In total, 77 copies of the questions for the structured interview were sent through electronic mail to the selected respondents. An undisclosed number was also circulated to members of the Royal Institution of Chartered Surveyors (RICS), through the public liaison representatives of the RICS Office, Edinburgh, United Kingdom. Consequent upon the low interest in participating in the interview, construction professionals with relevant publications on fuzzy set theory were contacted to shed light on their experience with fuzzy set theory. The participants from the industry were contacted through informal links to construction establishments. All the respondents that agreed to participate in the study were duly interviewed.

Structured interviews were eventually conducted with six construction professionals in England and Scotland. Four of the participants were university academics in construction management and the other two were an off-shore structural engineer and a construction site manager. All of the university academics that participated in the study were Heads of school of built environment or civil engineering in universities across the United Kingdom. Two of the participants had over 25 years' experience in the construction industry, another two had over 15 years' experience and the last two had just over 5 years' experience in the construction industry. The interview questions were sent through e-mail and the resulting conversations were recorded and transcribed.

The outline design set out to elicit the background information of respondents and the organization in regards to their experience in the construction industry, title and the organization's main construction activity. Other sections were aimed at aligning the literature review with current industry opinion and to investigate the informed views of individual construction practitioners.

The findings obtained from the structured interviews were subjected to intensive analysis through influence diagramming and concept filtering. Some empirical hypotheses were tested based on the numerical facts obtained from the investigation.

PRELIMINARY FINDINGS AND DISCUSSIONS

The preliminary findings obtained from the investigation suggest the appropriateness of fuzzy set theory as a valid mathematical modelling framework for analysing construction risks. Many of the interviewees suggested that fuzzy set theory should be applied to construction risks whose structure are well-defined and whose nature are considerably complex and can be quantified within a range of options. It was however instructive that fuzzy set theory will not function best as a stand-alone mathematical framework. Its utility and practicality is enhanced by combining the logic of fuzzy set theory with insights drawn from pre-existing mathematical formulations such as Probability Theory, Analytic Hierarchy Process, Latin Hyper Cube Sampling and Monte-Carlo Simulation. It is contingent that this practical dependence is indicative of its volatility and vulnerability as a conceptual approach within the risk analysis function. All of the interviewees confirmed that incorporating "matter of degree" into decision analysis is a primary essence of fuzzy set theory in construction risk analysis. This study discovered that fuzzy set theory facilitates an enhancement in reasoning for making rational decisions in an environment of uncertainty, incomplete information, equivocation and conflicting information. This study equally confirms that fuzzy set theory have much less axiomatic limitations than probability theory.

The study has also revealed that fuzzy set theory has far-reaching applications in construction risk analysis. Many of the interviewees however noted that the use of a sophisticated framework like fuzzy set theory for all risk analysis problems might suggest a lack of consideration for the economic aspects of construction projects. For instance, Rebiasz (2007) illustrated the fuzzy set theory evaluation of risks in the production capacity of a pre-existing business and found that the information concerning probable values of NPV is more useful than information obtained through fuzzy set theory. Although, the fuzzy set computations were more time-consuming and rigorous in comparison to those from probabilistic techniques (Rebiasz 2007), it proved to be of lesser use. Some simpler and easier mathematical models might achieve same results in certain instances. For example, in projects which are highly repetitive and small in scope such as household renovations, roadwork maintenance and minor dam rehabilitations, fuzzy set theory appears to be a superfluous model when considering the economics of scale, time and resources. Dubois *et al.* (2004) had earlier stated that the transformation of probability distribution to fuzzy set distribution leads to loss of information which invariably increases the co-efficient of uncertainty in certain situations. It is deducible that discretion should be exercised by the construction risk analyst as to situations where fuzzy set theory conveys great utility rather than a blind-adherence to its use.

In respect of the construction project lifecycle, many of the interviewees recognized that fuzzy set theory generally has lesser relevance in the earlier and much later stages of a typical but complex construction project. In the earlier stages of the project, dearth of information results in the absence of a robust structural framework for risk analysis. Equally, in the much later stages of a typical construction project (say project termination stage); risk generally has a declining profile (Ayyub 2003). Therefore, the utility of the risk analysis function is basically diminished. Many of the interviewees hinted that fuzzy set theory generally has great utility in the detailed design and project execution phase. In activity duration modelling, the fuzzy set theory representation of "as soon as possible" to execute activities in a construction project planning is considered to be a better framework for achieving a more effectively and efficiently managed project. The study discovered that the "Last Planner System" of project planning described by Ballard (2000) finds appropriate mathematical expression in the conceptual logic of fuzzy set theory.

The discussions stemming from the investigation have suggested that risk analysis as a discipline is progressing on a distinctive continuum. It was discovered that as the structure of the problem becomes better understood, considerable insights can be drawn from fuzzy set theory. The study equally finds that the explicit inclusion of dynamism and continuity in various facets of the construction lifecycle conveys a more realistic conception of the character of risks and uncertainties. Contextually, the uniqueness of construction products already restricts the transferability of knowledge in projects. Inclusion of greater and misdirected subjectivity in construction risk analysis holds potential of increasing the uncertainties faced by construction professionals. These higher potential of uncertainties invariably create a vulnerable and volatile situation in construction risk analysis. Consequently, it was suggested that this vulnerability and volatility of fuzzy set theory discourages construction industries and organizations from embracing the principles and applications of fuzzy set theory.

Finally the research exercise indicated the usefulness of fuzzy set theory but also confirms the cynicism towards its use. All of the interviewees confirmed a low level of awareness of the principles of fuzzy set theory among the professionals of the

construction sector. Although all of the respondents that participated in the interview were leading experts, three of them were initially reluctant to participate in the interview. Also, some responses reflected an educated guess rather than an intense familiarity with the subject matter. It was suggested by some of the interviewees that more attention needs to be given to enhancing the overall analytical capabilities of future construction professionals.

CONCLUSIONS AND FURTHER WORK

The study confirmed that fuzzy set theory represents a valid mathematical modelling technique for analysing risk in construction projects. Fuzzy set theory is applicable in many aspects of the construction project where risk attributes can be quantified within a range of options and whose nature is considerably complex. Analysing construction risks with fuzzy sets could enhance reasoning about the project delivery sequence. This implies that time-targets are better met; construction costs will be more accurate; safety and environmental sustainability requirements will be better achieved. This will hopefully lead to a situation in which the overall construction product becomes more innovative and resourceful leading to the creation of a competitive edge. In decision-making, it was found that fuzzy set theory could promote explicitness in many decision analysis functions. However, the actual decision-support function is still primarily dependent on the strategy of the respective organization.

In construction risk analysis, fuzzy set theory could be limited by the operational scope of the project. It was also discovered that fuzzy set theory as a stand-alone mathematical tool might not be sufficient to complete the risk analysis process. This was due to the vulnerability, volatility and computational intensiveness of fuzzy set theory. These limitations have potentials of discouraging construction practitioners from embracing fuzzy set theory as a more widely- acclaimed risk analysis tool. It was also found that some areas of fuzzy set theory still require further research and investigation. Specifically, these areas include the geometry of membership functions, defuzzification of fuzzy variables and informed guidance on the suitability of fuzzy sets for various categories of uncertain events in construction projects. Equally, the appropriateness of fuzzy sets needs to be examined in concert with the current human resource base. In considering broad-based issues of construction risk where multiple organizations are often responsible for project delivery, subjectivity often creates a larger scope of consideration in the decision-making paradigm.

The subsequent stages of this study will involve the utilisation of fuzzy set theory for risk analysis in an actual construction project. Equally, further research is planned to increase the number of participants from the industry in order to capture a more representative data set. This exercise will hopefully bridge the gap between fuzzy set theory and the construction industry's practice of risk analysis. It is also hoped that further research will attempt to establish best practice for fuzzy set theory in construction risk analysis. Following this will be a triangulation of the data obtained from both research methodologies.

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AN EXAMINATION OF THE RISK MANAGEMENT PROCESS IN VENEZUELAN CONSTRICTION PROJECTS

Erika Calzadilla, Kenneth Awinda and Anna Parkin

School of Civil Engineering and Surveying, University of Portsmouth, Portland Street, Portsmouth, PO1 3AH, UK.

The construction industry has many sources of risk some of which can be attributed to the complexity of processes, the environment of construction projects, financial aspects, organizational structures and technology usage. In the success of construction projects, the importance of identifying and managing risks is widely acknowledged. Delays in time and cost overrun have become the most common risks facing the industry worldwide. However, they are particularly prevalent in developing countries where adversities such as shortage of materials, lack of management skills, unskilled labour as well as socio economic and political problems must be dealt with; all of which make construction projects more difficult to manage. Interviews with project managers responsible for projects in the public and private sectors were carried out in order to evaluate their perception of risks, how they manage these risks and the effects of the risks on their projects. The results of the investigation show the main sources of risk identified relate to: the risk management process; organizational structure; labour unions; and economic factors. For example, the Venezuelan construction companies face risks as a result of the current economic situation brought about by the currency exchange controls applied 10 years ago. This is causing a negative impact on the procurement and costs of construction projects. This paper explains how these factors are managed and their impact on time and cost. One of the recommendations proposed as a way of improving the risk management process in Venezuelan construction projects is to assess the internal processes and organizational structure of project management companies. This will aid advanced identification of the sources of risk in order to allow timely decision making.

Keywords: organizational structure, risk management, sources of risk, time delays.

INTRODUCTION

The construction industry has to deal with constant change due to its dynamic environment and, as a consequence, has to face many risks (Ofori, 2000). A study by Baloi & Price, (2003) shows that risk factors are present in all construction projects everywhere. In fact, delays in time and cost overruns have become the most common risks facing the construction industry worldwide according to Raftery (1994), (as cited in Baloi & Price, 2003). It is important for the stakeholders involved such as clients, owners, contractors, project managers, etc., to deal with these apparent risks because the construction industry brings many benefits for the economies of countries and the value of the domestic construction enterprises (Ofori, 2000).

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This research aims to identify the key sources of risk faced by Venezuelan construction projects and explain how they were managed. Furthermore, the Venezuelan construction companies may have to face risks as a result of the current economic situation, especially with the currency exchange control applied 10 years ago which causes a negative impact in areas such as procurement and costs within construction projects (Bascaran, 2003).

This research is based on different kinds of construction projects developed in Venezuela for public and private clients. This study also reflects the current risk management doctrine adopted by Venezuelan companies, and shows the crucial role that such aspects as planning, scheduling and risk management have on construction projects. Finally this research attempts to find a framework for improving the risk management process in construction projects for this country.

LITERATURE REVIEW

The concept of risk has been explained by researchers such as Baloi and Price (2003) who indicate that risk is the probability of occurrence of an event that affects projects' aims in terms of cost, time and quality. Authors such as Perry & Hayes (1985) and Porter (1981) indicated that risks are the economic losses or gains within the construction environment, while Manson (1973) and Moanvenzadeh (1979) argue that risk is just about loss (as cited in Akintoye & Macleod, 1997).

On the other hand, Winch (2010) explains the concept of risk is based on four schools of thought.

1. Objectivist school: the likelihood of an event happening can be predicted from previous occurrences of a similar event in the past.
2. Logical school: engineers use logic to identify risk sources and their likelihood because they do not have enough data or limited data do so, during the design and construction system.
3. Subjectivist school: based on the experience and expertise, or belief, of the decision makers who predict that some events can happen during the project's life cycle.
4. Behavioural school: the decisions are made based on human behaviours.

The fact that risk is very much related to the likelihood of an event happening, leads to the necessity of implementation of risk management processes by project managers. As a consequence, there is a very close relationship between the behaviour, experience, and education of project managers and the way they deal with risk factors.

THE RISK MANAGEMENT PROCESS

The risk management process has become an important activity in the construction industry. According to Akintoye & Macleod (1997), it is important for minimising losses and increasing profits. At the same time, it can also be seen as a tool to reduce the chance of failure or to maximise opportunities in the projects (Loosemore *et al.* 2006). However, for a more practical understanding of this concept, this research uses a simple framework to explain the risk management process as: risk identification, risk analysis and risk response (Raftery, 1994).

Risk Identification: Through this stage the potential risks affecting construction projects can be identified. However, the careless way in which this process is undertaken in many construction companies is one of the causes of failure of construction projects (Loosemore *et al.* 2006). Moreover, the nature of risks could be

internal and/or external. Consequently, the identification process should be carried out by a professional with enough experience (Raftery, 1994), as if a risk is not identified in early stages, it will be handled in a reactive way, rather than a proactive manner (Loosemore *et al.* 2006).

Risk Analysis: Through the analysis it is possible to identify the scale of the risk, which areas of the project will be affected, what the possible responses could be and the necessary resources required to face the risks (Loosemore *et al.* 2006).

Risk Response: According to PMI, (2004, p. 260),"risk response is the process of developing options and determining actions to enhance opportunities and reduce threats to the project's objectives".

Nevertheless, risks cannot be eliminated; the challenge is identifying, assessing and managing them effectively (Loosemore *et al.* 2006). Therefore, Willians (1995) argues that the risk management process is based on the project manager's skills and knowledge to reach the project's objectives. This research explores the perception of risks as well as the manner in which project managers in Venezuelan companies carry out risk management processes. Thus, any inconsistency between the knowledge and the application of risk management skills by project managers and contractors can be determined. In some cases there is a lack of adequate knowledge in this field in the construction industry (Mulholland & Christian, 1999; Flanagan & Norman, 1993). This view is supported by Baloi & Price (2003) who argue that contractors in developing countries do not have enough experience and knowledge to deal with risk factors. They also identify the consequences of these factors through the outcomes in construction projects such as: delays in completion, deficient cost performance and bad quality.

A study by Bascaran (2003), found that just 4% of the civil engineers in Venezuela have got a masters degree in construction project management. As a consequence, there is a shortage of skilled staff in this field. It is important to highlight, that from the data gathered for this study, there is a lack of knowledge in Venezuelan companies, about how to carry out the risk analysis process which would account for the outcomes related to time and costs in construction projects.

SOURCES OF RISK AND CLASSIFICATION

A study by Zou, Zhang, & Wang (2007) states that the primary sources of risk are two: internal, related to the type of project; and external, associated with the environment in which the project is developed. Zhi (1995) reinforces this assertion stating that external factors are those linked with the national and regional market or local construction industry, and the internal factors are those related to the behaviour of the companies and that intrinsic to the project. Zhi (1995) also identified that in developing countries, projects are significantly influenced by external factors such as economic, political and social issues, meaning that the risk management process is affected by several sources of risk at the same time.

Although it is true that there are different classifications of risks in developing countries, Bascaran (2003), who conducted a study in Venezuela in relation to risk in construction project management, reveals that the main risks in this country are: design changes, organizational structure, shortage of material and lack of knowledge in risk management.

Delays in construction projects

Many studies have been undertaken in order to identify the causes of time delays in construction projects. Laufer & Tucker (1987), claim that time delays are the result of inadequate managerial actions. In contrast, other researchers (Assaf & Al-Hejji ,2006; Zou, Zhang, & Wang ,2007; and Odeh & Bataineh, 2002) state that the main causes of time delays originate from internal and external sources such as design variations, poor labour productivity, unpredictable weather conditions, shortage of skilled labour, inappropriate planning, project complexity, poor project scope definition and shortage of materials. A study by Gonzalez (2010) reveals that delays in Venezuelan construction projects are caused by internal factors, such as poor quality of the programme and project scheduling, shortage of skilled staff, lack of management skills and design changes.

Organizational structure

The way in which the goals of a construction project are accomplished is linked to organizational structure; how people work together, the way that work flows and the line of decision making in an organization (Martin & Martin, 2010). However, the organizational target is addressed by humans, so human behaviour greatly influences the way in which risks are identified and dealt with. As a result of the close relationship between human behaviour and organizational structures, companies can face structural deficiencies such as: slow and poor quality decision making; conflict and lack of coordination; and rising costs. Moreover, according to Ogunlana & Olomalaiye (1989) the deficiencies of organizational structures of companies in developing countries happen because most of them are managed by entrepreneurs who are in the business of making money at the expense of good management.

According to Loosemore *et al.* (2006), there are two main organizational structures: mechanistic and organic. Mechanistic structure is characterized by centralise decision making, vertical communications, rigid rules and procedures, whilst, organic structure is characterized by decentralise decision making, lateral communication and few rigid rules and procedures.

Guerra (2006), who studied a construction company in Venezuela, found that organizational structure and human behaviour had an important influence on the risk management process. The organizational structure of companies would seem to be a significant factor and, therefore, it will be discussed in this research.

METHODOLOGY AND DATA COLLECTION

As the aim of this research is to identify risks and explain how they are managed in Venezuelan construction projects, rather than test a hypothesis, an inductive approach was adopted. This was implemented using a case study strategy which was useful in gaining detailed information about a small number of cases (Robson, 2002). This strategy seeks to answer the questions "why" and “how”, as well as, “what" in relation to issues behind the reality. Qualitative data was sought for this research in order to obtain different points of view of the subject studied (Saunders *et al.* 2003). This was important in this management research, not only because of the complex subject matter, analysing risk management, but also because the situation within different cases studies may be unique (Saunders *et al.* 2003).

Semi-structured interviews were also undertaken enabling the researcher to explore the interviewee’s motives and feelings, and to explore other ideas that had not had a chance to surface using other methods (Saunders *et al.* 2003).

Case studies

Three construction projects were selected each with different characteristics. Interviews were conducted with project managers from each case. The questions were divided into three sections. The first section sought to discover what risks were faced on a project and how they were identified. The second section was focused on the risk management process, the organizational structure of the companies involved and the decision making process. This was in order to obtain a general idea about how risks were managed. The last section was concerned with the effects of risks on the projects. For the development of this paper the real names of the projects as well as the names of the interviewees have been kept anonymous. The three case study projects are summarised in Table 1.

Table 1: Case studies

Project	Type of Project	Area	Description	Client	Date
Project 1	Hypermarket	11,600 m2	Mixed structure of reinforced concrete and steel	Private	2008 - 2010
Project 2	Bank Headquarters	30,000 m2	Mixed structure of reinforced concrete and steel	Private	2002 - 2004
Project 3	Housing Development	11,100 m2	Concrete reinforced structure. Block of flats were built using Tunnel Formwork system	Public	2007 - 2009

Tables 2 and 3 present a summary of the results obtained through semi-structured interviews of the relevant project managers.

Table 2: Main topics of the interviews and results

Theme	Research Questions	Results
Risk Identification	Definition of risk	PMs perceive risks as any event can affect the time, cost and quality of the projects.
	Tools and techniques used to identify risks	They did not apply any formal method to identify risks in advance. PMs mainly used their experience to solve problems as they arose.
Risk Management Process	Organizational structure of main contractors	Most main contractor companies did not have structured departments such as planning, budgets, procurement of material. Only one company had a departmental structure but they did not have skilled staff to manage them
	Risks management process undertaken	Mostly reactive or applied in an empirical way to face risks.
	Decision making process	The decision making was carried out by the owners of the companies.

Table 2: Main topics of the interviews and results

Theme	Research Questions	Results
Risk Management process	Tools and techniques applied for planning and tracking the activities of the projects	The planning process activity was developed using Microsoft project software.
Effects of risks	Effects of risks on time	Time delays (See Table 4).
	Other areas affected by risks	Costs overrun. Poor quality and low productivity in projects.

Table 3: Risks and sources identified

Source	Risks Identified	Source	Risks Identified
Designers	Projects incomplete	Main Contractors	Organizational structure problems
Political and economic situation	Labour union, foreign exchange control		Centralised decision making
	Shortage of materials		Deficiencies in risks management process
Subcontractors	Unskilled labours		Poor quality of planning and scheduling
Owners	Slow decision making		Deficiencies in internal process

The impact on time in the three cases is shown in Table 4.

Table 4: Time delays of case studies

Project	Estimated Time	Delivered Time	Exceeded Time	Date
Project 1	17 months	22 months	5 months	2008 -20120
Project 2	14 months	24 months	10 months	2002 – 2004
Project 3	9 months	24 months	15 months	2007 – 2009

LIMITATION

It is important to highlight that the philosophy chosen for this research allowed only a small sample to be taken to meet the stated objectives. The interviews were carried out with key practitioners such as project managers, who provided the specific information to document this research. Furthermore, it can be stated that at least in these three case studies broadly similar sources of risks and risk management problems were found. However, it is not the intention of this research to generalize these factors to all the projects in Venezuela, as it is obvious that external factors like social, political and economic aspects have an important influence in the source of risks in Venezuela. These may have variations over time, and they can produce different effects in construction projects.

DATA ANALYSIS

The analysis of this research report is focused on two main areas: source of risks and risk management process. Therefore, after identifying the risks in the data collection

section, they were classified using as a basis the studies developed by Zou *et al.* (2007) and Wang *et al.* (2004), which stated that the sources of risk can be classified as external and internal. Figure 1 shows the sources of risks obtained in this research and their effects.

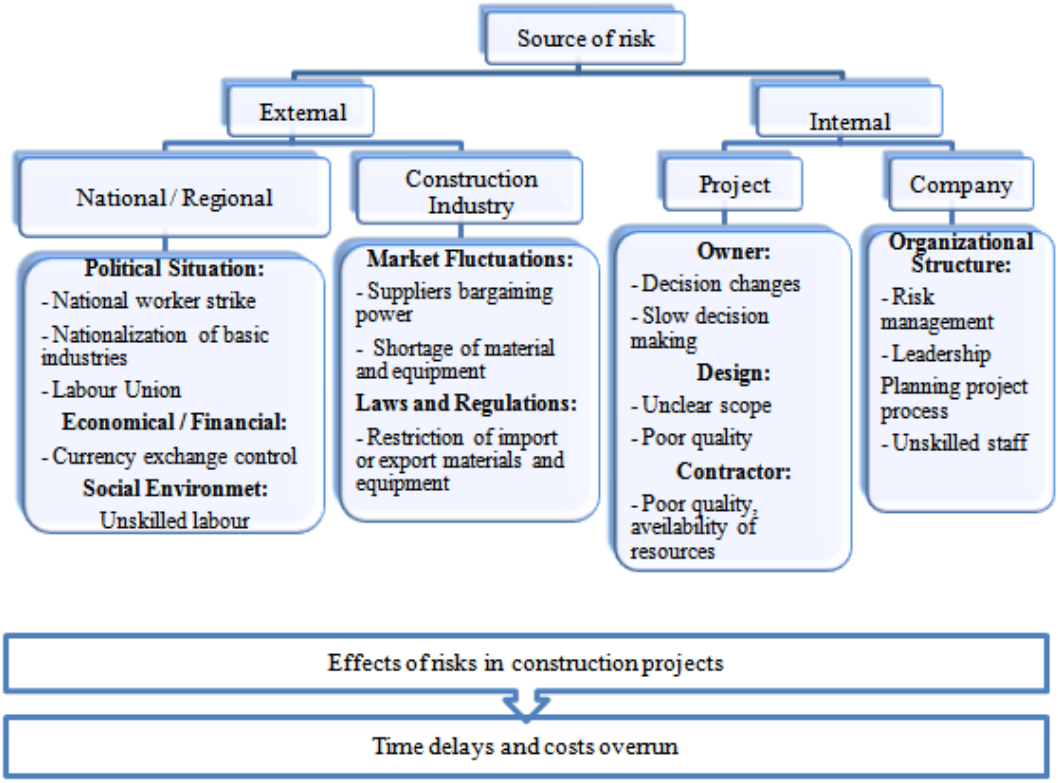

Figure 1: Sources of risks and their effects in Venezuelan construction projects

This classification is a result of the analysis based on the opinion of project managers on risks in each case study. There were risks which were the result of organizational structure or behaviour of the people linked to the projects, that is, internal source of risks, and there were other risks that affected the projects as a consequence of external factors.

Organizational structure and human behaviour have an important role in construction projects, because they are the basis of the risk management process (Willians, 1995); the success of the construction projects depends mainly on these factors. It was found that project management companies faced these internal problems in the three case studies presented in this research.

The project management companies studied can be identified as having a mechanistic organizational structure (Loosemore, *et al.* 2006) as they used a centralised decision-making process that relied on the project manager or the owner's company. They did not have structured departments with strong functional identities. This fact can be attributed to the size of the companies; Project 1 and Project 2 were carried out by small companies, whereas Project 3 was carried out by a medium size company.

Furthermore, it can be said, that organizational structure and human behavioural factors were important in these cases. This research stated that the perception of risk adopted by the project manager was from the subjectivist school. Consequently, risks were faced in a reactionary way rather than in an anticipatory manner. Therefore, risks were perceived according to the experience or beliefs of project managers (Loosemore

et al. 2006). What is more, the organization always managed the crisis rather than preventing them, and did not fully understand how human behaviour can affect perception of risks and therefore their impact on projects. These statements are supported by interviewed project managers, who agreed that they had not developed a risk management plan before the project execution phase. In addition to this, it was found that the project managers perceived a scheduling programme as a tool to predict and monitor risks. A scheduling programme can be classified as a good tool to monitor time and resources but it is not enough to manage risks. Essentially risks were managed in an empirical manner in these case studies.

All these case studies were affected by the foreign exchange currency control applied in Venezuela since 2003. Therefore, the main areas affected by this source of risk were procurement of material and equipment which increased the costs. In some cases the contractors had to buy the construction products through the parallel foreign exchange market, as a result of the inefficient exchange regulation applied by the national government.

Another external source of risk was the impact of the labour union on construction projects in Venezuela that has roots in political, social and economic factors. The construction industry has been impacted by this situation, as a result of the new labour legislation since 2007 which states that 75% of the workforce must be provided by the labour unions. Quality, time and costs have been negatively affected in construction projects because the majority of the workers are unskilled, resulting in low productivity. This last fact could be verified in the sample of cases studied, as the projects were constructed between 2002 and 2010.

As shown in Table 4, Project 2 finished in nearly double the time that had been originally estimated and Project 3 finished in more than double the time while Project 1 had the shortest delay on time. It can be argued that poor risk management processes, the lack of knowledge or the lack of effective tools and techniques to handle risk were the fundamental causes of delays in these construction projects. However, costs and quality were other areas which were also impacted as consequences of delays in construction projects, according to the results obtained in the interviews with project managers.

It can be argued that the time delays and cost overruns experienced by construction projects in Venezuela are linked, to the risk management process undertaken which has many technical deficiencies and is greatly influenced by human behaviours. Therefore, the final results are exceeded time and costs overruns.

CONCLUSION

The main sources of risks that the three different case study projects faced were identified as internal and external. As was mentioned earlier, the significant internal sources identified include organizational structure, poor risk management process, unskilled staff, slow decision making, design changes, and poor quality of contractors.

External source of risk as stated by Zhi (1995) arise from political, economic and social environments in developing countries. As a consequence in Venezuela economic factors such as foreign currency exchange control and inflation have affected costs of projects due to the material and equipments prices. Social factors such as unskilled labour have had an impact on quality and productivity. Similarly political factors, such as nationalization of basic industries, have caused shortages of

materials, while the increasing influence of labour unions in Venezuela in the last 10 years have reduced productivity in construction.

These projects also show the empirical way in which risks were managed, how some factors, such as organization structure and human behaviour, have an important influence on a project's success, (as shown in Table 4).

According to the findings of this research, based on a qualitative analysis, it is important to improve areas such as risk management process and Organizational structure, which can be considered as the basis of a successful project. Adopting suitable organizational structures in the project management and contractor companies would be a good first step to achieving success. In this way, the organizations should assess their internal processes in order to improve procedures for decision making, which was one of the areas that showed clear deficiencies in this study. Also, organizations should provide their staff with training in the management field to underpin their strengths and minimise their weaknesses and thus get better results in terms of time, cost and quality of projects.

Human behaviour and its influence on projects is another important aspect to be analysed and improved within the organizations in Venezuela because it would allow project managers and owners to modify their judgements and their perception of risk and thus help them respond properly to risks, rather than in a reactive manner. The sources of risks can be predicted in advance and their impact assessed allowing project managers and clients to make timely decisions to reach the objectives of the project.

Finally, it can be said that with an adequate risk management process and a good organizational structure, both internal and external risks and their impact on projects can be mitigated.

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REVIEWING RISK ALLOCATION FOR INFRASTRUCTURE PFI: BETWEEN THEORY AND PRACTICE

Dania Issa[1], Margaret Emsley[2] and Richard Kirkham[3]

School of Mechanical, Aerospace, and Civil Engineering, University of Manchester

Risk allocation (RA) in PFI infrastructures resides in a complex milieu. Tackling this issue from both theoretical and practical perspectives is important in order to understand its complexities. It is claimed that PFI deals can result in better value for money through proper RA. However, the common notion of the public sector transferring ALL risks to the private sector does not describe the reality nor define the optimum way of dealing with risks in infrastructure PFIs. In order to analyse the process of RA, an extensive literature review is undertaken to compare the theory and the practice of the process. It is concluded that a considerable gap exists and the main reason for that is the absence of consensus around the logic/theory of the PFI itself.

Keywords: infrastructure, PFI, risk allocation, risk identification, uncertainty.

INTRODUCTION

The pressure on governments to absorb the growth of cities and provide advanced services through building mega infrastructure projects contributed to the movement towards using private capital in the provision of public services. This approach, named Private Finance Initiative (PFI), officially started in the 1990s in the UK. It is argued that infrastructure projects are the only projects open to PFI arrangements (Mountain 1998 in Bing *et al.* 2005). Thus, the paper is concerned with RA in PFI infrastructure which involves financing projects from private money. The PFI approach has come with many promised fruits of fast delivery, advanced technology, innovative designs and high quality. It is claimed that it can deliver value for money through proper RA (Akintoye 1998; Treasury 1997). The paper aims to investigate the issue of RA in PFI infrastructure through an extensive literature review on the theory and practice of the subject. This is part of a research attempting to design an informed decision support model for RA. Therefore, the methodology is to track the process of RA from the outset; i.e. risk definition through risk identification and allocation. The word theory used in the paper includes both the risk management theory as stemming from project management and the logic (theory/rational) of PFI. The word practice includes

[1] dania.issa@postgrad.manchester.ac.uk

[2] margaret.emsley@manchester.ac.uk

[3] richard.kirkham@manchester.ac.uk

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professional bodies' recommendations, case studies, and surveys conducted and cited in the literature.

RISK DEFINITION

Generally, the word risk can be directly linked to danger or harm that should be avoided. However, in the world of project management, risk has two sides; danger (negative event) and opportunity (positive event). This is reflected in the objective of risk management as to increase the probability and impact of positive events and decrease the probability and impact of negative events in a project (PMI 2008). This idea of looking at risk is at the core of the private sector's thinking of risk bearing involved in delivering infrastructures. The link between risk and uncertainty is evident in various definitions of risk by various authors who see risk as derived from uncertainty or as a result of lack of certainty (Hillson 2002; PMI 2008). Thus, risk is defined as the effect of uncertainty on a project's objectives. Froud (2003) gave a comprehensive overview on the concepts of risk and uncertainty. She summarized the approaches towards the uses of risk and uncertainty as "technicist concepts", "post-modernist concepts", and "radical concepts". She linked them to the process of RA in PFI projects. The first and third concepts are discussed below, given their relation to the PFI infrastructure context.

Technicist concepts

This approach looks at risks as quantifiable using probabilistic techniques. Thus, it does not take uncertainty into consideration, or as Froud (2003) puts it "risk and uncertainty are conflated". A similar approach towards risk management is criticised by Holt (2004) who argued that seeing risks in terms of technical reasoning ignores many aspects of risk. This is due to ignoring risks when probabilities are uncertain (i.e. unknowable) (Froud 2003). Holt (2004) referred to the idea that the risk management process deals only with "tame" problems where it should deal with "wicked" problems which can better describe the project environment. The technicist approach also corresponds with the cognitive science perspective on risks (Lupton 1999) which is concerned with the calculation of the probability and impact of risk events. This makes it convenient for use in the cost benefit analysis usually used in PFIs (Hood & Mcgarvey 2002).

Radical concepts

This approach recognises uncertainty and differentiates it, conceptually, from risk. It suggests that the term risk (i.e. the ability to use probabilistic techniques) can cover the types of risks insurable by the private insurance, such as accidents. This is due to the ability to process information (i.e. experiences) from the past to forecast future outcomes. In PFI terms, safety, fire and security are all types of risks the private sector can transfer to insurance companies. Outside these types of risks, Froud (2003) argues, "uncertainty rather than risk becomes the relevant category". Again, in PFI terms, interest rates and demand levels over a period of 20-50 years are examples of uncertainties. Not only it is the long time frame that makes them uncertainties, but it is also the time gap between decision making and the occurrence of these outcomes. It is suggested that these decisions, taken in the present time and reflected in contracts, will partially shape the uncertain future outcomes (Froud 2003). Ultimately, attempting to deal with uncertainties as risks will, at least, result in a non objective probabilistic distribution. However, Hood and McGarvey (2002) argue that any discussion on the meaning of risk in a PFI project is 'rendered redundant'.

RISK IDENTIFICATION

The theory

Risk identification (classifying risks into categories and sub-categories) is the first step in RA. There are different ways of risk classification in literature. Some classifications are done in relation to project phases (e.g. design and construction, operation), others describe the environment of the project (e.g. political, economical, environmental, and financial) or they perceive risks as occurring at levels (e.g. macro level, meso level, micro level).

The theory of risk management provides a systematic approach towards risk management in general and risk identification in particular. The PMBOK (PMI 2008) uses the Risk Breakdown Structure (RBS) framework where risks are shown in categories and sub-categories that identify the main causes of risky events in a project (PMI 2008). Information on risks are gathered through a number of techniques, such as brainstorming, checklists, and Delphi performed by a team of experts and key stakeholders, to produce joint views on potential risks (Ghazali and Kabir 2009; PMI 2008). It is most important that identifying risks should be an iterative process that takes place over the project life cycle (PMI 2008; Boussabaine 2007).

In relation to the PFI context, from another theoretical point of view, Froud (2003) argues that risk identification is confined by the imagination of the parties to a contract. Thus techniques like brainstorming are not adequate, and a contract will definitely exclude some risks and/or create new risks. From a similar perspective, Hart and Moor (1988) described the situation of information asymmetry where not all parties to the contract can observe the state of the world. In a PFI, this situation stems from three factors; unacknowledged uncertainty, PFI complexity and long duration. Due to the use of the technicisit approach in defining and dealing with risks, the unknown will not be identified, thus some risks will not be allocated (Froud 2003). Moreover, the complexity of the PFI arrangement can generate new risks (Grimsey and Lewis 2002; Spackman 2002). Risks can emerge in a complex system (Brookfield and Boussabaine 2009).

The issue of contract incompleteness joins the above factors to create further difficulties in risk identification. Incompleteness of a contract is defined as the failure of a contract to specify parties' obligations when contingencies are realized (De Fraja 2002). In long term contracts, such as PFI agreements, incompleteness is magnified. Hart and Moor (1988) differentiated between information asymmetry and contractual incompleteness. The latter is due to the higher transaction costs that are incurred from trying to process information and reflect it in contractual statements. Thus, it is nearly impossible to anticipate all the possible contingencies that are needed in a contract.

Checherita and Gifford (2007) have a relatively similar view to that of Froud (2003) in relation to the specificity of PFIs in creating their own particular risks. They propose an interesting classification of risks as common and specific. Common risks are those which are usually encountered in infrastructure projects. Specific risks are those created or intensely stimulated by the PFI structure (i.e. PFI complexity). They are caused by the distinctive relationships between the public and the private and the way their economic interests are bundled. The risk of opportunistic behaviour is one of these specific risks.

Opportunistic behaviour is a result of contract incompleteness and institutional complexity (Williamson 1976). Opportunistic behaviour is manifested in the case of

contract renegotiation which is the direct product of either contract incompleteness or information asymmetries or both. Apart from additional costs, delay and potential disputes; contract renegotiation is obnoxious to the public sector as it shifts the power in the private company's favour. Weaknesses in the bidding process stemming from non objective assumptions and unrealistic estimates of future demand/production stated in the bidding documents (i.e. information asymmetry) can result in the less prepared firm winning the bid. After signing the contract and when the project becomes clearer and risks are realized and faced, the private firm will seek contract renegotiation.

The practice

In practice, specifically in the UK, risk identification relies heavily on standard risk registers recommended by official bodies, e.g. National Audit Office (NAO) and Office of Government Commerce (OGC) (Boussabaine 2007). A risk register is the output of the risk identification process. Its application is similar to the checklist technique described in the PMBOK (PMI 2008). However, Ghazali and Kabir (2009) criticized the use of a single technique in risk identification. They found that the NHS Trust uses only the brainstorming technique and they concluded that this technique is not adequate and other established techniques, such as Delphi, should be also used because they offer expert feedback and controlled views on risks.

The reflection of the theory of contract incompleteness in the practice of PFIs has some implications. Firstly, remedies to contract incompleteness are not applicable in the case of a PFI (Froud 2003). Interestingly, one of the remedies involves the ownership of assets which implies abandoning PFI concession as a mean of infrastructure delivery (Deakin and Mitchie 1997 in Froud 2003). Secondly, from a partnership viewpoint, PFIs should promote flexibility and transparency. In this regard, the Treasury Taskforce (1997) recommends that projects should not be over specified to allow for private sector's innovation. In fact, private sector innovation is one of the most sought 'fruits' for private participation in infrastructure delivery. However, there is a paradox between the need for quasi- complete contracts to avoid renegotiation and to limit the complexity of a contract as Hart and Moor (1988) stated, and the need for flexible contracts to encourage innovation. Complete contracts, apart from their impracticality in general, are not encouraged in practice under a partnership agreement.

The logic of PFIs, as stemming from a partnership approach and residing between traditional procurement and complete privatization, should not result in, theoretically, a dramatic effect on the position of the state as the ruling and controlling authority. This is because it is not privatization or a selling of governmental assets but a long-term 'partnership', although some authors such as Asenova and Beck (2010) argued that PFIs are mere capital investments.

In practice, the issue of governance is not attracting the required attention (Hodge 2004). PFI projects tend to focus on commercial risks which can be specified in the contract. However, governance risks that can undermine the role of the state in maintaining public interest are overlooked. Commercial risks are those which can be priced and quantified, thus reflected in the contract. On contrary, governance risks are usually intangible, referring to a possible deficiency in the government's role of protecting social interests. Therefore, it can be easily overlooked in the midst of rigid economic figures.

The case study of City Link Toll way project in Melbourne (Hodge 2004) is a clear example of poorly managed governance risks as opposed to well-managed commercial risks. Firstly, the concession, which has been granted for 54 years, is seen as considerably long due to the restrictions it applies on government's decisions. The Special Purpose Vehicle (SPV) claimed damages from the state government under a provision in the concession agreements that prevent the state from taking any actions that damages the toll-way revenues, as a result of poor demand (Hodge 2004). Thus, the SPV claimed $35.8 million when the state built another nearby public road. This implies two issues. Firstly, a contractual provision can be vague in such a way that enables an SPV to claim damages whenever it 'perceives' the situation is harmful to revenue. Secondly, a 54-year concession with such a provision would completely lock-in the state and prevent it from initiating any similar projects in the surrounding area. This idea is supported by Lonsdale (2005) who, furthermore, concluded that contractual balance between the state and its supplier under a PFI is difficult to achieve, thus a state being locked-in is highly probable. However, the author believes that long term concessions and vague provisions in the contract can maximise the imbalance.

A similar problem was faced in the delivery of a bridge in Lisbon, Portugal (de Lemos *et al.* 2004). The initial project was to deliver the "Vasco Da Gama" bridge as a toll crossing the river Tagus. However, the government included the maintenance and operation of an existing bridge "25 de Abril", serving the same area, in the concession agreement in order to mitigate traffic risk for the private company. "25 de Abril" was originally a toll under a 20-year concession after which it would be free for the public. The government did not accomplish that and furthermore it raised the tolls on a bridge that had been already paid for, to make it viable for the private investor. This resulted in a huge public outcry and increased media scrutiny and, consequently, this created a political risk. The government became unpopular and this contributed to its failure in the subsequent elections.

Conflict and legal disputes were characteristics of the Melbourne Toll-way and "Vasco De Gama" project. The effect of litigation on a state government is considerably different from that on a corporate because any legal case involving the government "makes good newspaper" (Hodge 2004). So, a central government, in deciding to avoid litigation, might settle for terms that restrict its future control and threaten its sovereign position.

RISK ALLOCATION IN PFI

Who to allocate to?

Parties of PFI deals, generally, include the public entity, the private sector, senior lenders and end users. However, the inclusion of end users as a stakeholder is not usually observed in practice and is under debate in theory. There exist two approaches towards dealing with end users or 'citizens'. One view sees them as distinct or 'peripheral' stakeholders who should be consulted during the development phase as they can influence RA outcomes (Chen and Hubbard 2012). On the contrary, others (Bing *et al.* 2005) defined RA as an assignment of risks between the project's direct participants; the public and the private. The latter view can be the output of two elements. First, the government should inherently take citizens' interests into consideration. Second, it is impractical and nearly impossible to include 'citizens', as an absolute party, to any commercial contract. This issue is also reflected in theoretical decision support systems which attempt to model the RA process between

PFI's parties. Yun and Wei (2008), in formulating their model for RA in BOT expressways, considered the 'product buyer' as a participator in RA. However, most models (Lam *et al.* 2007; Medda 2007; Li and Ren 2009) seek the optimal allocation of risks between the public client and the private company. Eventually, risk in practice is allocated between the contracting parties. Nevertheless, many argue (e.g. Ng and Loosemore 2007; Cooper and Tylor 2005) that risk will eventually be transferred to the end-user.

Principles of risk allocation

A common principle is to allocate risks to the party best able to manage it. However, the term 'manage it' is relatively broad, thus this principle is decomposed into two general principles (Medda 2007; Hood and McGarvey 2002). First, risk is borne by the party best able to influence and control the outcomes of risk. Second, risk is borne by the party able to bear it at lowest cost. However, adopting these principles in practice has two main implications. Firstly, these two principles are usually in conflict as the party that can control a risk source and influence it is usually not the same party that can manage this risk efficiently at a lower cost (Medda 2007; Boussabaine 2007). This is apparent in a concession-based PFI where the government has the overall control over demand levels of a toll road, but at the same time the private company has the capacity (resources) required to manage this risk. Secondly, these principles imply subjective judgment and are not easily reflected in a decision support model or in a real contract (Lam *et al.* 2007; Khazaeni *et al.* 2011). Jin (2011) proposed a theoretical framework for RA that interprets the RA decision making in terms of theories behind these two principles. He looked at the transaction cost economics and the resource-based view of organizations' capacity. However, in practice, value for money (VfM) assessment excludes the transaction costs from the Public Sector Comparator (PSC) calculations, which has been criticized by Cooper and Taylor (2005), mainly because transaction cost is high in PFI projects given the lengthy time required to negotiate and the cost of experts' participation (Bing 2003).

Risk allocation and its implications

In theory, it has become a common notion that a PFI's core aspect is to transfer risk from the public to the private sector (Bing *et al.* 2005), although it is argued that risk transfer has arrived only as a 'fortunate' by-product (Froud 2003). Thus, theoretically, the majority of risks should be transferred to the private sector which is responsible for the financing, designing, construction and operation of the infrastructure project. However, the so-called 'advantage' of risk transfer is a controversial issue both in the academic literature and in practice (Boussabaine 2007; Froud 2003; Pollok *et al.* 2002; Spackman 2002) due to three main factors. First, risk transfer is strongly linked to achieving VfM in PFIs. Second, the underlying theoretical base that makes a PFI deal 'good at' transferring risks is questionable in practice. Third, RA relies heavily on the context. These factors are discussed below.

In the UK practice, VfM assessment is undertaken through a PSC based on the Net Present Value (NPV) technique. VfM is only observed when risk transfer is made, therefore if risks are not transferred this value will be diminished (Shaoul 2005; Boussabaine 2007). The output of the comparison between publicly-funded infrastructure (PSC) and a privately-funded one is always in favour of the PSC unless risks are added to the PSC. The private capital cost is usually higher than the public cost in infrastructure projects mainly because governments can borrow money for lower interest rates. However, when risks are incorporated into the NPV, the private

option appears to be the cheapest. Boussabaine (2007), Pollock *et al.* (2002) and Froud (2003) noticed that even when calculations show that the PFI is the better option, the differences between numbers are marginal and sometimes are not enough to make a decision in favour of PFI. Moreover, it is doubted that risks, to be transferred, are priced in a way that make the PFI option seem cheaper.

The advantage of risk transfer in a PFI comes mainly from a strategy in dealing with risks; called risk spreading. It involves the ability to spread risk to a relatively high number of bearers, thus, theoretically eliminating it. Checherita and Gifford (2007) believe that PFI deals provide the required environment for risk spreading and diversification to multiple parties. However, from a practical viewpoint, diversifying risks down the project supply chain implies that each bearer will need compensation in a form of risk premium. Premiums will accumulate and a higher cost would be incurred (Ng and Loosemore 2007). Furthermore, some public risks, e.g. risks involved in environmental-related goods, cannot be easily quantified and consequently cannot be widely spread (Spackman 2002).

Context-related issues can evidently contribute to the failure of the RA process. Context is concerned with the project's external environment through which different levels of power and influence are reflected. Power relations between a PFI's stakeholders have the ability of distorting RA in favour of the strongest party (Chen and Hubbard 2012), where generally a partnership between two parties should, in theory, imply a power balance, the practice of PFIs suggests different situation. The delivery of a BOT toll road project in China is a good example (Chen and Hubbard 2012). The private company, the public authority, and citizens have all played their role in the power shift over the project's phases. The public authority did not satisfy its obligations regarding certain compensation when demand was below expected. End users exerted their power through not using the road and relying on other alternatives. Three main conclusions can be observed. First, RA, although done through contractual agreements, does not reflect the reality where risks are shifted to the less powerful party. The power a specific party can exert depends on the project phase; i.e. pre-contract and post-contract phases. The power possessed by a party can be exerted only if allowed by a juridical system. Therefore, the public sector's power in developing countries is more evident since judiciaries are not independent compared with western developed countries. Another problematic point is the relative power of different governmental departments. A well-documented government guarantee could be of no value when it contradicts with a higher policy or a sovereign law. Such a problem was encountered by the private company in the Bangkok Second Stage Expressway (Checherita and Gifford 2007).

Government support

Government support in PFIs is seen through governments' guarantees and subsidies. From a theoretical viewpoint, government support is required to mitigate for risks outside the private sector's control, such as political risks that can affect demand and/or revenue levels. However, guarantees should be balanced to keep the private contractor incentivised and reduce risk exposure. Brandao *et al.* (2011) developed a model for determining an optimal incentive mechanism for transportation projects. They concluded that for a given risk reduction level, the lower cost alternative for government results from increasing the Minimum Demand Guarantee (MDG) and decreasing the amount of subsidy. However, in practice, government guarantees are dependent on the economic and political context. As Ozdoganm and Birgonul (2000)

put it "A government guarantee against political risks is always as good as the government itself". Moreover, a government operating in an unstable environment may need to provide excessive guarantees to convince private investors, to the extent that a traditional way of procurement would be cheaper (Singh Bajaj 2007). Moerover, in practice, when the guarantees' value is larger than the financial loss related to the risk, the private partner would prefer that the risky event will occur in order to gain profit (Medda 2007).

Critical risks and risk preferences in different contexts

There is a consensus that in concession-based, stand-alone PFIs, revenue risk, as dependent on demand risk, would be considered as the most critical since it is the only source for the private company to service its debt and to generate profit to satisfy shareholders (Checherita and Gifford 2007; Thomas *et al.* 2003). It should be noted, however, that revenue risks are not always dependent on demand risks. Certain payment mechanisms exist to reduce the demand risk on the private service provider who would be paid for the availability of the facility itself regardless of its real use (e.g. water treatment, power generation stations).

RA preferences vary depending mainly on the context. In relation to the controversial demand risk, some believe demand risk should be transferred to the private sector (Li and Ren 2009). In fact, transferring demand risk to the private sector would be the biggest motive for governments to deliver transit projects through PFIs (Siemiatycki and Friedman 2012). Others believe that this risk should be a matter of negotiation (Forrer and Kee 2002). However, not only does practice show that transferring this risk to the private is not feasible but it also indicates that stand-alone transit projects perform poorly when the private provider is compensated merely through end-users fairs (Siemiatycki and Friedman 2012).

The influence of context on RA can be seen in the politically-stable UK where the government retain political risks as it is cheaper and there is "little to be gained" from trying to transfer them (Bing *et al.* 2005). The UK-based survey conducted by Bing *et al.* (2005) showed that demand risk is allocated to the private sector but with perceived opportunity for sharing. Risks such as interest rate volatility, availability of finance and geotechnical conditions were preferred to be retained solely by the private sector. On contrary, in China, the results of a survey on RA preferences conducted by Ke *et al.* (2010b) showed that most risk categories are either retained by the public or shared with the private sector and no risks were preferred to be transferred completely to the private sector. Ke *et al.* (2010a) compared RA preferences in Hong Kong and China with those of UK and Greece and concluded that UK is the best able to transfer risks to the private sector then comes Greece, Hong Kong and China. This could be related to the stable political context and the well-established PFI policy in the UK.

DISCUSSION

The theory has introduced significant advances in the approaches towards risk definition but in practice, governments and local authorities are still stuck in the traditional (technical) approach of defining risks. Recognizing uncertainty is of a great importance in a PFI environment given the long time frame. If there is substantial uncertainty concerning cost and time data, cost plans may have little value for decision making (Boussabaine 2007). The way risk is defined is reflected later on in the identification and allocation processes. When risks are not identified, they are not

allocated and thus retained by the public sector because contracts can only specify obligations for identified risks.

Infrastructures PFIs have distinctive features that affect the allocation process. Firstly, the objectives of the two contracting parties are in conflict, and not complementary as they should be in a partnership agreement (Bresnen and Marshall 2000). In a PFI, maximising profit is a priority and public need is serviced only when it generates profit during the operation phase. Moreover, an inner conflict may occur within the same party as Ozdoganm and Birgonul (2000) suggested. The contractor is playing the owner side, as a member of the SPV, whose main duty is to protect the project. At the same time the contractor side, aiming at mere profit, has a strong presence. One of the reasons for creating an SPV is to direct the stakeholders' efforts and loyalty towards the project itself rather than their own conflicting objectives. Similarly, the goal of RA, as well, is to minimize the overall risk cost of the project and not the cost for each party (Lam *et al.* 2007), but this is not observed in practice (Ozdoganm and Birgonul 2000). Secondly, these projects are complex from all perspectives; financially, contractually, relationally and politically. Complexity increase risks (Ng and Loosemore 2007). Thirdly, payment mechanisms play a profound role in infrastructure PFIs. The private sector, pushed by lenders, may impose payment mechanisms which lower its revenue risks at the expense of end-users. Payments for toll roads, for instance, have various forms, with each imposing a different level of risk on the private SPV and their lenders. These payments mechanisms are situated on a spectrum ranging from availability-based tolls with no demand risk, to the riskiest tariff-based user-paid tolls (Bain 2009). Between these two extremes there exist a number of arrangements; each is trying to create the balance. Therefore, it is recommended that payment mechanism reflects both the level of service and the amount of risk transferred (Akbiyikli *et al.* 2011). Fourthly, RA is highly dependent on the context. Developed countries may have entered into these deals as part of a neoliberal agenda. However, for developing countries it is only because of lack of public money and looking at PFIs as the only way to deliver crucial infrastructure. Still, it is harder for developing governments to secure balanced RA. The government would be either aggressive to protect itself, and consequently hinder the relationship, or 'negatively generous' to incentivise the private sector at the citizens' expense.

It would be reasonable to say that most risks, after the project is built, are passed back to the public or the citizens. The characteristics of contract incompleteness, long duration and high potential for renegotiation are inherent in any PFI deal and are enabling the private sector to pass back risks to the public through, for instance, changes in payment mechanisms. It could be said that risk is like 'energy' in physical terms. Risk is neither eliminated nor created from "scratch", rather it is transferred and converted from one form to another. This is truly evident when a demand risk can be converted into political risk if not treated properly, thus transferred back to the public sector.

The relationship between risk factors is not adequately addressed in practice. This relationship could be best described by the formation of a snowball. Risks can aggregate; the occurrence of one risk can easily lead to another risk and so on. A default in the design can lead to higher operation and management costs and/or lower performance, and consequently lower demand for the service. Similarly, the occurrence of a risky construction event would cost the SPV a significant amount of money. The private sector will seek to compensate for this through a higher tariff, possibly causing public outcry and political risks.

It is noticed that there are two gaps. A gap exists between theory and practice since a balanced RA is not observed in practice. At best, a PFI deal might be theoretically good in transferring risks to the best party to manage it; however, it creates qualitative risks which are not accounted for. Another gap exists within the theory/logic of PFI itself. A consensus on the nature of PFI's origin and its underlying objectives is missing. On one hand, some are viewing it as a procurement route for governments to rapidly deliver advanced infrastructure and satisfy its role towards society while others are seeing it as an investment-driven approach that sees profitability as its first priority (Asenova and Beck 2010).

CONCLUSION

RA has been researched between theory and practice. The methodology was to track the process of RA from the outset; i.e. risk definition through risk identification and allocation. Areas of contradictions between theory and practice have been highlighted. It is concluded that a gap between theory and practice exists and a second gap exists within the theory of PFI itself.

It is concluded that uncertainty, rather than risk, prevails in any PFI deal. Therefore, contracts are not the best way of dealing with risks in a PFI structure. Governance risks are overlooked and PFIs are criticised as hindering government positions. However, this view is the outcome of the second gap that exists in perceiving PFIs and the real objective behind these deals.

If the private sector is to commit capital over a long period of time, then it needs a considerable compensation in return. The trade-off between this compensation and the advantages claimed by this financing method is a long standing debate. On one hand, governments will benefit from off-balance sheet projects delivered faster and operated to higher standards. It will also transfer the risks associated with time, cost (financing) and quality (performance) to another party, who might actually be the end user. On the other hand, it is suggested that this method will deprive the public sector from its superior control over public services resulting in a distorted balance of power. Thus, it could be inferred that the whole argument on the viability of PFIs is founded on the way of dealing with commercial risks and governance risks. However, discussing governance risks is difficult when a consensus on the logic of PFI is absent.

Generally, what is happing in PFIs is enforcing risks to adapt to a contractual agreement (commercializing risks), under a partnership agreement that cannot in any way deal with risks over 50 years, rather than adapting the contractual context to the nature of risks in a PFI deal. Practice of PFI is controlling the way risks are defined and allocated. In theory, RA models are trying to model the allocation of quantified risks and only few quantitative models for RA exist.

Risk conservation and the snowball syndrome have been introduced to describe the nature of RA in PFI. In short, for an infrastructure PFI deal, the private sector will always seek to pass the risk back to the public even though the theory presents a 'perfect' world where balanced power and RA exist.

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SUSTAINABILITY – (OPERATION AND PRACTICE)

EVALUATING FACTORS IN SUSTAINABLE ROAD CONSTRUCTION AND MANAGEMENT – A LIFE CYCLE APPROACH

David Thorpe[1]

Faculty of Engineering and Surveying, University of Southern Queensland, Springfield, Brisbane 4300, Australia

Roads perform an important connecting function for the community. At the same time their design, construction and operation are not always easy from the point of view of sustainability. Achieving sustainability in this process requires the undertaking of initiatives such as sound environmental management, water sensitive urban design, use of advanced and recycled materials, and environmentally responsible project management and construction. The contribution of such factors to a particular road project can be different for alternative options for constructing and managing the road. This can be an issue in comparing these options. A methodology is proposed to address this issue through calculating a weighted score of the sustainability related economic, environmental and social factors for each option, using a life cycle management approach that considers stakeholder requirements. As the variables in this process tend to be measured in a range of units and may be either quantitative or qualitative, each variable in a given road construction option is both given a weight and also assigned a suitable comparative score obtained though calculation for quantitative variables, or using a utility approach for qualitative variables. The calculated total weighted scores for various road construction and management options may then be compared when assessing the most sustainable option. An example calculation that compares the weighted sustainability for two road construction options is provided. The approach described is flexible and may be used in conjunction with other methodologies, and is also capable of being developed into a suitable computer based modelling tool.

Keywords: sustainability, roads, development, construction, management.

INTRODUCTION

While roads are important transportation and communication links, there are some concerns about their sustainability aspects. In particular, while roads have both economic and social benefits, there is concern about their impact on the natural environment. The main environmental issues with roads tend to revolve around greenhouse gas emissions from the traffic they carry. They also have other potential

[1] thorped@usq.edu.au

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environmental and social effects, such as their ability to impact on natural landscapes and on those who live near them.

However, it is possible to construct and manage roads in an environmentally and socially responsible manner. Another aspect of road sustainability is that roads, as a significant component of the transportation fabric of society, should be available for as much time as possible. In particular, major routes should wherever possible. If they are not, essential goods may not be able to be transported and there is significant impact on the economy. In the flood disasters in 2011 in Queensland, Australia, for example, some major transportation routes were unable to be used both during and for some time after being flooded, with consequent social and economic effect.

Roads are significant contributors to national wealth and are vital elements of the social fabric in many nations. They also represent a significant component of national infrastructure capital.

Given the tension between the environmental impact of roads and their importance in modern society, road authorities and governments have provided guidance on the planning, development and operation of roads in a sustainable manner. For example, the United Kingdom Stationery Office has provided a guide to sustainable highways for the use of local authorities (Department of Transport Office, 2008). This document provides advice for local authority engineers on the choice of sustainable materials and techniques for highway maintenance and construction.

Similarly, the European Union Road Federation has produced a discussion paper on sustainable roads (European Union Road Federation, 2007). This particular document discusses the importance of reliable road networks in developing countries in the connection of communities (and hence their prosperity), the trend towards cleaner road transport, environmentally sound road design, and the ethical balance between the societal advantages of road provision and environmental sustainability.

While it is recognised that many aspects of sustainable roads are developed during planning and design, this paper concentrates on the construction and operation phases of the road life cycle. It uses a life cycle approach to demonstrate, from the point of view of stakeholders, a methodology for the evaluation of environmental, economic and social aspects of road construction and management. This approach focuses on the road pavement and surfacing, and therefore excludes road transportation activities (which would have been considered in the planning and design phases of the road life cycle) and the development of drainage structures, road furniture and similar construction.

Following a discussion of the relationship between the road and its environment, this paper discusses some potential issues in the construction and management of sustainable roads, discusses the road life cycle and investigates options for evaluating these factors using a strategic approach based on this life cycle.

THE RELATIONSHIP BETWEEN THE ROAD AND ITS ENVIRONMENT

To better understand the issues in sustainable roads, it is firstly important to understand the concept of sustainability, and then to understand how roads interact with their environments and communities.

The concept of sustainability used in this paper is based on the well-known definition of sustainable development used by Brundtland (1987), which is “meeting the needs

of the present without compromising the ability of future generations to meet their own needs." Such sustainability, as commonly understood, has three components, all of which require to be kept in balance - economic sustainability, social sustainability and environmental sustainability. Thus, while from an economic viewpoint roads are required to be built and managed to a budget and provide economic benefit, it is also necessary to consider their impact on society and the physical environment.

Figure 1 shows a simplified view of a road within its physical, environmental and social environments. The road consists of a sealed pavement, along which flows traffic. It is built on a subgrade and interacts environmentally with the biosphere (atmosphere, lithosphere and hydrosphere). It also interacts with the economic environment (for example, construction and maintenance cost, benefits and costs of transportation, bringing business to local communities) and the social environment. The social environment in this model consists of three overlapping communities - the road owner, the road user and the external community.

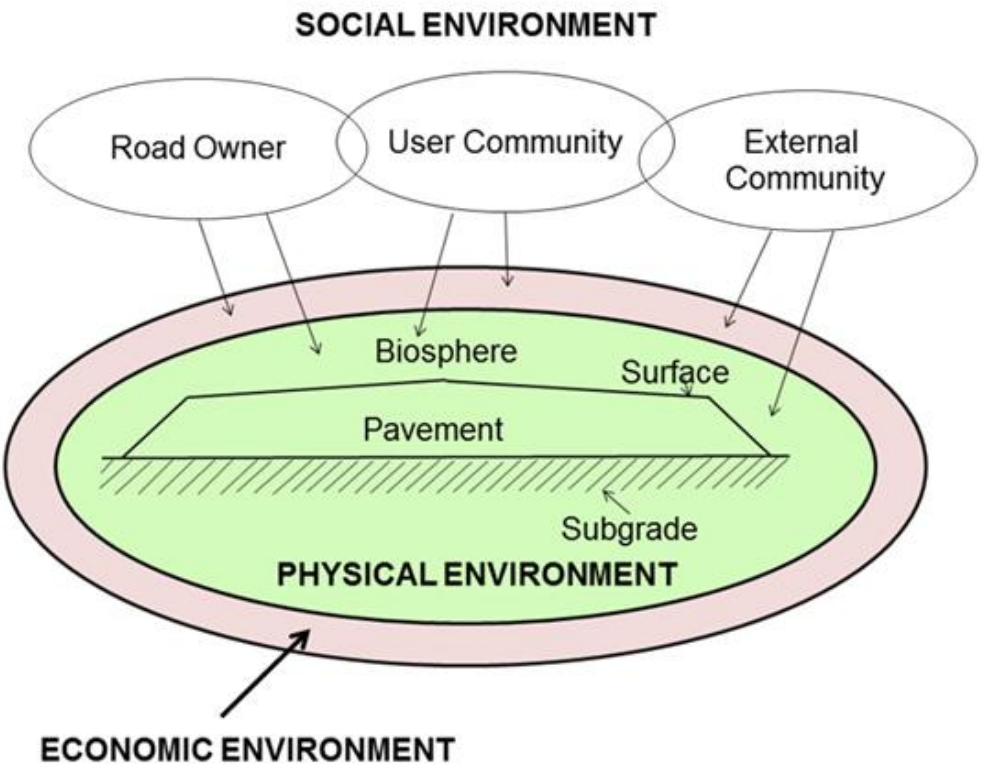

Figure 1: Relationship between road and its environments.

The owner of the road will expect the road to perform to a particular standard of service at minimum cost and provide maximum return on investment.

Road users expect the road to convey them as quickly, efficiently and smoothly as possible. They interact with the economic environment (for example, benefits and costs of transportation), and the social environment (for example, social benefits of using the road).

The external community consists of those people or organisations affected by the road. They may be property owners or tenants bordering or near the road, people who depend on the road for delivery of goods and produce, taxpayers who pay for the road, and other people are impacted by the road. The road may either deliver to this community benefits (for example, better access to transportation, improved property

values) or costs (for example, noise, pollution, resumed property, reduced access to local facilities). They are likely to be the group most directly impacted by the presence of the road, and have considerable influence within the local social environment.

These communities, or stakeholders in the road, therefore each have different requirements of the road. Sustainable road construction will require consideration of these requirements, and of stakeholder expectations within each of the physical, economic and social environments. It will also be required to meet legal environmental management requirements.

FACTORS IN THE CONSTRUCTION OF SUSTAINABLE ROADS

The construction and management of a sustainable road therefore requires consideration of a number of factors related to both legislative requirements and good sustainable management practices. Some of the factors in this process, as related to construction and management of the road, are described below.

Road Material Selection and Use

As with buildings (Sattary and Thorpe, 2011), it is important to minimise the embodied energy in road construction and maintenance materials. For example, consideration should be given to the selection, subject to their suitability, of locally occurring materials for aggregates, in order to reduce embodied energy of the transportation effort of importing material onto the construction site.

Minimising embodied energy is enhanced by the use of recycled materials and the recycling of pavement and surface materials during road rehabilitation or replacement. The use of recycled aggregate is quite common and recycled glass has also been used for road or pathway pavements in Australia (Fisher, 2010). As with all materials, caution is required in using recycled materials. For example, it is important to take measures to reduce leaching of contaminants from residual Portland cement in recycled concrete aggregate (Petkovic and Engelsen, 2004). However, provided the materials for recycling are selected with care and knowledge about their advantages and disadvantages, judicious reuse of selected materials can lead to substantial embodied energy savings and decrease waste.

Another option for addressing embodied energy of material is in-situ stabilisation of existing materials, using materials like cement, lime, or powdered polymers. This process can be used to effectively utilise available materials without using non-renewable pavement material. It reduces the use of imported material (often to a small percentage of the host material), and it is claimed that the pavement life can be similar to that of a pavement using aggregate (Wilmot and Wilmot, 2003).

Road Construction Processes

As construction activities significantly impact on waste, energy use and greenhouse gas emissions (Wallace, 2005), sustainability has increasingly become important from a project delivery point of view. Consequently, there has been pressure for the construction industry to be more accountable for its social and environmental impacts. Road development organisations have also recognised the importance of sustainability, with organisations like the International Roads Federation supporting green public procurement, which aims to procure goods, services and works with a reduced environmental impact throughout their life cycle (Roads Australia, 2012).

The importance of sustainable practices in construction is being recognised by regulatory authorities. Thus, the United Kingdom has a strategy for sustainable

construction that considers both the means (procurement, design, innovation, people and regulation) and the ends (such as climate change mitigation and adaptation, water, biodiversity, waste and materials) for sustainable construction (Department for Business, Innovation and Skills, 2008).

Planning and Design

The planning and design process defines the parameters of the road development, and also specifies the construction parameters. Sustainable planning and design may lead to reduced energy use, sustainable management of resources and waste management (Sinclair Knight Merz, 2009). Design also impacts on items like material selection and pavement design. For example, water sensitive urban design, which can be managed by innovations like permeable concrete pavements, is likely to impact on both construction and material selection and placement (Thorpe and Zhuge, 2010).

An important consideration from the social aspect of sustainability is safety in design. In Queensland, Australia, for example, a designer has an obligation to minimise risks in the design of a structure so that the design does not adversely affect the workplace health and safety of persons either during or post construction (Queensland Government, 2007). This requirement has implications for the whole road life cycle.

Finally, one important consideration in both design and construction is ensuring quality of materials and construction processes. For example, control of variability (such as in the properties of materials) will contribute to improved and more predictable outcomes for the road over its life cycle (Thorpe, 1998, pp. 116-124).

Availability of Key Roads

In January 2011, there was significant flooding in Queensland, Australia. This flooding caused damage to infrastructure, including roads, and therefore impacted on society and the economy. One estimate is that the Queensland transport sector lost AUD 467 million in revenue during this month (IBISWorld, 2011). The temporary loss of main connecting roads at such a time underlines the requirement to construct and maintain key roads so that they remain open as much as possible.

THE FACTORS AS PART OF THE ROAD LIFE CYCLE

While it is necessary to comply with legislation and it is highly desirable for road development to achieve recognition for sustainability, stakeholders are also likely to expect optimum sustainability performance for a particular road. To achieve this goal, it is necessary to consider and assess the contribution of the factors in the construction and management of the road over its life cycle. As a first step in this analysis process, the factors in sustainable road construction may be classified by the phase of the road life cycle in which they occur, and the stakeholder group impacted by the factor.

The road life cycle can broadly be subdivided into planning, development and operational phases. Each of these phases can be further subdivided into sub-phases. For example, the development phase may be subdivided into analysis, design, and construction. The operational phase may be subdivided into operation and retirement (Thorpe, 1998, pp. 22-25). For the purposes of evaluating sustainable construction, the life cycle may be considered as starting at the design phase.

Table 1 illustrates some of the factors, based on those discussed above, in sustainable road construction, their relationship with the life cycle phase in which they occur and the potential stakeholder groups interested in or affected by them.

Table 1: Selected sustainable construction factors by life cycle phase and stakeholder group.

Factor	Life Cycle Phase	Economic Environment	Physical Environment	Social Environment
Energy usage over life cycle	Construction Operation	Owner	Owner External	External
Use of locally occurring materials	Design Construction	Owner	Owner External	External
In-situ stabilisation	Design Construction Operation	Owner	Owner External	External
Use of recyclable materials	Design Construction Operation	Owner	Owner	External
Sustainable procurement practices	Construction Operation	Owner	Owner	External
Management of waste	Construction Operation	Owner External	Owner External	External
Innovative sustainable construction	Construction Operation	Owner External	Owner External User	Owner External User
Water sensitive design and construction	Design Construction Operation	Owner External User	Owner External User	External User
Safety in design	Design Construction Operation	Owner External User	Owner External User	Owner External User
Quality of materials and processes	Design Construction Operation	Owner External User	Owner External User	Owner External User
Ability to use road at all times	Design Construction Operation	Owner External User	Owner External User	Owner External User

Most of these factors listed above are measured in different units. However, they require consideration in any evaluation of sustainability on an equivalent basis. In addition, several are qualitative in nature. They may also be stochastic in nature and have some interdependency. In order to simplify and make practical the analysis process, a methodology, using three stages, that assumes in the first instance that variables are deterministic and independent, is proposed below. This process is based on, but considerably simplifies, that of Thorpe (1998), and may be applied at either the individual stakeholder level or from an overall viewpoint. The stages in it are:

- Adopt a scoring system that enables factors expressed in different units of measurement to be included in the evaluation on an equivalent basis.
- Weight the factors with respect to each other.

- Calculate a weighted total score combining the weights and the scores of individual factor values.

Adopting a scoring system that to allow the factors to be considered on an equivalent basis

In order to provide an approach that permits a mix of quantitative and qualitative variables to be combined in the same analysis on an equivalent basis, it is proposed that each variable in the evaluation be assigned a score on the same rating scale (for example, ranging from zero for the lowest value to five for the highest value). For quantitative variables, the score would be assigned on the basis of calculation based on a formula that relates the scores to actual variable values. For some factors (for example, energy use), the lowest value of the variable may correspond to a high score and vice versa, and in such cases an inverse formula would be used. Thus for energy use, for example, low energy use might have a score of (say) 4.5, and high energy use might have a score of (say) 0.5.

Assessment of qualitative variables (for example, use of good water management practices) tends to be more subjective. While such variables can be ranked on an ordinal scale, one approach to assigning a score to them is by assigning to them a utility value derived from a risk profile based on the indifference point between various combinations of worst and best expected outcomes, given the probabilities of receiving each (Hamburg, 1970, pp. 631-644). For example, the benefit of a particular road could be traded off against the risk of poor drainage practices resulting from the construction process. In this case, a score of five, for example, might be allocated to best practice sustainable water management and a score of zero to poor practice such as blocking natural water flow. Other scores would be between these extremes, the exact profile of scores being determined by the risk profile of affected stakeholders.

A disadvantage of this process is that it is not easy to accurately assign utility values without an understanding of stakeholder views and what they might accept as a trade-off between risk and return. Therefore, it may be necessary to convene public meetings, undertake surveys, or undertake other stakeholder consultation activities.

Weighting the factors

There are a number of options for weighting each of the factors on a comparative basis. One approach is to use a relative importance index (for example, Lim *et al.* 1995). Another approach is to use a compared comparison approach to rank the variables, in which variables may be assigned weights by judgment, or by sophisticated tools such as the Analytic Hierarchy Process (Saaty, 1990). This last approach is particularly useful where there are a range of sub-factors involved.

Another approach is based on the rational management process discussed by Kepner and Tregoe (1981). This approach formulates a goal statement (for example, maximise life cycle construction sustainability for a particular road), and considers the objectives supporting this goal by dividing them into musts (which are not negotiable) and wants. The wants are then grouped into related variables, and the groups are ranked using pair wise comparison or other techniques (Thorpe, 1998, pp. 182-184).

In any of these approaches, which tend to be designed around qualitative variables, benefit and cost may be may be considered separately from the analysis, or else assigned a score and included in the analysis.

Calculating a weighted score

The final step is to calculate a total weighted score by summing the individual weighted scores, as follows:

$$T = \sum_{i=1}^{n} WiSi$$

Where:
T = Total Weighted Score
Wi = Weight for factor i
Si = Score for factor i

ILLUSTRATIVE EXAMPLE

As an example, consider a two-lane sealed road, of 9 metres width and 5 kilometres long. There are two options for its construction, which are shown in Table 2. Option A is a bitumen sealed pavement constructed from recycled aggregate. Option B is constructed of permeable concrete with the aim of good storm water management. Both options have the same expected service life of 20 years.

Possible construction sustainability factors for these roads are compared in Table 2.

Table 2: Evaluation of total weighted scores for two road construction options.

Factor	Weight	Option A	Unit Score	Total Score	Option B	Unit Score	Total score
Energy use over life cycle	0.20	Low – embodied energy 0.1 MJ/kg	4.00	0.80	High – embodied energy 1.9 MJ/Kg	1.00	0.20
Sustainable material use	0.20	Use recyclable materials	4.00	0.80	Permeable concrete	1.50	0.30
Waste management	0.15	Very good waste management potential	4.00	0.60	Good waste management potential	3.00	0.45
Innovation in construction	0.15	Potential for some innovation	2.00	0.30	Significant scope for innovation	4.00	0.60
Water management	0.20	Standard water management practices	2.00	0.40	Water sensitive - permeable pavement	4.50	0.90
Availability at all times	0.10	Road unavailable for average of one day per year	1.00	0.10	Road is drivable quickly after storm as undamaged	4.00	0.40
TOTALS	1.00			3.00			2.85

This table omits factors (such as service life) that are common to both options, and also omits factors, also common to both options, that are related to sound sustainable management, such as meeting and managing stakeholder requirements, sustainable procurement practices, and managing quality and safety.

In this table, the weights (assessed by judgment) of each of the listed sustainability factors are shown in the column to the right of the factor. For each option, there is a brief description of the extent to which the factor is met, plus an estimated score

allocated through considering its utility to the owner, and an overall weighted score for the factor (named "total score" in the table). The weighted scores are aggregated.

Option A is estimated to cost AUD 5 million to construct and AUD 120,000 per year to maintain. Over the 20 year life of the road, using an inflation free discount rate of 6% per annum, the present value to the owner of this option is approximately AUD 6.376 million. It overall sustainability score is 3.0 out of a possible 5.0.

Option B is estimated to cost AUD 5.5 million to construct and AUD 60,000 per year to maintain, leading to a present value of cost to the owner over 20 years at 6% per annum of AUD 6.188 million. Its overall sustainability score is 2.85 out of 5.0.

Thus while Option A is slightly more expensive on a whole of life basis to develop than Option B, it has a slightly better life cycle sustainability score. As neither option is clearly, on an overall basis, better than the other, further investigation should be undertaken, including a sustainability analysis of the views of the user and external stakeholder groups. The allowable construction budget also requires consideration. If, for example, there were only AUD 5 million available for construction, Option A would probably be selected given the closeness of the other evaluation results.

CONCLUSION

The methodology discussed in this paper evaluates, using a life cycle concept, options for constructing and managing roads in as sustainable manner as possible. As illustrated in the example, this methodology is conceptually simple and uses a scoring system based on principles similar to those of rational management. While it may be argued that the proposed evaluation methodology is similar to that of green rating tools, it is more flexible than such tools; considers all of economic, environmental and social aspects of sustainability; takes account of the views of all stakeholders; and focuses on the construction and operation phases of the road. Its flexibility also allows it to be used in conjunction with other methodologies. The worked example, for instance, uses a two stage evaluation, which calculates the present value of life cycle cost and separately evaluates, using a proposed weighted scoring system based on utility, life cycle environmental and social sustainability. It could alternatively have considered combining economic and non-economic factors in a single figure if it was considered that doing so resulted in a better evaluation.

There are disadvantages with this approach. The main disadvantage is the subjectivity and difficulty in assigning utility scores unless extensive consultation is undertaken. The methodology also assumes independence of variables. This may affect its accuracy. However, steps can be taken, such as careful checking of dependencies with respect to the likely impact on the final result and the use of techniques such as conditional independence of the variables with respect to factors common to all options. Finally, the methodology as presented also does not consider the stochastic nature of many variables. This weakness can be addressed through techniques like sensitivity analysis.

In conclusion, the proposed methodology uses a relatively simple approach to the evaluation of the sustainability aspects of road construction. While it may have some disadvantages, it is capable of enhancement through approaches like the Analytic Hierarchy Process to better weight variables and extend the detail of analysis, and it can be extended to improve its rigour through other considerations such as stochastic variables. It can also be developed into a suitable computer based modelling tool.

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INVESTIGATING A SUITABLE LEARNING ENVIRONMENT TO ADVANCE SUSTAINABLE PRACTICES AMONG MICRO CONSTRUCTION ENTERPRISES

Michael P Gleeson[1] and Craig S Thomson[2]

School of Engineering and Built Environment, Glasgow Caledonian University, G4 OBA, UK

Sustainability in the construction industry is increasingly at the forefront of current debate and government policy. The majority of sustainable strategies and research has focused on large contracting organisations with little attention given to Micro Construction Enterprises (McE's). With McE's comprising of 98% of all UK construction firms they clearly contribute significantly to the delivery of sustainability. There is little understanding of the unique challenges McE's face in learning and knowledge acquisition to advance sustainable practices. McE's are a diverse group of professional practices, specialist trades and general builders and it is doubtful they are well equipped to support the learning culture necessary to appreciate the current myriad of sustainability issues. This research explores the requirements for a suitable learning environment for McE's to advance sustainable practices. Through semi-structured interviews with eight owner/associates of different types of McE's in Glasgow, the research explored their preferences for learning in order to establish the basis for a suitable learning environment. Formal methods of learning like seminars and CPD events entail prohibitive cost and resource barriers, but analysis suggested that these constraints could be appeased by facilitating voluntary informal learning pathways in order to progress the agenda. Since the majority of the study participants were members of some trade or professional association it is recommended that these bodies are best placed to deliver contextually relevant resources in a suitable narrative for McE's.The paper attempts to differentiate between formal and informal learning styles to promote sustainable practices among McE's.

Keywords: knowledge, learning, micro construction enterprise, practice, sustainable construction

INTRODUCTION

Irrespective of personal views on Climate Change a large body of corroborated evidence suggests that the industrialised nations of the world are having an adverse effect on the earth's ecology and climate systems, to devastating effect (IPCC, 2007). The UK government's goal is to achieve an 80% reduction in carbon emissions by 2050 (RAENG, 2010) in line with a path for sustainable development which seeks to

[1] mgleeson10@yahoo.co.uk

[2] craig.thomson@gcu.ac.uk

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balance social and economic progress within environmental limits. To counteract the construction industry's impact on the environment, various UK government strategies have been drawn up to drive the sustainable construction agenda (BIS, 2010a).

This represents an ever changing landscape within which mico-construction enterprises require to learn and evolve their practices. The European Commission, define micro enterprises by a headcount of between 0-9 employees, with an annual turnover or balance sheet of 2 million Euros or less (EC, 2009). Although certain studies distinguish between micro, small and medium enterprises the majority of studies use the Small and Medium Enterprise (SME) classification only. Previous research has shown that micro construction enterprises (McE's) are a distinct group from SME and worthy of special attention (Sommerville and McCarney, 2003). Recent statistics illustrate that 98% of all construction industry firms in the UK comprise of McE's (BIS, 2010b), with a significant 85% of these firms being sole traders or self employed individuals. With McE's representing 62% of employment within the UK construction economy (BIS, 2010b), it is fair to propose the collective 'ecological footprint' of small firm's warrants serious attention (Revell, 2007). Various commentators agree that McE's are often overlooked in big policy movements with low levels of engagement in the environmental agenda (Davey *et al.* 2001). Yet, with the proliferation of sub-contracting in recent times perhaps the most important group in a construction project is the sub-contractor, often completing up to 90% of the project value (Sommerville and Thomas, 2009). The research aims to explore a suitable learning environment for McE's to advance sustainable construction practices to promote the triple bottom line principles of sustainability.

CHALLENGING CONTEXT: LEARNING AND DEVELOPING PRACTICE WITHIN MCE'S FOR SUSTAINABILITY

The adoption of an integrated vision between all the project stakeholders is essential in tackling sustainability (Desai, 2009). Various strategic reviews of the UK construction industry in the last 20 years lament the dichotomy between design and construction, with the problem surrounding the structure of the industry being continually discussed and revisited (Walthamstow, 2009). Part of this fragmentation is the abundant use of sub-contracting as the preferred procurement route within the UK construction sector resulting in a loss of in-house technical expertise. Walthamstow (2009) maintains that subcontracting represents horizontal interfaces which place further barriers against the free flow of information and innovation. Therefore any proposed learning environment for McE's must take cognizance of these constraints which impede the integrated thinking and working that is necessary for sustainable practices. In addition, it is important to recognise that McE's act in a diverse array of roles, as professional consultants, specialist or general main contractors, sub-contractors and as individual sole traders. Large contracting organisations are constantly lauded as industry leaders yet they do not undertake the majority of renovation and maintenance of the UK's private housing stock. This is predominately carried out by 'Small and McE's'. This is important since it is the UK government's goal to achieve an 80% reduction in carbon emissions by 2050, while it is estimated that up to 80% of buildings occupied in the year 2050 have already been built (RAENG, 2010). Hence, the example of retro-fitting highlights the case to better understand what constitutes a workable learning environment for sustainable construction and design among McE's. Time and financial constraints usually have an adverse impact on McE's ability to engage in learning and the development of skills needed for sustainability. It seems that the apparent failure of the agenda to date could

be attributable in part to a lack of serious engagement and targeted consultation with McE's. Through a feasible learning path and collaborative measures McE's could regain some of these technical expertise required for sustainable learning and practice.

Collaboration - building alliances for learning (challenges & remedies)

Wheeler (2004) aptly concludes, no singular solution is enough by itself rather a mutually reinforced set of actions is necessary at all levels. Some commentators propose that the collective problem of un-sustainability necessitates both top-down directives and bottom-up innovations and initiatives (Rees, 2009). In others words, it becomes imperative to inspire an integrated vision between project participants and stakeholders to build sustainable communities (Desai, 2010). Sommerville and McCarney (2003) view it as misdirected policy to assume that change will trickle down from large enterprises and ultimately to micro firms, the evidence of which is the relatively meagre progress made to date in sustainable practices. This lack of interaction between macro and micro level learning appears to be a crucial problem and is perhaps a reflection of the industries ingrained traditional top-down management mentality. Through promoting clusters of McE's with external consultancies and trade association's such alliances and new ways of thinking required for sustainable development can be cultivated (Will, 2007). Such collaborative working can serve to mitigate uncertainty and provide a confluence of specialists to address the problem of un-sustainability. Perhaps the radical thinking and appreciation for sustainability among McE's can forge meaningful collaborations for sustainable practices, where profit is not always the bottom line.

Policy and legislation

Revell's (2007) study found that most SME's considered the best approach was to implement more rigorous legislation, in a similar way to how Health and Safety has been tackled. Regulation could create a level playing field regarding learning for environmental obligations for SME's in spite of the unpopular bureaucracy it entails (Holland and Gibbon, 1997). The array of current policy needs to become ratified in a practical approach to help cultivate a more structured learning environment for McE's. A similar study among house builders highlighted legislation as a key driver to cultivate a learning setting for McE's (Thorpe *et al.* 2008). With mixed views regarding legislator's ability to steer a sustainable course, consultation and meaningful engagement may play a key role in informing the most suitable learning methods for McE's. While balanced legislation and robust policy have their place it is important to define McE's position and galvanise their commitment so that they can be rallied towards sustainable concerns in the most efficient and effective manner.

Formal learning

Murray (2009) advocates the personal approach to sustainable development by securing a level of personal engagement from the learner which empowers the individual to recognise the opportunities and act upon them with confidence and competence. Rees (2009) also hints at curriculum reform, proposing a need to instil creativity in students to shape this new dynamic built environment. Traditionally, education was highly discipline specific, making teaching an appreciation of sustainability more challenging due to a lack of disciplinary integration (Brncich *et al.* 2011). As Wheeler (2004) underlines the problem of compartmentalization and disjointed style of old-fashioned approaches are an impediment to a holistic outlook required for sustainability. Several professional bodies are recognising the need to incorporate sustainable teaching and are driving this forward, albeit confined to their

respective disciplines (Murray and Murray, 2007). This suggests a challenging cultural change is required with some suggesting a need to de-link some of the accreditation of courses by professional bodies (Brncich *et al.* 2011). As a compliment to core subjects, teaching in formal academic settings must impart the wide expanse of holistic knowledge needed to address the multifaceted reality surrounding sustainability in the construction sector. Such a formal learning strategy with an increased awareness of subsidiary subjects could equip new graduates with an awareness of the inter-connectivity of all knowledge and openness for collaborative working. Professional bodies like the CIOB, RICS, and the RIBA are highly influential in forming educational structures for their respective programmes and should take the lead in supporting learning for sustainability among McE's. Desai's (2010) perceives this setting at a personal level where teaching is imbued by a sense of how, individually, we can positively impact on the sustainable agenda.

Informal learning - Craft skills and professional disciplines

Davey's *et al.* (2004) action learning study found that SME's are capable of being leaders of government initiatives to drive the industry, not simply the recipients. However, with 75% of McE's owners having not attended any sort of training programmes the lack of organisational learning was found to be a significant contributor to business failure (Sommerville and Thomas, 2009). To help rectify this, Holland and Gibbon (1997) advocate a consciousness-raising exercise, with a realisation of the impacts McE's place on the environment through trade associations, local authorities and business clubs. From a practical outlook the industry must develop enough trade's people and professionals with the necessary skills and competencies needed for sustainable practices. It is both vital for business durability and tackling the diverse issues which encompass sustainability.

Research indicates that education surrounding the sustainable agenda in construction was skewed in the main towards technology based solutions (Murray, 2009). Yet, an overemphasis on technology does not provide a truly coherent vision of sustainable living in the world (Desai, 2010). With the advent of technology driven sustainable practices this situation may become exacerbated and warrants further examination in practice. Informal learning styles may be more suitable for McE's with trade and craft backgrounds simply due to their inherent practical characteristics. This may suggest that there are differing learning needs and styles between professional consultancy practices, builders and craftsmen.

Influences of trade and professional bodies

Trade and professional bodies were seen as providing relevant and contextual based knowledge and awareness about sustainable practices for small firm needs (Coetzer and Perry, 2008). Concerns relating to risk and finance could be abated through an educational process, one driven by trade bodies who could converse in a common language with their cohorts (Thorpe *et al.* 2008). Hence, it is essential to understand the factors which influence the experience of reality for McE's. Trade and professional associations could play an important role in supporting learning and the acquisition of relevant knowledge for McE's to advance sustainable practices. These bodies can support McE's to overcome resource limitations and through cooperation act as knowledge hub in tackling the agenda.

The review suggests that a suitable environment is required for McE's to learn in order to allow them to emerge as a significant force for change within the industry. It is suggested that to be successful this environment needs to draw on formal and informal

learning styles and engage with a range of education providers whilst promoting a holistic approach to sustainability driving process improvements within the industry.

RESEARCH METHODS

The phenomenological paradigm was adopted as the most suitable framework to examine a variety of McE's and their relationship with learning for sustainability in the construction context. Sustainability elicits a diverse range of views depending on the level of knowledge, values and attitudes people hold towards the subject area and this paradigm ensures the research engages with practice.

Data collection: The EC terms enterprises as split between micro, small and medium as indicated on Table 1. This definition of McE's was utilised to identify appropriate participants to partake in the research project.

Table 1: Micro Construction Enterprises - European Commission (Source: EC, 2009, p.3)

Enterprise category	Ceilings		
	Staff Headcount	Turnover	Balance sheet total
medium-sized	< 250	≤ €50 million	≤ €43 million
small	< 50	≤ €10 million	≤ €10 million
micro	< 10	≤ € 2 million	≤ € 2 million

Key themes emerging were explored with eight owner/ associates of McE's during in-depth interviews. Given that the research concerns the exploration of opinions, feeling and perceptions of practitioner, these themes were considered in a loose/ flexible way to avoid enforcing an agenda and to allow the responses to be framed from their own viewpoint. The sampling frame consisted of interviews with eight owner/managers/directors of McE's within the Greater Glasgow area, to examine their learning needs and styles for sustainability as outlined in Table 2. By limiting the geographical scope it allowed the richness of the local environment and support structures to be considered in relation to the different McE's. It is hoped that the design parameters of the inquiry would protect against overstating any findings while the study is very much viewed as a pilot stage and platform for further research.

Table 2: Research participants - Micro Construction Enterprises

Professional Consultancy Practices Nr:1,2,3	General Building and Specialist Contractors 4,5,6	Individual / Sole traders 7,8
1: Director, Structural engineering consultancy (1 employee)	4: Director, Construction and Refurbishment Contractor (8 employees)	7: Architectural technician (Sole trader)
2: Architectural practice (partnership)	5: Director, Specialist Joinery Contractor (9 employees)	8: Specialist Renovation Contractor (Sole trader)
3: Architectural practice (partnership)	6: Operations Manager, Building Contractor (2 employees)	

A cross section of these firms provided an opportunity to examine the ‘individual/sole traders’ as a distinct group within the sampling frame of McE’s. Interview participants

were provided through personal contacts who in turn suggested other likely participants from the McE's grouping, with the additional use of online directories. Each interview lasted an hour on average and were recorded and transcribed in close proximity to when the interview was conducted (to facilitate ease of understanding and clarity). A limitation is reflected by only one interview being conducted for each McE category but this reflects the pilot stage of this research.

Data analysis: To aid the interview analysis a bespoke/hybrid coding method was adopted based on open coding techniques. This allowed the researcher to filter the coding process of the transcripts across paragraphs rather than on a line by line basis. The emerging findings were then organised under existing themes present in the literature review or new topic areas with a view to identifying the varying learning styles among the McE's participants within the study. The paper attempts to differentiate between formal and informal learning styles to advance sustainable practices among McE's.

RESEARCH ANALYSIS AND FINDINGS

The study highlighted the importance of understanding that several auxiliary challenges exist to impede the learning process and ultimately its implementation in the context of MCE's and these are presented in Table 3. The discussion focuses around current status and future requirements for the two key learning environments surrounding sustainability in McE's- formal and informal.

Table 3: Challenges to learning for sustainability among McE's

CHALLENGES	
Lack of consensus on the definition and distinction of sustainability terminology	Too much information - a need to filter information and knowledge(relevant and contextualised) for McE's
Formal learning entailing prohibitive costs, while McE's operate with scarce resources	Misconceptions about sustainability - "it always costs more"
Greenwash - a need to curb the cynical/insincere use 'sustainability'; creates unnecessary market confusion	Attitudes - Narrow-minded, entrenched attitudes need to be explored through the learning process
A business case for sustainability not perceived as a feasible outcome in practice for McE's	Policy and legislation - Many conflicting government strategies and misdirected legislation
Bureaucracy and regulations - fallacy to believe the agenda can only be progressed through policy alone	Lack of Client engagement - education in building usage; motivate both client and contractor to learn
Assuming the agenda can only be advanced through large Contracting and Multi-disciplinary Consultancy firms (consumes support and learning resources)	Over-specialisation of knowledge sometimes hinders a broad appreciation of sustainability (curriculum reform - in craft/ vocational based training and academia)
Risks with new materials/technology. Perceived risk in using new unfamiliar/unproven materials	

Formal learning

Influences of trade and professional bodies

Most of the McE's interviewed were members of a trade or professional association, except for the two sole traders interviewed. For the majority of McE's participants their influence was somewhat limited in orchestrating a formal learning setting perhaps due to the current voluntary nature of these practices. However, given a strong awareness of what these associations had to offer they may be ideally suited to delivering resources in a common language which is contextually relevant for McE's.

Two of the architects interviewed worked as part time lecturers which provided opportunities to access more formal sustainability information and increase knowledge. When working as sub-contractors on large projects with more demanding clients, learning and knowledge for sustainability is enforced in a more regimented manner. One specialist joinery contractor felt that *"knowledge and learning for sustainability is mostly taken from a peer"*. However, many McE's also act as main contractors or design consultants and must instigate their own independent learning. The following sentiments of one contractor give some indication as to why formal academic routes for learning are sometimes not suitable: *"to achieve the knowledge most McE's will not have the finances to educate themselves and need some government or European backed funding"*. Although it has been found that McE's have negative perceptions about sustainable practices being forced on firms. One Architect interviewed felt that McE's were at a disadvantage for learning; *"there is support there, but it's easier for bigger practices to absorb cost, as training and conferences cost a fortune to attend"*. There seemed to be a feeling among all respondents that current formal modes of learning are difficult to access, cost too much and consumes time that is too valuable to lose.

He suggested a formal consensus on best practice, knowledge based solutions for sustainable retro-fitting and renovations were needed. For micro construction enterprises their suppliers and manufacturers play an important part in filtering information and making distinctions which can advance sustainable practices. One contractor suggested; *"they need to filter the good practical research with feedback and engagement from McE's"*. This could in part be conveyed through formal academic learning in addition to product manufacturers - *"when you are pricing a job you know exactly what you have to use, the architect knows, the engineer knows and the builder knows it's one or two materials and it's well known, available from one supplier"*. It was widely viewed among interviewee's that sensible regulations were integral to fostering learning and knowledge for sustainable building practices. One joinery contractor stated; *"McE's make up 97% of the industry, if these guys aren't been forced into increasing their competency and increasing their awareness they never will"*. Thus, regulations seem to be a necessary method in forming minimum standards for sustainability which requires training and this would work much better if cooperation and mutual consent was sought from McE's.

There was agreement among most interviewee's that attitudes could play an important part. A specialist joinery contractor thought that attitudes among McE's could be positively engaged in a similar manner to Health and Safety; *"like H&S, if we could change the attitude to sustainability by government saying every guy on site must have an awareness of what sustainability is and having set parameters for benchmarking to measure improvements"*. Likewise, another consultant architect proposed to overcome a poverty of aspiration; *"the biggest challenge is turning people away from habits of a lifetime and getting across to people what's in it for them"*. This alludes to marketing a strong narrative which creates a tangible vision for McE's to learn and instil personal responsibility. These McE's perceptions illustrate the prominence of attitudes on the sustainability agenda. Given the complex issue surrounding the agenda 'attitudes' may have more influence than regulations. Through probing and the exploration of attitudes within a learning setting McE's could be challenged to deliberate and reflect over their attitudes and beliefs in a positive way. For some contractors learning about sustainability was relatively easy but a wide gap existed in terms of implementing it in practice. Hence, learning initiatives for McE's must

ensure that the actual knowledge gained can be applied in construction practice, although a difficulty exists due to its often over-specialised nature. Indeed recent calls have emerged for changes to formal education curriculums within construction faculties to give student a broader appreciation and knowledge of other disciplines (Brncich *et al.* 2011; Rees, 2009).

Just one contractor identified the potential of supporting learning and developing knowledge around the context of retro-fitting, but it is clear from past studies that energy use in existing building stock must be targeted for reduction. For certain renovation works, due to the limited scope of suitable materials, knowledge for retro-fitting might be more easily tackled in terms of learning and practical applications for McE's. For all the McE's who participated in this study accessing existing support for formal learning, like CPD courses, was far too costly and often not easily accessible due to time and distance constraints. Collaboration between the many trade and professional bodies could potentially help to absorb some of the costs for their members through subsidies of events and learning materials.

Informal learning among McE's

It's perhaps not surprising informal learning seemed to be favoured among McE's, resource constraints and work pressures made the suitability of this mode of learning attractive. Informal learning styles were sometimes influenced by professional bodies or by testing out practices in the field. As one consultant architect advocated; *"a lot of learning is practical application, reading literature, talking to suppliers, manufacturers and becoming knowledgeable about the product"*. In some cases professional and trade associations can promote informal learning and a knowledge environment for McE's. At a basic level this involved being kept updated about changes in regulation and sustainable building technologies. This was also achieved through e-newsletters and association websites and was one of the *"free ways to disseminate information"*. The internet, with its broad accessibility, was seen as a very useful tool for accessing information and helping to alleviate time and cost barriers associated with more formal learning methods. This sentiment was highlighted by a self-employed renovation contractor; *"If I get stuck for something I'll just go on the internet and try to research it, and I can do that after my work"*. To keep abreast with developments and increase their knowledge of sustainability some of the builders utilised industry websites, internet forums and even the video sharing website You Tube. A building contractor felt this was a progressive approach; *"the CIOB are very forward thinking trying to do different initiatives like a lot of forums and CPD events"*. Forums could offer a unique platform for challenging ideas, building consensus and providing McE's an increased awareness of the bigger picture.

In addition, sole trader seemed most optimistic about the benefits of You Tube; *"for some aspects of carpentry work on YouTube, you actually see a guy showing you how to do it from start to finish"*. The merits of such a learning tool may be specifically fitting for sole traders since they face the most pressing restraints in terms of time, human resources and finances. A more formalised approach to accessing educational materials via the internet offers the opportunity to reach McE's in rural areas aiding the wider promotion of sustainable practices. Such a mechanism informed by research, trade and professional bodies could ensure the credibility of information in the learning process could be validated for McE's. If the efficiency and effectiveness of learning can be improved among McE's the resultant knowledge acquired could be more readily translated into meaningful sustainable actions. Considering the advances

of online learning in recent years a similar thoroughness should be adopted and remodelled in a context and language appropriate McE's. A video sharing community could have wider appeal to McE's as a platform for the promotion of practical ideas and solutions relative to their work methods. Yet, one unique sustainable project showed that through voluntary labour and the testing of ideas on demonstration style projects provided a business case resulting in several funding bodies supporting their endeavours and the participants learning on the job.

Three of the contractors interviewed were members of some trade association. Perhaps not surprisingly, two of the sole traders, a renovation contractor and architectural technician, were not members of any associations. This possibly suggests some dissimilarity in terms of their varying ability to access available support compared to other McE's. Delivery of informal learning through the internet appeared to be suited to all McE's, and especially sole traders. Informal learning through associations seemed to be more prominent in professional practices among McE's. Learning specific to sustainability must provide a broad appreciation of the issues which is lacking via the over-specialisation of knowledge. This appreciation is fundamental to purposeful action for sustainable practices.

CONCLUSIONS/RECOMMENDATIONS

This research revealed that consultancy practices and professionally managed contactors appear more inclined towards formal modes of learning than the sole trader (e.g. joiners and architectural technician). However, due to resource limitations both increasingly resort to informal methods of learning. Yet, the informal learning environment relies on the array of disparate bodies involved in compiling knowledge for sustainability which clearly lacks the joined up thinking necessary. The interviews revealed that such an environment provided a fragmentation of knowledge creating more confusion. McE's require knowledge to be emitted in a clear, plainly written manner with illustrative pictures for targeted audiences like tradesmen working on building sites with a focus to making their work easier.

The use of regulations to drive sustainability and stimulate a learning culture was viewed by most interviewee's with a negative perception due to additional bureaucracy and cost, and therefore needs to be considered carefully when proposing any new strategy. Evidence suggests that an agenda that is forced on McE's will not foster a learning culture, although lessons can be taken from the health and safety agenda. However, when abstract global ideas are contextualised to the micro construction level, a business case can be created for sustainability and therefore a perceived need to learn might be more clearly fostered. The research highlighted that sustainability needed to be viewed as a broader more holistic concept than just green products and that changing attitudes is pivotal to cultivating a learning culture. Undoubtedly, genuine consultation should result in McE's being at the forefront of developing practical ways for knowledge to be devised and implemented given their significance within the industry. However, it is vital McE's get more financial support to create a suitable learning environment which is both formal and informal or increased support provided freely by way of seminars, CPD events or through the internet. This paper was preliminary in nature providing impetus for more in-depth research in the area of learning and knowledge to advance sustainable practices among McE's.

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GREEN BUILDING CHALLENGES: EVALUATING THE OPERATION OF ADOPTED BUILDING ASSESSMENT TOOLS - CASE STUDY

Mpakati-Gama, E.C[1], Wamuziri S.C[2] and Sloan, B[3]

School of Engineering and the Built Environment, Edinburgh Napier University, 10 Colinton Road, EH10 5DT United Kingdom.

In recent years, the green building environmental assessment tools (BEATs) are increasingly being adopted from one country to the other. Previous authors have proposed several ways for improving the performance of BEATs precisely, the second generation tools adopted from elsewhere. However, a few studies have focussed on how the tools are operated in their new contexts. Therefore for further advancement of this emerging field in the property and building sector, the current work compares the operation criteria of the original and adoptive tools in order to analyse the implications associated with the adoptive tools hence suggest ways for improvement. Focusing on the Green Star tool as a case study, a few implications have been highlighted relative to facilitation, accreditation and implementation criteria of the tools. Although there is no clear-cut for promoting BEATs based on how are structured, continuous improvement of the BEATs in specific contexts is needed.

Keywords: adoptive countries, building assessment tools, green building, green star tool, operating criteria.

INTRODUCTION

Green building environmental assessment tools (BEATs) are being advocated for use as one of the ways for promoting sustainability in the built environment in most countries in recent years. Although not originally developed for the building industry (Cole 1999), the BEATs are now widely accepted in the building and property sector following the adoption of environmental management certification system based on the ISO (International Standardisation Organisation) 14000 series (Haapio and Viitaniemi, 2008). Consequently, the several tools and methods which exist in developed countries (WGBC 2010) are now rapidly being adopted in other parts not able to develop their own tools. However, (Kibert 2007) considers that the pace in these developments has been slow relative to the rate of depletion of the resources.

[1]e.mpakatigama@napier.ac.uk

[2] s.wamuziri@napier.ac.uk

[3] b.sloan@napier.ac.uk

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Other authors (e.g. Cole, 2005) therefore suggest the need for a common tool as one way of speeding up the developments.

Despite the absence of a common tool, the BEATs are contributing to the advancement of sustainable construction although more is yet to be done (Ding, 2008). So far, the BEATs are being used as yardsticks for minimising the adverse environmental impacts contributed at various stages of a building's lifecycle (Cole 2005; Saunders 2008). As marketing tools, BEATs are also contributing to awareness on use of green building products to various building stakeholders through eco labelling of buildings (Saunders, 2008). It is therefore, not surprising that the BEATs designed for national use are continuously being adopted in other parts of the world despite the social and economic problems affecting the construction and property industry in some countries. Consequently, through the facilitation of the local and World Green Building Council (WGBC), well established BEATs are available for use to those undergoing economic and structural problems to formulate their own tools.

In spite of these on-going developments, the performance and operating systems of the BEATs appear to continue haunting their contribution to sustainable construction in most countries. A few attempts have been made by previous authors to analyse the performance of original and adopted BEATs. Most of these compare and contrast various combinations of tools with reference to various factors. For instance, Xiaoping *et al.* (2009) compared and contrasted the similarities and differences of some mainstream tools used in Japan, United Kingdom, United States of America, China, Singapore and the internationally designed Green Building Tool (GBTool). Similarly, Crawley & Aho (1999) compared and contrasted the potential marketing applications of BREEAM (Building Research Establishment Environmental Assessment Method), LEED (Leadership in Energy and Environmental Design) and others. Furthermore, Cole (1999) contrasted how the greenness or sustainability of the building environmental tools could be described although not concentrating on a particular tool. Finally, Potbhare *et al.* (2009) also highlighted the changes made to the LEED-US (n-c) to make it suitable for the Indian context. Interestingly, so far, a few efforts have been made to evaluate how the adopted tools are operated in their new contexts compared to the original counterparts.

Therefore, using the Green star as a case study, this study compares and contrasts the operation of the Green Star tools in the countries of origin and the new contexts. The review study is based on an intensive literature of an on-going academic research to find ways for promoting environmental sustainability in the construction industry in developing countries. In this paper, the limitations associated with the adopted BEATs are operated in promoting sustainability in the building and property sector are analysed. For the purpose of this study, operation of the tools signifies the various procedures involved in the entire certification process. However, the focus in this study is limited to facilitation, and implementation and the accreditation procedures. In contrast, performance of the BEATs, though not the major focus in this study, is defined as the effectiveness of the BEAT in assessing the environmental implications of a building or a project. That is, performance is not related to the building's rating results at operational stage of its lifecycle as defined in the latest Green star performance tool under development (GBCA, 2012).

BUILDING ENVIRONMENTAL ASSESSMENT TOOLS - BACKGROUND

The past decade has seen a rapid development of building environmental assessment tools (BEATs) in many countries. Although the rate in the developments of BEATs is not fast enough to cope with the level of resource depletion in most regions (Kibert 2007) several BEATs have been developed so far to encourage sustainable development at global and national levels. This section provides a brief overview of the mainstream tools and their advancement in adoptive countries. As highlighted by previous researchers, the BEATs used in United Kingdom, Japan, Australia and the United States of America are part of the most well-known tools commonly used for green building assessment. BREEAM in particular, is the first comprehensive and commercially available green building tool developed in the UK in 1990 (Crawley and Aho, 1999) by the Building Research Establishment (BRE). BREEAM was basically aimed to be used by engineers and surveyors in life-cycle costing of buildings (Tam *et al.* 2004). However, BREEAM has since been used for eco-labelling to address the local and global ecological issues attributed to the building industry in the UK (Ibid 2004; Crawley and Aho 1999). With a similar aim, several tools have developed in different countries to date following BREEAM. The Leadership for Energy and Environmental Development (LEED-US) tool for example, is the first tool designed for environmental assessment of buildings in the US. Although its first version focussed on the operational level, with much emphasis on technical aspects related to energy use (Saunders 2008; Tam *et al.* 2004), there are now several versions concentrating on several other environmental issues. Similarly, the Australian Green Star tool addresses a wide range of environmental aspects based on the 10 versions launched since its first launch by Green Building Council Australia (GBCA) in 2002 (GBCA 2012). Although these tools are meant for national use, buildings can be registered with more than one tool despite the problems to compare the results due to a variation in rating tools and assessment criteria used (Saunders 2008).

Figure 1:Developments in adoptive adoption of BEATs

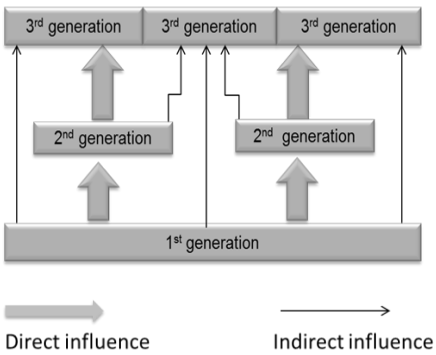

Table 1: Examples of original and tools at different levels

1st generation	2nd generation	3rd generation
BREEAM	SBTool/GBTool	CASBEE
	Green Star Australia	Green Star South Africa
	LEED-US	LEED-India

Sources: GBCA (2012); Malanca (2010), Xiaoping et al. (2009); Cole, 2005

As the interest in green building and eco labelling continues, most of the national tools are being adopted in other countries which are not able to develop their own. LEED-India, Green Star South Africa and HK-BEAM (Hong Kong Building Environmental Assessment Method) are few examples originating from the LEED-US, Green Star-Australia and BREEAM respectively (table 1). Previous authors such as Xiaoping *et al.* 2009; Ding 2008 etc. provide details of other tools established in various countries.

Xiaoping *et al.* (2009) in particular, figuratively demonstrates the three hierarchical levels of change as illustrated in figure 1. As the levels increase, the operating processes also keep on being modified to suit the next contexts' needs. The changes could however be in response to previous authors' recommendations (e.g. Cole 1998; Ding 2008 and Kyrkou *et al.* 2011) on how to improve the performance of the adopted tools. Potbhare *et al.* (2009) provide a detailed outline on how the Leed-US new construction tool was modified to suit the local Indian green building assessment requirements. In contrast, some authors consider that the changes being made appear to increase the disparity between the original and the new tools (Xiaoping *et al.* 2009). However, this can be well discussed based on typical examples.

OPERATION OF GREEN STAR AUSTRALIA AND SOUTH AFRICA

General overview

Green Star is one of the rating tools developed in Australia to address a wide range of environmental aspects related to buildings. Under the facilitation of the Green Building Council Australia (GBCA), who also owns it, more than a few versions have been developed since its first launch in 2003 (GBCA 2012). The existing 10 versions aim to address office, retail and residential building environmental aspects while the 2 forthcoming versions aim to address the performance and community related issues at a building's use stage. Although originally designed for the Australian property industry, the GBCA permits other GBC's to use the Green Star directly or indirectly. With Green Star tool adoption procedures, the adoptive GBC is given a mandate to conduct all the required processes in contrast to other BEATs such as the LEED-US where the mother GBC takes the responsibility of most of the operating activities (Potbhare 2009). However, a mandate for the Green Star certification is only given where the financial and legal agreements are made with the mother body, the GBCA (Malanca 2010).

Hitherto, there are several examples of Green Star Australia based BEATs. The Green Star South Africa (GS South Africa), based on the Green Star Australia (GS Australia), is a typical example of a directly adopted Green Star tool. Launched in 2008, the GS South Africa has 2 operational versions, 1 pilot and one other version under development (GBCSA 2012). To date, the GS South Africa is being used in other countries not able to meet the financial and other technical obligations to adopt the original Green Star Australia. Ghana Green Star is an emblematic example in this respect. It is based on the Green Star South Africa but also follows the original Green Star Australia assessment requirements indirectly. Currently, it is unclear on how such tools are being operated as most of them are still in their early stages of development. For this reason, these have been truncated from the present study. Therefore, the operation comparison presented below only represent the second and third generation of Green Star tool, using the illustration in figure 1.

Operation the original and adopted Green Star tool

As defined earlier, operation of the tools in this regard refers to the processes of facilitation, implementation and the accreditation of the various tools. With reference to the Green Star in Australia and South Africa, the GBCA and GBCSA are responsible for facilitation, implementation and accreditation of their tools as summarised in table 2. As would be expected, there are some similarities between the two tools considering that the latter is based on former tool. On the contrary, some

disparities also exist due the changes made to the Green Star South Africa to make it compatible to the local conditions.

With regard to facilitation, both the GBCA and GBCSA are not only responsible for the ownership, development and running of the tools but they are also in charge of the review processes of the rating tools. The reviews for both tools are based on public consultations and stakeholder inputs although it is not very clear on how the GBCSA conduct the consultations. Despite the similarities in development and the review processes, a number of disparities also exist. For instance, paid consultants and voluntary members of the Technical Working Group are involved in the GS-SA tool development while the Green Star Faculty, comprising of 18 individuals from member organisations, is responsible for similar actions related to the GS Australia. The other difference is that the GS Australia is extensively advocated through the government institutions such as the federal, states and territories as well as the local government. In addition, it contributes to review and proposal of sound sustainability policy guidelines. In contrast, it appears that the GS South Africa is not well embraced in most of the cities based on the case studies presented by the GBCSA (GBSA, 2012).

Beside facilitation is the accreditation or certification process. This which is grouped here into two categories namely, projects and professional accreditation systems (see Table 2). Although it cannot be generalised, the project accreditation processes are persuaded by the local GBCs for both the GS South Africa and the GS Australia tools. However, the third party or independent assessors are involved in the preliminary assessment and scoring which are based on both the rating criteria and the level of assessment requested by the applicant. However, with the GS Australia, a member of the project team can purchase the assessor's manual to conduct an assessment of a particular project although the final score is determined by the assessing panel. Therefore, the project will be awarded depending on the rate of pass ranging from a minimum of 45 points at both the design and also construction stages. Contrary to the GS Australia criteria, 2 different certificates are issued for the GS South Africa project rating, referred to as 'Design' or 'As built' certification. Furthermore on project accreditation, the Green Star South Africa provides 2 extra points to the project incorporating an accredited professional from the beginning of the project. In contrast, the GS Australia offers a fee discount to accredited members at project submission stage. This therefore demonstrates that, although the award systems are different, the professional accreditation qualifications or membership of an organisation is vital at project submissions stage of the accreditation process. So far, project accreditation is not required by law in both Australia and South Africa hence the progress may not be as fast as the need to promote sustainable construction is. However, the labelling credits obtained by participating individuals or organisations provide further opportunities for marketing of the building to the environmental conscious customers although this is considered to work better in matured markets as discussed later.

Unlike the project accreditation, whose criteria are more or less similar, wider differences exist between the two tools with regard to professional accreditation. For instance, with reference to the GS Australia, independent assessors are responsible for the professional accreditation through the issuing of certificates while the GBCSA is liable for the running of the courses to qualify for building assessment for Green Star in South Africa. Similarly, full training with the green Star Faculty is a requirement for one to qualify as a GS Australia assessor although alternative arrangements including online courses are also available. In contrast, attendance of an interactive

multi-disciplinary accreditation course is a necessity for the GS South Africa followed by an examination.

Although a one off examination fee payment of R850 (about US$100) is enough for the required online examination, payments are recurring until one has obtained not less than 75% passing rate in order to qualify as a GS South Africa assessor. In contrast, the GS Australia course fees are payable depending on the mode of training. These include the in house for member organisations or public course, further area of inspiration or continuous professional development (GBCA 2012).

The final aspect, implementation, relates to the financial support structure of the tools. Similar to facilitation and implementation criteria, there are some similarities and differences between the GS Australia and the GS South Africa with regard to the implementation criteria. For instance, both the GS South Africa and the GS Australia, whose first launch was funded by the founding members with support from other organisations, continue to rely on individual organisations sponsorship to support the development of new versions. The GS Australia categorises them as principal, Gold, Silver and Bronze sponsors depending on the extent of support as detailed in Table 2. On the contrary, sponsorship of GS South Africa tool is directly allocated to the activities being sponsored. That is, apart from the sponsorship made with the founders of the tool, conferences, conventions and tool development sponsorships are always needed from those who are interested in becoming green building leaders. In principle, individual and organisational membership financial support is the one major financial source for implementing these tools. Therefore based on these criteria, a few implications are considered to affect the performance of the Green Star South Africa tool with respect to the way it is operated.

Table 2: Operation criteria of Green Star tool in Australia and South Africa

Operation criteria	Green star Australia	Green Star South Africa
Facilitation		
Tool ownership	Green Building Council Australia (GBCA)	Green Building Council South Africa (GBCSA)
Responsible parties for tool development	Green Star Faculty (made of 18 individuals from member organisations)	Paid consultants, voluntary Technical Working Group
Tool updates and reviews	Through public reviews and stakeholder feedback	Consultations
Promotion	Though local Government institutions, contribution to green policy guidelines	Not specified
Project accreditation		
Accrediting body	Third party certified assessors	Independent assessors
Assessment requirements	Voluntary	Voluntary
Accreditation (certification) procedure	2 rounds of submission and assessment. Score based on assessment panel's recommendations and GBCA awarded credits	2 main stages: submission and scoring processes. 2 extra points awarded for including an Accredited Professional
Certification obtained	Green Star Certified Rating to project score of 45 plus	Design certification and As Built certification
Fee structure	Based on total ground floor area Members obtain a fee discount	Based on project ground floor area
Professional accreditation Accrediting body	Green Star Faculty (third party)	GBCSA
General procedure	Face to face, online courses and continuous professional development courses	Interactive multi-disciplinary accreditation course and Green Star SA examination
Professional accreditation fee per person	Members: AU$230-450 (in-house courses), non-members AU$160-650 (public courses)	R850 paid for exams for members and non-members
Implementation		
Green Star running costs	Sponsorship from organisations	Sponsorship from organisations
First launch Sponsorship	GBCA founding members	GBCSA founding members (once off sponsorship)
Other sponsorship categories	Principal sponsor AU$80,000 + GST Gold AU$60,000 + GST Silver AU$30,000 + GST Bronze AU$20,000 + GST	Continuous contribution by green leading organisations, conferences, conventional and rating tools sponsorships

Source: GBCA (2012), GBCSA (2012)

IMPLICATIONS OF THE OPERATING SYSTEM OF ADOPTIVE GREEN STAR IN PROMOTING SUSTAINABILITY

As much as the advancements in the adoption of BEATs are contributing to ways of advancing sustainable construction in a number of countries, it appears that there are also some implications associated with how they are operated. Focussing on the Green Star South Africa, as summarised above, one of the major implications related to facilitation for instance is the lack of compatibility between the tool and the existing policies. Although there is a wide range of government set targets to address greenhouse gas emission and other building related environmental issues, it is not clear on how the tool is amalgamated with the existing sustainability policies and regulations or vice versa. Consequently, as it is with most adoptive tools, there is little evidence of the GS South Africa's contribution towards the local policies addressing the building environmental issues to supplement what is stated in the mission or vision statement. This is even more problematic with the next generation tools with reference to those states without clear environment and sustainability policies as previously discussed by Mpakati-Gama *et al.* (2011).

The other implication relates to the accreditation procedure. The GS South Africa for example, assesses buildings at two different stages namely; 'design' and 'As built' accreditation. Although a design certification is not a prerequisite for obtaining the 'As built' accreditation, there is a requirement that these have to be achieved within a 24 month period of the practical completion. Although this is practically possible, it is still problematic with some low cost projects. For instance, most of mass projects involving low income families are built at different phases and at owner’s pace relative to financial availability. Such buildings, which have no certain completion schedule, seldom meet the basic assessment requirements for registration or certification based on how the GS South Africa operates. Therefore, this remains one of the great challenges for most less industrialised countries to deal with in promoting the use of BEATs focussing in low-cost housing projects.

Another area of concern relates to the professional accreditation method employed and applicability in promoting sustainability. As discussed earlier on, trained and accredited professionals conduct the assessment of projects and also submit them for registration and other evaluation processes. Although the training enhances the knowledge and understanding of the trainees in their areas of interest, accreditation depends on the interest of the organisations or individuals in green issues. Eventually, for some reasons, others would opt not to participate if this outweighs the benefits. A few major examples with professional accreditation are the prohibitive training procedure and the examination costs particularly recurring payments for resitting examinations. In a long run, the extra expenses to new and underprivileged professionals limit participation although empirical studies are needed on this.

Finally, focussing implementation of the tool, a few implications exist based on the way the adoptive tools are operated. As indicated earlier, the award system promotes competition for the use of green products (Saunders 2008). However, in places like Africa, it appears that there is little contribution the eco labelling or certification has made so far possibly due to the small market size as highlighted by Malanca (2010). Consequently, there is slow progress in its development. The slow progress could however, be exacerbated by financial implications involved at various stages of the assessment and accreditation processes. As it is the case with the GS South Africa, sponsorship of the activities is dependent on companies and organisations. However,

very few companies and individuals in last developing countries, most of which rely on government funding for running their projects, are not only unavailable but also would be able to make such financial commitments. In contrast, poor participation could be due to the lack of interest to advocate the Green star tool in particular geographical areas. With reference to the GS South Africa, the available few registered buildings appear to be located in certain cities but not others not that some are more environmentally conscious than others but this would also be to lack of awareness. Some recommendations are highlighted below as a way forward.

RECOMMENDATIONS FOR IMPROVEMENT

A few recommendations presented here are not only applicable to the case study but also other parts facing similar problems. In South Africa, where the tool is already operational, extension programmes are required to involve a wider spectrum of the property industry. According to Malanca (2010) incorporating the green assessment tools in the policies on mandatory basis is considered as a way forward is to advance the use of BEATs hence sustainable construction. Even though this appears to be one of the appropriate ways, there are also several problems Malanca (2010)'s suggestion may come across. For instance, restructuring the regulations to incorporate sustainability policies in most countries is not only costly but also requires ample time and political will as highlighted previously by Mpakati-Gama *et al.* (2011). In addition, incorporating them in regulations will marginalise other groups such as the informal sector who rarely follow the policies and regulations. We therefore suggest the involvement of other active bodies to take a leading role as demonstrated elsewhere in the literature. For example, in addition to the African Architects Union already involved in influencing building professionals need to incorporate the green building assessment at design level (Malanca 2010) while the national construction councils where they exist, can facilitate the operation of the tools alongside or in the absence of formal GBCs. Consequently, this will help to cut the number of hired consultants, avoid voluntary assessors and consequently, minimise the assessment overhead costs over the entire process. Subsequently, this will promote participation by a wider range of building stakeholders although the challenge to incorporate the informal sector to go green requires further actions by various actors. Promoting the public private partnerships operating in most countries is one of the opportunities to be utilised as a way forward to take the informal sector on board. On the contrary there is need to create more new accreditation categories to accommodate the marginalised professionals and projects. This therefore will not only promote membership but also promote marketing of projects under the new category. However, a clear definition of sustainability requires to be worked upon by a wide range of stakeholders promoting the green building tools for easy understanding of various stakeholders.

CONCLUSION

Focussing on the adopted Green Star South Africa, this work provides a conceptual framework for future empirical studies to improve the operating procedures of BEATs in adoptive countries. It should be appreciated that the GS South Africa used as a case study is only just about 5 years ago hence it's still in its early stages of development. Consequently, its contribution will take a while to be evidenced. On the contrary, based on the operating criteria currently in use, it appears that both the small projects and new or non-qualified professionals are marginalised on the eco market. However, there are a number of opportunities that can be utilised for further improvements

briefly summarised in this paper. Finally, as sustainability marketing tool, the BEATs need to be promoted through awareness programmes to reach various building sector categories including the informal sector which currently appear to be marginalised. This will not only promote the marketing tools but also enhance sustainable practices in the property and building industry at all levels. However, so far, there are a few studies conducted on how the green assessment tools are operated particularly with reference to both original and adoptive tools from which comparative studies on their operation can be based. Therefore, the need for further empirical studies in this emerging field cannot be overemphasised.

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INVESTMENT APPRAISAL TOOLS AND SUSTAINABILITY EVALUATION IN SOCIAL HOUSING

Anthony Higham[1] and Chris Fortune [2]

[1] *Department of the Built Environment, Sheffield Hallam University, Howard Street, Sheffield UK*

[2] *School of the Built Environment, University of Salford, The Crescent, Salford, UK.*

Conventional decision making in all aspects of the asset management sector has largely been based around the key concepts of risk reduction and maximisation of returns. Yet the RICS (2009) has called for surveying professionals to significantly modify their current practice to ensure it aligns with the government policy which has sought to encourage sustainable development through sustainable construction and property management. For organisations operating in the social housing sector this has meant reinvesting, through regeneration and improvement programmes in their existing socially excluded neighbourhoods in order to deliver 'sustainable communities.' The work reported in this paper focuses on a quantitative study executed to assess the extent to which current practice in the social housing sector has been modified to consider sustainable aspects of property investment, and specifically to identify the tools and techniques used. Using a questionnaire survey data was gathered from 250 social housing providers in the United Kingdom achieving a response rate of 15%. The interim findings suggest whilst social housing property directors understand the importance of considering sustainability they have not yet achieved the paradigm shift in terms of its implementation called for in the literature.

Keywords: asset management, investment appraisal, social housing sustainability.

INTRODUCTION

Over the last two decades the nature of the social housing association has changed from being social housing providers into financially freestanding commercial organisations (Flier and Gruis 2002). Mullins (2010) opines this change is likely to have significant implications for the future evaluation of the social housing sector. Yet in the short term, these changes are forcing social housing to function as commercial businesses, in a difficult, fast changing and dynamic trading environment. As a result these organisations face the significant challenge of balancing their social objectives with the harder commercial appraisals required to sustain the business. To continue to do this successfully it is imperative housing associations adapt to the changing demand and aspirations of their customers. A goal which, if it is to be attained, requires them to place sustainable communities at the heart of their activities so as to ensure lasting solutions to housing problems are generated.

[1] a.p.higham@shu.ac.uk

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The research reported in this paper identifies and appraises the extent to which the dimensions of sustainability influence the asset investment processes. The work builds on the authors' initial exploratory research (Higham and Fortune 2011) which suggested that there was a lack of suitable toolkits for the appraisal of sustainability in the social housing sector and that this had prevented any meaningful evaluation of the socio-economic benefits of potential investment. The paper concludes by proposing further research to identify the key socio-economic criteria which are likely to influence the final investment decision.

THE LITERATURE

Investment Appraisal in Social Housing

Over the last six decades, a number of researchers (Needleman 1965; Lean 1971; Bell 1981; Boon and Robertson 1990) have developed various tools, in an attempt to provide a suitable model for housing investment decision making. Prior to 1980, these models largely adopted a pure economic approach to the appraisal of property investment decisions. The first, proposed in the seminal work of Needleman (1965) provided a purely economic tool, which facilitated the evaluation of possible investment levels. The Needleman model restricted itself to the consideration of a project's demolition and rebuilding or various levels of refurbishment based on their capital cost. The model aimed to devise the most appropriate approach but it failed to factor in any allowance for social costs, such as disturbance, which may be involved in the execution of the project (Nutt *et al.* 1976: 17). Whilst this work presented the first model, several modifications where proposed, these included Sigsworth and Wilkinson's (1967) amendment to include inflationary cost increases and Schaaf's (1969) suggestion that depreciation should be included within the formulation. The next step change in such investment models, emanated from the work of Lean (1971). This work advocated the need to base decisions on the perceived value of a proposed building. Although grounded firmly in economics, Lean's proposals did consider accommodation standards and to some extent the environment, however, both these variables where allocated a capital value.

Increasingly in the social housing sector, there has been a growing recognition that housing associations cannot invest in housing alone, it is now imperative that such organisations recognise the importance of generating a social as well as a financial return whilst also having a successful and sustained impact in their communities to create successful neighbourhoods (Mullins 2010: 3). This shift in focus within the sector has led one major body, the National Housing Federation (Treanor and Walker 2004), to advise member housing associations that the retention and maintenance of existing stock and the investment in new developments cannot be completed in isolation from the wider community. If this vision is to be achieved it is asserted that the sector will require refined option appraisal tools which align the financial decision with the wider socio-economic benefits such investment will trigger within the wider community.

This assertion is however not a recent one, as early as 1981 academics where identifying the limitations of the finance led approach to option appraisal. The seminal work of Bell (1981) called for a paradigm shift in emphasis towards option appraisal models which consider wider benefits of investment. Bell was critical of the earlier work indicated above and argued that decision making should be reflective of the social and environmental importance of a proposed housing development and not just the economics of the decision. To reflect this change in focus, Bell proposed a more

holistic model. The model was devised through the medium of case study research with Bolton Metropolitan Borough Council. Bell postulated that investment decisions in the housing arena should be based on a full appraisal of both the project's financial decision attributes together with the anticipated environmental and social benefits. It was argued that such an approach would allow the professional to reach an informed decision based not only on the anticipated financial resources required, but to also map to the outturn social and environmental benefits against the various spend profiles. However, Bell's work did not provide sufficient detail of the decision evaluation process. This omission limited the model's practical applicability. In their later work undertaken on behalf of the National Housing Federation Treanor and Walker (2004) attempted to advance Bell's seminal work. Through the analysis of five case study organisations the work identified eighty five possible socio-economic indicators which could be integrated into the evaluation process for neighbourhood level investment appraisals. To facilitate this wider project appraisal the authors proposed a simple analytical framework in which each of the variables could be evaluated and quantified. Although advancing Bell's earlier research the work failed to provide clear guidance in relation to the identification of socio-economic variables which would be critical to the final decision or the process by which the housing association should evaluate and select potential variables. Such omissions left the user with the difficult task of deciding which social, economic and environmental aspects were the most relevant and which should be incorporated or be rejected.

Sustainability in the social housing sector.

Sustainability has become a key component of new social housing development over the last decade, with the Homes and Communities Agency (HCA) and its predecessor the Housing Corporation issuing a myriad of best practice and policy guidance to housing associations, registered social landlords and others involved in the delivery of social housing. The resulting effect of this increased focus towards the attainment of sustainable development within the sector triggered a significant growth in the number of toolkits developed. Since 1998 the social housing sector has been inundated with frameworks, toolkits and models aiming to provide practitioners with guidance on how sustainability should be implemented in practice (Carter and Fortune 2007).

Yet when these toolkits are examined in detail, the deficiencies in their applicability are revealed. As part of their EPRSC funded research Edum-Fotwe and Price (2009) evaluated 625 potential sustainability assessment toolkits available to assist built environment stakeholders adopt and implement sustainability. The researchers concluded that none of toolkits adequately evaluated the full sphere of sustainability. This view was further advocated by Brandon and Lombardi (2011: 25) who opined that most of the toolkits available were "either incomplete or totally unstructured" in either case they asserted that their application was impossible.

Some of these toolkits, including 'the sustainability policy wizard' (Talbot 2002); 'A toolkit of indicators of sustainable communities' (Long and Hutchins 2003) and 'the six steps to sustainable development for the social housing sector' (Beyond Green 2004) are so comprehensive that attempts to implement them at either individual project or even strategic portfolio level would be almost futile. Closer examination of the guidance reveals they provide the practitioner with advice on every possible manner of incorporating sustainability. Yet the range of possibilities is so immense that incorporating all the guidance into one scheme would be unattainable. This would leave the housing association with the difficult decision as to which aspects of the

guidance are most relevant and which should be incorporated or rejected. In addition to these, other more commercially focused toolkits' have been developed such as the BREEAM toolkit developed by the Building Research Establishment (BRE), and the housing focused toolkits such as the Code for Sustainable Homes and Ecohomes XB. The code for Sustainable Homes is a version of BREEAM specifically designed for the evaluation of housing. This assessment tool aims to balance environmental performance with quality of life indicators. The strands of sustainability assessed are grouped into seven categories: energy; water; pollution; materials; transport, ecology and land use; health and wellbeing. The standard has been well received and provides a clear grading system for potential schemes to be compared. The apparent suitability of the tool, led the Housing Corporation to commission a modified version of the assessment model for maintenance and refurbishment interventions to existing buildings (Yates 2006). Yet the tool's heavy environmental focus, the use of a total aggregate score or rating and concerns about the robustness of the methodology (see Rees 2009) has raised concerns that the tool maybe masking some unsustainable aspects of developments and may even led to unsustainable solutions being erroneously deemed sustainable (Rees 2009).

Surveys of industry practice by Carter and Fortune (2007) and later by Cooper and Jones (2009) have reaffirmed the social housing sectors willingness to engage with sustainability, whilst also raising important questions about how this willingness is translated into actual practice. The latest large scale survey compiled by Cooper and Jones (2008) as part of a major research study into social housing maintenance practice funded by the Engineering and Physical Research Council suggests that the majority of respondents feel sustainability was an integral aspect of the maintenance decision process. When the same respondents were asked to rate the suitability of existing sustainability toolkits ranging from conventional two-dimensional models such as the stock condition survey, through to the comprehensive frameworks including Housing Quality Indicators and Ecohomes XB. Then the majority of respondents evidenced a clear bias towards conventional toolkits. Such respondents indicate that practitioners continue to favour tools which fail to adequately consider sustainability. However, the survey's limited focus prevents the findings being accepted as a full mapping of the state of the art in terms of sustainable decision practice in the social housing sector. Nonetheless, the work of Cooper and Jones (2008) adds weight to Brandon and Lombardi's (2011: 24) assertion that existing sustainability toolkits are insufficiently developed to be applicable in practice.

The literature reviewed above reveals that the increased importance the adoption of sustainable development principles into built environment practice will have if practitioners are to grapple with the conflicts between the business decision-making process and delivery of the Triple bottom-line of sustainable development practice. This conflict is emphasised by the RICS (2009:11) in their report which identifies that "in no area is this a greater challenge than in asset management, where conventional decision making is based on the concepts of risk reduction and maximisation of returns". Yet as the literature review reveals there are no adequate techniques available to assist the built environment professional in the implementation of this paradigm shift in practice.

RESEARCH APPROACH

The research aimed to evaluate how housing and built environment professionals, at the delivery level, both interpret the policy documents pertaining to sustainable

communities and explore how their interpretations are reflected in the early stage evaluation of both projects and programmes of asset management. The results of the survey are anticipated to assist in the eventual development of a framework to aid practitioners make sustainable asset investment appraisal. The research reported in this paper aimed to evaluate the current state of the art relating to the theory of strategic investment appraisal together with the perceived importance of sustainability in the social housing sector. This called for a quantitative research design that made use of a measuring instrument that allowed data to be collected from a large number of practitioners in the field. Creswell (2003) indicated that the most appropriate data collection tool to use for this study was a questionnaire survey. The design and use of such an instrument enabled the study to ascertain the extent to which organisations had started to recognise the importance of sustainability to the asset management process. In addition the study also identified whether this recognition had been translated into practice, through the investment appraisal process and more specifically the nature and type of toolkits selected to facilitate this process.

Following the piloting of the questionnaire, it was resolved to develop a random sample of 250 property directors drawn from a commercially available database of all the 2,000 social housing providers operating across England and Wales. The electronic survey distributed via email and administered in a single phase achieved a 15% response rate (n=35). The results obtained cannot necessarily be deemed representative of the social housing sector as a whole as a result of limitations in both the size of the sample frame and the response rate achieved. Rather a further phase of data collection is required to increase the response rate to a level where the results become statistical significant and therefore allow more meaningful conclusions to be drawn.

KEY FINDINGS FROM THE SURVEY

The results have been analysed using descriptive statistical techniques in order to determine: (i) current priorities for investment in the social housing stock; (ii) the level of importance attached to sustainability within the organisation; (iii) the extent to which asset management practitioners consider sustainability to be important to their decision making process and finally (iv) appraise how this translates into the practice of investment decision making, using toolkit selection as a proxy indicator.

Focus of Investment Expenditure

The first section of the questionnaire asked social housing practitioners how stock investment was distributed. The analysis of the data shown in figure 1 revealed a drive towards the delivery of capital projects in terms of the construction of new homes, for either sale or rental. This work accounted for approximately 30% of RSL investment expenditure and 15% of traditional housing association expenditure. Yet neither type of organisation demonstrated a major commitment to the refurbishment of their existing stock as the data revealed that investment in this area only accounted for between 6% and 7% of total investment expenditure.

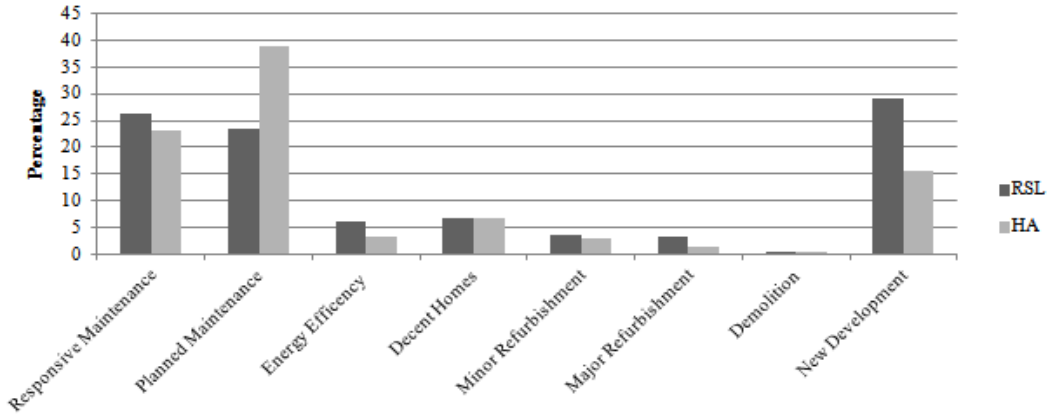

Figure 1: Focus of Investment in Social Housing Providers

Importance of Sustainability

The second section of the questionnaire asked asset managers questions which aimed to appraise their commitment to delivering sustainable asset management investment. The first questions sought to appraise how sustainability had been integrated into the business at an organisational level, primarily through the implementation of a sustainable development plan. The results revealed that only 49% of the organisations surveyed had a sustainable development policy in place. Although a further 21% of respondents highlighted that they were in the process of developing such a policy.

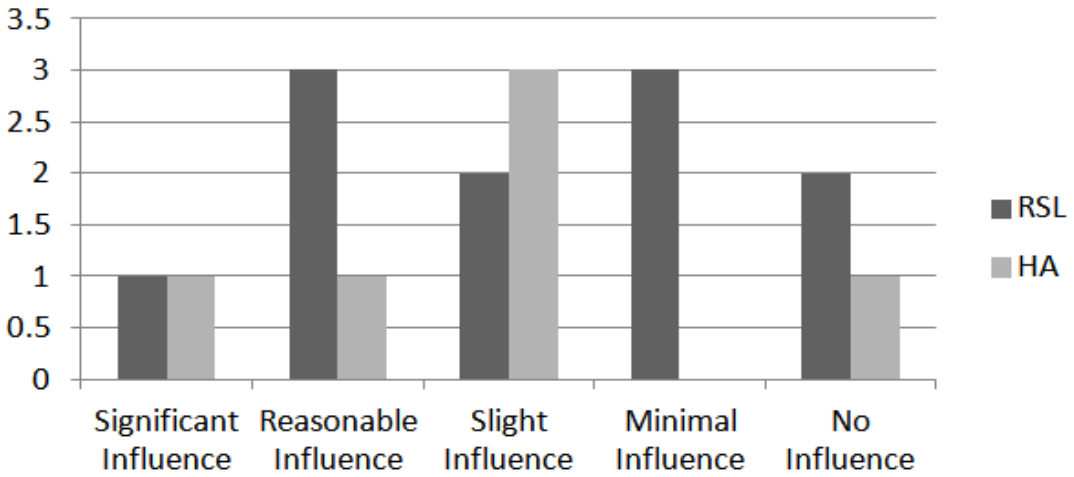

Figure 2: Influence of Sustainable development Policy on Investment Decision Making

Those respondents who indicated they had or were developing a sustainable development strategy where then asked to appraise how they felt the policy had influenced their organisations investment decision making. Figure 2 shows the breakdown of how respondents from both RSL's and HA's felt that their sustainable development policy influenced their approach to investment decisions. This question used a five point likert scale, with the middle range response being "slight Influence". Of the 17 respondents indicating their organisation had or were developing a sustainable development strategy some 35% (6) felt the sustainable development policy had not influenced the investment decision process. A further 35% (6) of respondents felt the policy had impacted on the approaches taken to their decision making. The final 30% (5) of respondents opted for the neutral response, suggesting that the policy had only had a slight influence on their practice. However, the largest

percentage of respondents appeared to suggest the introduction of an organisational policy relating to sustainability would influence their decision making environment.

The final question in this section of the questionnaire sought to appraise the levels of importance individual property directors attached to various features of sustainability that they would consider to be important to stock investment decisions. Each respondent was asked to rank several features of sustainability that were drawn from the literature, together with the more traditional physical indicators used by social housing organisations within the decision making process. The mean ranking of the three dimensions of sustainability together with the conventional decision criteria shown in Table 1 suggest physical and social features of the housing stock are likely to be the more dominating factors the investment decision rather than environmental and economic dimensions.

Table 1: Importance of Headline Sustainability Indicators

1 = Critical; 5 = Not Relevant	Critical	Relevant	Slightly Relevant	Minimal Relevance	Not Relevant
Physical Criteria	6.29	3.29	5.14	9.14	4.86
Environmental Sustainability	5.33	4.00	1.00	7.67	7.00
Economic Sustainability	3.86	4.43	4.86	8.14	5.57
Social Sustainability	7.75	2.50	0.75	6.00	8.75

Toolkits used to appraise Investment Decisions

Section three of the questionnaire sought to evaluate the extent to which key features of sustainability translated into current practice. To allow this to be evaluated, the respondents were asked to rank several toolkits which could be used for the appraisal of potential investment projects. These models can be loosely classified into (i) conventional tools and (ii) varying types of sustainability toolkits identified from the literature.

The results, in Table 2 reveal that despite practitioners recognising the importance of sustainability to the investment decision this commitment has yet to be translated into practice. The results of the survey show that conventional finance based toolkits continue to dominate decision making practice.

Table 2: Investment tools used in the Social Housing Sector (1= always used 5 = never used)

	Always	Occasionally	Hardly Ever	Never	Rating Average	Response Count
Capital Cost	16	6	2	2	1.62	26
Life Cycle Cost Analysis	14	9	2	1	1.62	26
Own In-House system	15	4	1	4	1.75	24
Discounted Cash Flow (using NPV)	15	4	4	3	1.81	26
Cost Benefit Analysis	5	11	5	4	2.32	25
Social Return on Investment	6	7	7	5	2.44	25
Proprietary System	10	0	2	9	2.48	21
Social Impact Assessment	3	4	6	11	3.04	24
National Housing Federation Framework	0	7	4	13	3.25	24
Eco Homes XB	0	5	6	14	3.36	25
Social Capital Studies	0	3	8	13	3.42	24
P.R.I.S.M	0	0	5	19	3.79	24

DISCUSSION OF RESULTS

The provisional findings from the questionnaire survey reveal a significant disparity between property directors of RSLs and HAs understanding and perception of the importance of sustainability and how these perceptions translate into practice. The majority of property directors surveyed demonstrated a clear commitment to sustainable development, with the majority suggesting all three aspects of sustainability where important to the investment decision. Although as expected, the social dimension of sustainability dominates their decision making.

Unfortunately however, this personal commitment to sustainability does not appear to translate into either organisational policy or individual practice. Of the thirty three property directors responding to the survey only forty nine per cent of the organisations in which they are based actively promoted sustainability within their policy framework. This funding was very similar to that observed by Cooper and Jones' (2008: 28) who discovered that only 50% of surveyed organisations had a sustainable development policy in place. This appears to suggest that no significant progress towards the development of sustainable development policies has been recorded in the sector over the last four years. This apparent stagnation in progress appears to validate Carter and Fortune's (2007) suggestion that sustainable development plans were implemented as a result of regulatory pressure. However, as this pressure dissipates then it can be seen that the publication of additional policy within social housing organisations has also abated as suggested by Mullins (2010). However, this reduction in policy may in its self reduce the sectors commitment to sustainability. The research also exhibits the positive impact such policies can have on the organisation. With the majority of property directors indicating that the requirement to comply with the organisations sustainable development policy has prompted them to consider the sustainable benefits associated with potential investment thus making a start toward the improvement of practice.

However, this personal and organisational commitment to the inclusion of sustainable development principles into an organisation's investment evaluation practices has yet to translate into reality with the majority of RSLs and HAs continuing to favour the use of the more conventional economic models for their project investment appraisals. This reluctance to implement sustainability focused toolkits into practice appears to be common place across the built environment professions. With recent research recording similar levels reluctance to fully engage with sustainable project evaluation. For instance Fortune and Cox (2005) observed quantity surveyors rarely appraise sustainability during the economic evaluation of projects. This finding was supported by Dixon *et al.*'s (2008) comprehensive survey of the Royal Institution of Chartered Surveyors membership which revealed only a limited number of members had activity engaged with sustainability and sustainable development. Finally Cooper and Jones (2008: 17) survey of social housing maintenance managers provided further evidence that this reluctance to appraise the full range of sustainable benefits with asset managers instead favouring the use of conventional toolkits or at best those toolkits which focused on the energy usage of the stock.

CONCLUSIONS

The findings from this research raise questions about the social housing sector's continued reluctance to engage with sustainability and sustainable development. The research findings suggest that the virtuous circle of blame observed over a decade ago has yet to be broken. The work also raises important questions about the usefulness of the toolkits correctly available to built environment professionals. As the literature evidenced, no single toolkit yet adequately evaluates the full sphere of sustainability and this has led to a situation where despite a growing understanding of the importance of sustainable development there is a problem in translating this desire into practice. Weaknesses in existing toolkits appear to present a major barrier to the successful implementation of sustainable project evaluation.

In an attempt to advance knowledge in this area, further work, with a regional housing association is proposed. The research will attempt to refine the framework initially proposed by Treanor and Walker (2004) so as to allow the social housing sector to implement a paradigm shift in practice towards sustainable benefit evaluation of public sector housing investment programmes. Such a move in practice was initially proposed by Bell over thirty years ago. The first stage in this process will be to confirm, through a grounded theory-like approach, the socio-economic variables which could influence the investment decision.

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EARLY STAGE EVALUATION OF THE SOCIO-ECONOMIC BENEFITS OF BUILT ENVIRONMENT HOUSING REGENERATION PROJECTS

Julius Akotia and Chris Fortune

School of the Built Environment, University of Salford, Greater Manchester, M5 4WT, UK

In recent years, sustainable regeneration has been recognised as being of major economic and social concern in the world. In the UK for instance, government has initiated a number of policies and evaluation methods to deal with some of the environmental problems associated with regeneration projects. However, the post construction evaluation of these projects has often resulted in them being seen as not achieving their set objectives. Attempts aimed at evaluating the implementation of sustainability by built environment professionals have primarily been limited to their assessment of the projects' potential environmental impacts with the associated socio-economic aspects being neglected. While there have been a number of studies on sustainability and its evaluation in relation to regeneration projects in the UK, there has not been any well-defined built environment research that has been able to deal holistically with the broader issues of sustainability in terms of benefits/impacts of the regeneration projects to the end-user and the communities concerned. The findings of an exploratory study that adopted a semi-structured interviews approach for data collection from six senior regeneration managers of construction industry organizations involved in housing regeneration projects in the UK are presented in this paper. The findings reveal a lack of a mechanism to evaluate the socio-economic benefits of sustainability in relation to housing regeneration projects at the early stage of the project's development. The results suggest that the environmental factors of sustainability continue to be the most dominant factor of sustainability considered by built environment practitioners as compared to the consideration of a project's potential socio-economic benefits.

Keywords: socio-economic benefit, sustainable housing, regeneration projects.

INTRODUCTION

The concept of sustainable development and regeneration has been an essential focal point of government policy for sometime in the UK and it has contributed to the enhancement of many communities' physical structures (Haran *et al.* 2011). Many of the earlier initiatives that were meant to tackle socio-economic disparities have focused on improving the physical and environmental aspects of regeneration. In more recent times, there has been a number of research projects which sought to study and analyze how the UK built environment is responding to the challenges of integrating sustainability into regeneration projects (Dixon, 2006). The Sustainable Development Commission, (SDC, 2003), suggested that the development of regeneration has proved to be a testing and on-going challenge for government agencies, construction industry

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practitioners and communities within the UK. The appreciation of such challenges has led to the development of various management strategies and systems to guide and direct industry practitioners to achieve higher and improved sustainability standards.

However, attempts aimed at implementing sustainability assessment have primarily been limited to the assessment of the environmental performance of building. According to Brandon and Lombardi (2011), previous works undertaken on sustainable regeneration have shown that they lack a conceptual clarity related to sustainability assessment. Brandon and Lombardi (2011) identified sustainable regeneration/development as an evolving field and suggested the need for further study as they asserted that there had not been a well-defined evaluation framework developed that was able to deal with the issues of social and economic benefits/impacts and their evaluation in a comprehensive and a decisive manner. It is quite clear that the present project management systems, the industry and its governance structures, and the nature of the assessment systems all have an influence on the current construction industry practices' related to the delivery of regeneration programmes. Consequently, the quest for the delivery of sustainable housing regeneration calls for an exploration of new ways of evaluating, at an early stage, sustainable regeneration projects that are under-pinned by strong socio-economic considerations; and which better address sustainability concerns in a holistic manner to maximise the sustainability benefits of these projects.

The early stage evaluation of socio-economic benefits of sustainable housing regeneration projects in the UK is explored in this paper. Initially, literature is reviewed on sustainable housing development and regeneration, pre-project evaluation practices and their limitations. A discussion is then presented on the findings from an exploratory study that adopted semi-structured interviews with six senior managers of leading construction industry organizations involved in sustainable housing regeneration projects in the UK, and draws a conclusion. The work draws from on-going research which is concerned with the development of a framework for socio-economic benefit evaluation of regeneration projects in the built environment.

LITERATURE REVIEW

Sustainable housing a driving force of regeneration

According to Winston (2009) the quest for regeneration has largely been dictated by the need to provide much higher levels of new and affordable housing facilities, which has traditionally been unresponsive to meet the demand. Traditionally, the UK regeneration strategy has focused on housing conditions of the poorer communities (Special Economics Research Center Strategies (SERC), 2011). It sets out to provide high quality housing that contributes to the creation and maintenance of sustainable communities. The government's Green Paper (HM Treasury, 2007) outlined the need to increase the level of house building and tasked the UK government to meet a target of three million new homes by 2020. A recent study by Maliene *et al.* (2008) has recognized the housing sector as a major concern requiring an intervention of government and other key stakeholders. Maliene *et al.*'s work underscored the fundamental importance of housing provision within the community regeneration programmes. Generally, the focus on sustainable housing development echoes the important role housing plays as a major driving force of regeneration schemes (Haran *et al.* 2011). Because it is often seen as an indicator for growth and sustainable development of an area (Winston 2009).

Bailey (2010) described the housing sector as a symbol that represents the entire scope of urban development and regeneration process, which should be considered as the "heartbeat" of regeneration concept that has considerable potential to drive local regeneration and provide substantial benefits in terms of creating sustainable local communities (Smith, 2006). To deliver sustainable housing as advocated by the government's Green Paper (HM Treasury, 2007) will require a strong and strategic approach to housing development to meet local needs. It can be seen that housing is directly rooted in our community set up, for that reason, focusing on housing development has enormous potential to drive the regeneration process towards the attainment of a sustainable community (Smith, 2006). The growing pressures on national and local governments to meet the decent homes demands by way of regenerating areas of poor housing facilities; particularly the social housing sectors (Smith, 2006) make the call for sustainable regeneration timely. If the supply of sustainable housing is not matched to the rapid growth of human population, there is a possibility that the government agenda to achieve sustainable housing target for all by 2020 will be hampered (Mezher, 2011).

In such a case, the socio-economic condition and the quality of life of society will also be affected. Housing has a key role to play in delivering regeneration that addresses the socio-economic decay in areas that have the potential for growth (HM Treasury, 2007). Housing-led regeneration can contribute to the sustainable development of a community through the creation of new and affordable houses. An empirical study by Gibson *et al.* (2011) found a linkage between poor housing, employment and quality of life. Poor housing facilities can be damaging to people's self-esteem and their general welfare (Gibson *et al.* 2011). Adair *et al.* (2003) indicated that the improvement of the physical structures in the housing sector would provide the driving force for regeneration policy and initiatives to strive in a complex and unstable environment. It has been acknowledged that, a successful housing regeneration programme that is centered on the socio-economic well-being of the people concerned is more likely to deliver tangible and sustainable benefits (Haran *et al.* 2011). However, a pre-requirement to the attainment of such benefits is to improve the current early stage project evaluation systems to ensure that such regeneration projects deliver sustainability benefits in a holistic manner.

Pre-project evaluation practices

The significance of early consideration of evaluation of sustainability factors has been acknowledged by (Lee, 2006). Lee argued that the timing of the evaluation process for any project is paramount since potential project outcomes can be ascertained during the pre-construction stage. This argument was supported in a subsequent work by Smith and Jagger (2007: 38) who argued that, the decisions taken during the early project development stages (for example at the briefing, feasibility or inception) result in "more far reaching economic consequences than the relatively limited decisions which can be made later in the process". Evidence to-date points to the fact that, evaluating projects' success factors early at pre-development stages is central to unearthing any risks associated with the projects leading to more desirable and acceptable project outcomes. A case study conducted by Ugwu *et al.* (2006), indicated that incorporating project sustainability evaluation early at the design stage has the potential to provide cost savings and facilitate value for money business decisions. Ugwu *et al.* (2006), went on to suggest that, many decisions that influence project success outcomes are established during the "front end" rather than the "back end" approach currently being adopted by practitioners to evaluate the sustainability of

their projects. Yet the absence of any comprehensive and well structured framework makes such early stage evaluation practices progressively more problematic and doubtful.

However, with a greater demand for sustainable buildings coupled with the requirement to develop such systematic and multi-dimensional sustainability assessment models (Ding, 2008), requires an understanding of the current state of evaluation practices within the industry. Lee (2006) advocated a paradigm shift toward assessment systems that constitute a satisfactory integrated approach to the evaluation of sustainability impact rather the current mechanistic approach currently being adopted. The bottom-line is, for projects to attain their sustainability objectives, things have to be done differently. While some sustainability factors may be easier to identify and quantify using methods such as BREEAM and LEEDS, other indicators relating to socio-economic sustainability may be difficult to quantify using the same BREEAM and LEEDS approaches. Therefore, it is essential that emergent evaluation systems clearly set out and define their boundaries and parameters. It can be argued that an evaluation framework that advocates the proactive assessment of sustainability dimensions (such as the social, economic and environment factors) in a holistic and integrated manner presents a greater chance of arriving at a more satisfactory sustainability-driven project related decision.

Limitations of current evaluation methods

Although a number of evaluation methods have been developed and applied in the construction industry over the period, their focus and attention has remained limited to evaluating the environmental impacts of a proposed building at its design stage (Hurley and Horne, 2006). Such evaluation objectives and procedures have traditionally been limited to design cost and environmental factors, and their validity and reliability for evaluating socio-economic sustainability factors at both pre-project and post project stages still remain to be tested. Brandon and Lombardi, (2011) pointed out that the current list of available methods including cost benefit analysis do not reflect the complexities of issues they were designed to address especially if evaluation of individual projects is required. They noted that most of the existing evaluation methods were based on environmental criteria that were derived from ideas and assumptions of individual practitioners. Studies carried out by Cole (2005) and Ding (2008) identified data intensiveness, impracticality and late application as some of the major criticisms that have been labelled against current evaluation tools. Cole (2005) went on to suggest that a number of the current evaluation methods were still functioning as voluntary and market place mechanisms and this was undermining their importance and usefulness. Similarly, over generalization and reliance on environmental factors were also recognized by the industry practitioners as some of the weaknesses inherent in the current evaluation systems (Jeswani *et al.* 2010). These weaknesses have played a major role in contributing to the poor performance of the current evaluation systems (Ding, 2008) and their inability to offer a comprehensive evaluation approach to maximize the sustainability benefits of the projects.

RESEARCH APPROACH

In order to explore the main sustainability issues to meet the objectives of the study, a qualitative research approach was adopted with semi-structured interviews utilised to collect data. This approach reflected an interpretivist philosophical position that made use of inductive research strategy and qualitative methodology. A qualitative research approach is considered as an effective method that occurs in a natural setting which

enables the researcher to develop a level of detail from involvement in the practice (Creswell, 2009). Initially, 15 leading construction organisations in the UK were selected, based on their experience and knowledge in sustainable housing regeneration projects, through a purposive snow balling sample technique. Formal letters were then sent out to these organisations as an invitation to participate in the study. Follow up telephone calls were also made to these organisations to explain further the purpose and the context of the study. In all, a total number of six (6) organisations agreed to participate in the study. The profiles of these agreed organisations are shown in the table 1 below. Face-to-face in-depth semi-structured interviews were then undertaken (between September 2011 and February 2012) with the senior sustainable/regeneration managers of these respective organisations. Each interview lasted for between 30-45minutes. The interviews were formatted around a range of open-ended questions to explore the sustainability issues under investigation. The responses to the exploratory nature of the questions were analysed to identify the emerging themes and issues in the current practices related to early stage evaluation of sustainable regeneration projects.

Table 1: Profile of leading industry organizations interviewed.

Respondent	Position	Type of organization
A	Senior manager, sustainability/regeneration	Contractor organization
B	Senior manager, sustainability/regeneration	Contractor organization
C	Senior manager, sustainability/regeneration	Contractor organization
D	Senior manager, sustainability/regeneration	Contractor organization
E	Senior manager, sustainability/regeneration	Contractor organization
F	Senior manager, sustainability/regeneration	Contractor organisation

DISCUSSION OF RESULTS

The objective of the study was to explore the state of the art in early stage evaluation of sustainable housing regeneration projects and how in particular the socio-economic sustainability factors were being articulated and evaluated during the early stages of projects. The main themes that emerged from the data analysis included sustainability factors, sustainable regeneration objectives/benefits, the evaluation framework and socio-economic impact/benefit. The gap between theory and practice has also been summarised and illustrated in figure 1 below.

Sustainability Factors

The first interview question put to the interviewees explored their organizations' understanding of sustainability and the importance the practitioners and their organizations attached to such sustainability factors when evaluating project viability. A significant theme that emerged from their responses was the lack of conceptual clarity of sustainability factors by the respondents. All the interviewees provided relatively simplistic definitions and understanding of sustainability in relation to their business operations. Typical of the comments made were as follows:

"Sustainability is something ingrained and inherent in our business processes something that the business has to pay attention to in order to stay competitive…It is about protecting our business from the risks of today and ensuring that we respond to the challenges and opportunities that tomorrow brings…" (Respondent E).

"I think sustainability is being one of the key driving forces behind our operations. It has a short to long term benefits to our business. First and foremost it fits with the vision and values of our business. Adopting sustainability makes us competitive in the environment we operate… It helps us to reduce our carbon footprint, enhances our long-term values…" (Respondent B).

The responses highlighted the limitation in the practitioners' perception and understanding of sustainability. The ambiguity of what constitutes sustainability was also identified as a major problem in works done by Evans and Jones (2008) and Brandon and Lombardi (2011).

Sustainable regeneration objectives and benefits
When the practitioners were further asked about their understanding of the main objectives of sustainable regeneration projects, the respondents provided mixed responses. Some interviewees commented:

"To achieve decontamination, re-use site soils in a sustainable manner and create the proposed landform that will enhance public amenity and wildlife biodiversity" (Respondent F).

"…To ensure comfort and safety. To be aware of the social and physical environment and to endeavour to improve the quality of life to residents…Is about achieving the right balance through our innovative design solution and area transformation, while maintaining a clear focus on the overall objectives of creating a robust infrastructure and services …"(Respondent C).

"All regeneration needs to be profitable and if isn't profitable, there's no point doing it, if there won't be any kind of benefit. So without the benefit element, no regeneration happens unless you get a philanthropic developer who just wants to spend millions of pounds to make people happy for things to happen." (Respondent A).

Discussing the issues further about the benefits to their organisations and the end-users, most of the respondents indicated that company reputation and profit making was the main benefits for adopting the sustainability principles by their organisations. However, the majority of respondents were of the opinion that issues related to energy usage and in particular cost savings on fuel bills was the main benefit to the end-user.

Evaluation and evaluation framework/mechanisms
According to Kazmierczak *et al.* (2009), the evaluation process provides an effective management mechanism on which decision-makers can base their judgement in a variety of ways. In exploring the evaluation mechanisms currently in practice, many of the interviewees indicated BREEAM as being the main evaluation mechanism used for their projects. As some interviewees noted:

"BREEAM is the main assessment method used for our projects as it focuses on low or zero carbon technologies and designs…It is a vital part of our culture and scheme to promote the adoption of cohesive sustainable solutions across all our specialism as a best practice to meet our sustainability objectives" (Respondent C).

"…BREEAM is easy to use as it provides a guideline and specifies the environmental impact of the final products. BREEAM ultimate benefits are recognisability in a sense that it tends to capture the main environmental aspects of projects…Compliance with the existing environmental legislation and principles and best practices" (Respondent D).

Evidence from the responses showed that sustainable regeneration practitioners still consider environmental factors to be the most dominant feature of sustainability and they tend to neglect the consideration of any socio-economic factors. Most of the respondents emphasized on the environmental credentials of BREEAM and also regarded its application as representing the industry's best practice relating to sustainability. It is worth noting that BREEAM parameters are prescriptive in nature and largely based on quantitative assessment which tends to ignore the processes and issues relating to socio-economic factors of sustainability of the projects. This finding is also consistent with the earlier work done by (Essa and Fortune, 2008). When asked further about just when the evaluation frameworks were being applied during the project life cycle, there were mixed responses. Some of the interviewees noted:

"This varies from project to project. If our property business is involved then we are involved at concept stage through design and construction. Most of the time we would be contracted at RIBA stage D and E" (Respondent A).

"Ultimately it depends on the nature and duration of the project…We adopt a flexible and innovative approach based on the requirements of the project we are involved in by demonstrating compliance with the specific targets and key performance indicators agreed by all parties on sustainability relating to the construction and operation of the facility…" (Respondent D).

In addition, another interviewee who alluded to the use of an evaluation model commented:

"We do not have a structured evaluation framework per se, what we do have is some models for planning and benchmarking…Yes we tend to apply our models throughout our project duration to identify and address actions as soon as possible where the greatest sustainability impact may be available…This provides our sustainability team with a brilliant opportunity to look at a broad range of performance issues against the set of our sustainability targets and benchmarks" (Respondent F).

These responses however revealed the lack of a structured evaluation framework and a lack of an appreciation of early stage evaluation mechanisms for appraising the direct and indirect socio-economic benefits/impacts of their sustainable housing projects.

Socio-economic impact/benefit

Finally, when interviewees were asked for their views about the socio-economic impacts of their housing regeneration projects on the communities, a significant misconception emerged between sustainable regeneration projects, community redevelopment and renewal projects. Although all the respondents interviewed were involved in sustainable regeneration projects, their responses indicated a limited knowledge of socio-economic aspects of sustainable regeneration projects. This was demonstrated by the comments given by some of the interviewees as:

"Remediation of an existing hazardous environment in a sustainable way. Creation of public amenity, the improvement of public access on site and improved existing wildlife habitats that will encourage greater biodiversity on site…Redevelopment of site for use of both commercial/residential and public open spaces" (Respondent E).

"It is the social and economic impacts that we find most problematic. Our main goal across all our disciplines is to take a responsible attitude toward renewal of our communities. We are keen on providing modern community facilities, improving the physical environment of our communities as well as safeguarding the environment as a whole for the benefit of our communities" (Respondent B).

Many of the interviewees expressed their views in line with the potential environmental benefits of a project and also gave emphasis to sustainability factors that fitted within their own understanding and agenda (Evans and Jones, 2008). The limited consideration given to socio-economic factors in practice was also identified in a study carried out by (Carpenter, 2011).

THEORY AND PRACTICE - THE CURRENT GAP AND BARRIERS

Much of the sustainable regeneration literature has shown that the concept of sustainability has not been well understood by many stakeholders within the built environment. The concept of the "triple bottom line" of sustainability places equal importance on the economic, social and environmental dimensions (Essa and Fortune, 2008) which are fundamental ingredients in any regeneration project. The gap and barriers identified within the exploratory study with the practitioners are presented in figure 1 below. The current gap and barriers existing between theoretical concepts and the 'reality' in practice was revealed from the findings as all the six practitioners have consistently placed emphasis on the environmental credentials of projects to the neglect of the social and economic sustainability aspects of projects. This was evident in the trend of responses in all the main areas explored. This is highlighted in figure 1 below, in which practitioners' practical knowledge and understanding of sustainability has acted as a major barrier to the pursuance of social and economic aspects of sustainability in practice. Following the exploration of the issues with the practitioners, it can be seen that the challenges associated with the current delivery of regeneration housing projects are products of the key players' knowledge, perception and understanding of sustainability. Consequently, this is reflected in the way sustainability has been articulated and applied in practice (see fig. 1). It can also be suggested that the high emphasis placed on the environmental features could partly be attributed to the government policy on green building and the existing evaluation tools such as the BREEAM which are focused on measuring the environmental impacts of projects. However, it is argued that environmental sustainability by itself cannot function properly in any successful regeneration project if it is not accompanied and complimented by social and economic benefits.

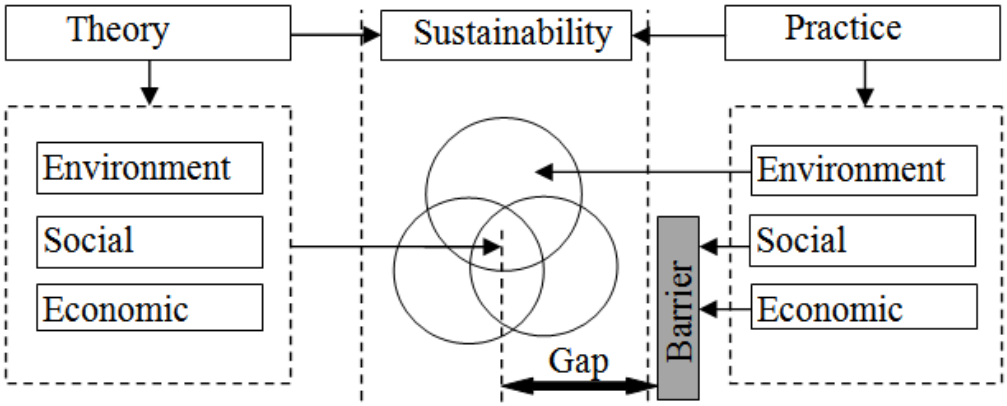

Figure 1: Summary of the findings

CONCLUSION

The early stage evaluation of socio-economic benefits of sustainable housing regeneration projects in the UK has been explored through an initial study that used a semi-structured interview approach to collect data from six practitioners in the field. The study identified a disparity between the theoretical concept and the reality in practice of sustainability factors on a personal and organisational level. The main findings from the study established that the consideration of sustainability was still viewed as being concerned with environmental issues by built environment professionals to the neglect of the socio-economic factors in sustainable housing regeneration projects. Another major limitation that was identified in the interviews was the lack of any existing early stage evaluation frameworks or mechanisms for evaluating the direct and indirect impacts/benefits of socio-economic outcomes of sustainable housing regeneration projects. The findings also identified that while all the interviewees seemed to have accepted the sustainability concept in principle; their responses indicated a lack of appreciation of the wider meaning and understanding of the composition of sustainability. The results of this initial study support the need to collect more data from other built environment regeneration projects to enhance the reliability of the findings.

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BUILDING REFURBISHMENT: HOLISTIC EVALUATION OF BARRIERS AND OPPORTUNITIES

Ibrahim Babangida[1], Femi Olubodun[1] and Joseph Kangwa[2]

[1] *Faculty of Advanced Engineering and Sciences, the University of Bolton, Bolton, BL3 5AB, UK*

[2]*School of the Built Environment and Engineering, Leeds Metropolitan University, Leeds, LS2 8AJ, UK*

With the significant reduction in the number of construction projects due to the economic meltdown in the last three years, which is feared, may continue well into this second decade, the refurbishment of old and existing buildings may be perceived as a strategic avenue through which property owners could secure value for money. It is common knowledge that aged buildings are constantly growing in number with a concomitant growing pressure to maintain their utilitarian values in the face of changing technology, legislation and sustainability issues. Indeed, the majority of buildings in the UK pre-date the emergence of the modern concepts of sustainable development. Wholesale demolition of these buildings can be quite unhealthy from an environmental protection perspective as it causes heavy pollution as well as placing more demand upon depleting resources. Nevertheless, the demand for sustainable, energy efficient buildings from both regulators and occupiers is increasing despite the recession. However, is the inclination to refurbish rather than demolition and new-build becoming stronger? This paper explores the barriers and opportunities for building refurbishment schemes as an economically motivated activity through which the performance and value of a property can be enhanced. It is based on comprehensive literature review as part of on-going doctoral research programme on risk structure in building refurbishment schemes. It concluded that refurbishment is substantially cheaper than demolition and new-build and that a refurbished building can be as functionally efficient as new-build.

Keywords: existing buildings, refurbishment schemes, sustainable development

INTRODUCTION

The global economic meltdown in the last three years, which is feared, may well continue into this second decade, has resulted in arguably, the worst downturn experienced by the UK commercial property market since the second world war (GVAGrimley, 2010; Construction Industry Council-CIC (2009), resulting in lack of development finance which has consequently led to significant reduction in the number of construction projects (CIC, 2009). The office of the Deputy Prime Minister-ODPM (2005) and National Refurbishment Council-NRC (2010) reported that the UK has some of the oldest building stock in Europe, with almost a quarter of

[1] i.babangida@bolton.ac.uk

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buildings in England built before 1919. These buildings pre-date the emergence of modern concepts of sustainable development. The implication is that, there is increasing demand for sustainable energy efficient buildings from both regulators and occupiers (NRC, 2010; GVAGrimley, 2010; Gorse and Highfield, 2009). Moreover, from the public sector perspective, there is a concomitant growing pressure to meet current government's targets for carbon reduction in buildings. Indeed, in 2008, the UK Government passed the Climate Change Act to help combat rising carbon dioxide levels. This Act implemented a carbon emission reduction target of eighty per cent, with at least twenty-six per cent by 2020 set against the 1990 baseline. According to the Committee on Climate Change -CCC (2010), the UK was the first country in the world to implement such legally binding framework. The Department of Energy and Climate Change –DECC (2006) spearheaded the Climate Change Act which covers all aspects of carbon emitting sources such as energy consumption, transport, agriculture and domestic and non-domestic buildings.

It comes as no surprise that it is the DECC (2006) initiative that created the propensity for the Committee on Climate Change (2010) to send a clarion message to all sectors of the construction industry stating that in the UK, energy consumption in buildings is responsible for forty five per cent of carbon dioxide emissions. Of this, twenty-seven per cent comes from domestic buildings and the rest (eighteen per cent) from non-domestic buildings. For instance, in the domestic sector alone, seventy-three per cent of emissions come directly from space and water heating, and yet eighty per cent of these - heating systems - are fuelled by gas, the biggest source of emissions (DCLG, 2006). Therefore, by improving energy efficiency in buildings, the amount of carbon emissions emitted can be significantly reduced. However, there also exists a general apprehension about spiralling levels of disrepair such that most of the existing building stocks are easily discounted as outdated and inefficient with poor energy performance (Roberts, 2008), thus, unable to deliver the best returns on investment. While there might be some merits in such concerns, what Roberts (2008) ignored to observe is the mere fact articulated by the UK Green Building Council-UKGBC (2008) that existing buildings still have an important role to play as nearly eighty per cent of the buildings that will be inhabited in 2050 are those already standing. This clearly emphasises the significance of refurbishing and retrofitting existing buildings up to standard not only to meet carbon emission targets, but also to improve the general living conditions fit for the occupants and therefore tomorrow's generation. It follows therefore, that the scale of this challenge and the magnitude of the increase in number of aged buildings coupled with the decline in development finance have incontrovertibly led to the search for cost-effective alternatives to demolition and new-build.

While building refurbishment is a well-established alternative to demolition and new-build for many years, it is now more widely recognised that it makes far greater sense to retain and refurbish buildings in preference to demolishing and new-build (Corus, 2010; Gorse and Highfield, 2009; Marsh, 1983). From an environmental protection perspective, recycling of buildings through refurbishment and retrofitting is ideal whereas wholesale demolition of buildings can be quite unhealthy as it causes heavy pollution as well as placing more demand upon depleting resources (Zavadskas *et al.* 1998). Corus (2010) reported that refurbishment presents a means of improving the value and performance of existing buildings without the economic and environmental costs associated with new-build construction. Thus, it is widely accepted (Corus, 2010; GVAGrimley, 2010; Mansfield, 2009; Gorse and Highfield, 2009; Marsh, 1983)

that a refurbished building can be as functionally efficient and can attain the same environmental sustainability as new-build. Corroborating these views, Marsh (1983) argued that tearing down every building that became older than 30 years is a sheer waste of economic resources. Furthermore, through reuse of old and aged buildings, less construction waste is generated and less material resources are required (Edward and Turret, 2000), and therefore beneficial to the environment.

Compelling as refurbishment and retrofitting may be, there is nevertheless a widespread view among investors that new buildings are the most sustainable buildings. Even more so, from the sustainability perspective which has become an area for concern in recent years, and one that will continue to increase in importance, it is believed that new buildings will have better energy performance and less environmental impact when compared to refurbishment (Baker, 2009; NRC, 2010; GVAGrimley, 2010). This implies that in some cases demolition and rebuild will likely be considered as a preferred alternative to refurbishment. However, Kangwa and Olubodun (2006) have been quick to warn that due to the inevitability of entropy all new buildings will physically deteriorate over time, and at some stage it will become necessary to consider whether to refurbish or completely redevelop. If the cost of refurbishment is higher than the cost of new-build, it will be unwise to opt for refurbishment unless overriding reasons exist as in the case of listed buildings (Gorse and Highfield, 2009).

Despite such significance of refurbishment, it is still not certain whether the inclination to refurbish rather than demolition and new-build is becoming stronger? Indeed, the suggestions that large-scale and accelerated demolition would help achieve the energy and climate change targets is debatable and yet to be substantiated. This paper, presents some of the issues facing refurbishment as a strategic avenue through which the value and performance of a property can be enhanced. The Objective of the paper is: To evaluate the opportunities for, and barriers to effective building refurbishment schemes.

IS REFURBISHMENT THE GENERIC TERM?

The overall purpose of refurbishment as reported by Markus (1979) is to extend the beneficial use of an existing building by providing a cost-effective alternative to redevelopment. However, this definition is debatable as it implies that refurbishment is a cost-effective alternative when the economic life of a building is almost over. Although, this may be true but not always the case as Aikivouri (1996) suggests that refurbishment may be as a result of profound damage that has occurred to physical structure or planned in advance in relation to rate of deterioration. This means that the extent of deterioration of a building will, in some cases influence the type of refurbishment work to be undertaken, not necessarily at the end of a buildings lifespan. Although, this view contradicts with CIRIA (1994) who reported that refurbishment is not restricted to buildings whose physical condition has deteriorated to the detriment of their original purpose or earning capacity.

Refurbishment therefore, has become an important part of the entire building and construction process. Notwithstanding its importance, it is also complex to define as there are different terms used to describe the improvements from actual state of a building to acceptable standards. For instance, Mansfield (2001) argued that many of the terms are used as if they are interchangeable. Indeed, refurbishment can be viewed from different perspectives and these may include but not limited to economic, legislation, functional, technical, and legal as well as the sustainability.

According to Marsh (1983) refurbishment is making use of what is usable in the ageing building stock; the skilful adaptation of a building shell to a new, or an updated version (in other words modernisation) of its existing use. This definition does not make reference to conversion and alteration therefore, limiting its scope to updating to modern standards although mentioned the skills requirement in executing the works. However, CIOB (1987) described refurbishment as a process which allows the alteration of an existing building to improve the facilities and rearrange internal space and/or the structural life span without changing the original function. Unlike the definition by Marsh (1983), this definition however, includes alteration and the original function of the building is maintained. Egbu (1996) perceived refurbishment to encompass renovation, rehabilitation, extension, improvement, conversion, modernisation, fitting out and repair which is undertaken on an existing building to permit its reuse for various specified purposes. This definition differs from that of Marsh (1983) and CIOB (1987) in that Egbu (1996) provided a wider and holistic perspective to refurbishment. However, all the three definitions have one thing in common; the building exists, and requires upgrading for new use. Therefore, refurbishment is multi-faceted and can be regarded as a generic or umbrella term which requires collaborative efforts to overcome the physical challenges. Some construction activities relating to existing building refurbishment are summarised in figure 1.

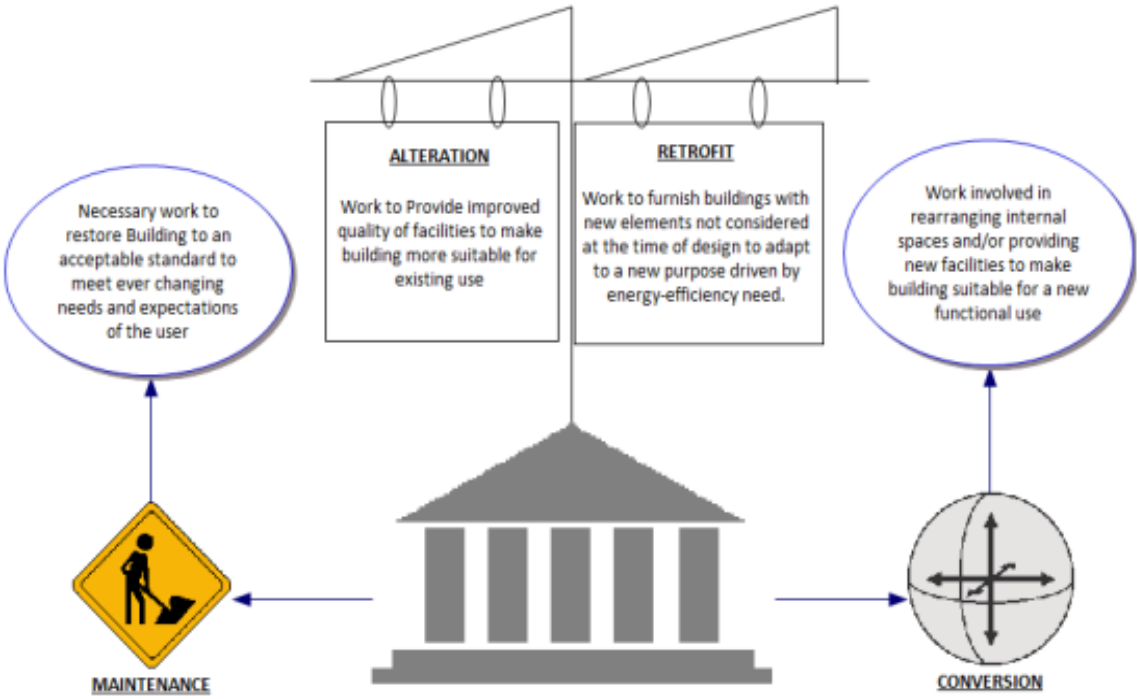

Figure 1: Construction activities relating to existing building refurbishment

OVERVIEW OF THE UK REFURBISHMENT SECTOR

The UK Construction Industry remains an important part of the economy with Seventeen per cent (17%) of all jobs created in the economy (RICS, 2008). The Office for National Statistics (ONS) categorises construction output as ‘new work’ or ‘repair and maintenance’. Indeed, refurbishment is as a generic term is broadly categorised as repair and maintenance by the UK government mainly for statistical purposes (Gorse and Highfield, 2009) as there are no official statistics specific to refurbishment in the UK (Rahmat and Ali, 2010).

However, it appears that this lack of specific data have prompted the use of repair and maintenance statistics to represent the trends in the refurbishment sector. A review of literature suggests that refurbishment has been ever-present element of construction workload, and one that becomes more important in the downturn. This would appear to corroborate with CIRIA (1994) who maintain that refurbishment is one of the most important sectors of the national construction programme. Thus, the UK refurbishment sector is claimed to have grown rapidly, and has become an important economic driver (CIRIA, 1994) and it has been expanding in comparison to new development, hence, Kherun *et al.* (2002), CCCIS (2005) and Gorse and Highfield (2009) claimed that almost 50% of the constructions activities undertaken in the UK were mainly maintenance and refurbishment. Indeed, UKGBC (2008) emphasised that nearly eighty per cent of the buildings that will be inhabited in 2050 are those already standing thus, indicating a clear opportunity for the refurbishment sector, which invariably means that refurbishment will continue to be a significant part of building activity for the foreseeable future.

ASSOCIATED RISKS AS BARRIER TO BUILDING REFURBISHMENT SCHEMES

Mansfield (2009) is of the opinion that risk and uncertainty exist in all projects, irrespective of type, size or location. Accordingly, in his opinion, risk can be considered to be the possibility of a forecast variable (for example, refurbishment cost) being different from that at completion. However, from review of literature it was clear that through a systematic strategy called risk management (RM), it is possible to minimise risks and uncertainties associated with development projects. Hillson (2003) has argued that RM is recognised as an essential tool to tackle the inevitable uncertainty and risk associated with projects, leading to an acceptable and manageable level of risk. He goes on to suggest that projects still fail to meet their objectives and expected benefits, despite the theoretical principle that RM should contribute to project success.

Nevertheless, on the basis of uncertain nature of refurbishment, which in some cases hinders the achievement of desired outcomes, effective risk management process will still be required in order to manage the schemes. For instance, CIRIA (1994) reported that 'not only do refurbishment projects involve all the normal problems of a building, often in an aggravated form; they can also present special problems. Elsewhere, Reyers and Mansfield (2000), Rawlinson and Wilkes (2008) and GVAGrimley (2010) claimed that dealing with an existing building introduces many sources of uncertainties, substantial risks and technical challenges which can affect the scope of work, the total cost and the time or schedules.

Indeed, managing refurbishment projects is faced with some unique problems in dealing with people, the environment and the project itself (Lam *et al.* 2010). Quite a number of remarkable studies on refurbishment highlighted that refurbishment projects generally contains high risk than new build (CIRIA, 1994; Reyers and Mansfield, 2001; Mansfield, 2008; Lam *et al.* 2010; Rahmat and Ali, 2010), due in part to the extent of deterioration which is hardly obvious at the outset of the project. They are also considered to be more difficult (CIRIA, 1994; Zavadskas *et al.* 1998; Rahmat and Ali, 2010), requires experience and capability (CIRIA, 1994; Zavadskas *et al.* 1998; Corus, 2010), more technical and economic uncertainties (Ali *et al.* 2010; Mansfield, 2008; Reyers and Mansfield, 2001; CIRIA, 1994), requires collaboration (CIRIA, 1994), fragmented and uncoordinated (Lam *et al.* 2010), thus, the

complications experienced on new building projects doubles in refurbishment (Marsh, 1983; Abd Karim *et al.* 2007). For example, repairing or reinforcing works of an existing building involves risk that need to be minimised or eliminated. Hence, the management of risks is essential in refurbishment schemes as the design information such as specification, duration and costs are unclear at inception (Abd Karim *et al.* 2007), thus, indicating a clear need for specialist expertise in dealing with the schemes effectively.

In considering how complex and uncertain refurbishment can be, CIRIA (1994) reported that the uncertainty may extend well into construction stages, with a high likelihood that unforeseen events will occur from site discovery. Thus, the most common areas of risks were identified as lack of information about original designs (CIRIA, 1994), issues on neighbouring buildings/party walls (Rawlinson and Wilkes, 2008; CIRIA, 1994), effects of demolition including disposal (Corus, 2010; Rawlinson and Wilkes, 2008), specialist expertise (CIRIA, 1994), the condition of existing structure (Rawlinson and Wilkes, 2008; GVAGrimley, 2010), building occupancy (CIRIA, 1994), health and safety issues (Corus, 2010; GVAGrimley, 2010; Highfield, 2000; Egbu *et al.* 1996; CIRIA, 1994), contingency requirement and procurement strategy (GVAGrimley, 2010), as well as the need to comply with statutory requirements (CIRIA, 1994; Highfield, 2000).

Restriction on Extent of Works as Barrier to Refurbishment Schemes

Apart from the presence of risks and uncertainties associated with refurbishment projects, there are certain cases where developers have to come to terms with the extent of work that will be allowed on a building. This is especially the case where a listed building is acquired (a building of special Architectural or Historic Interest). Being of historical importance, CIRIA (1994) reported that listed buildings generally require a statutory approval usually referred to as 'listed building consent' in addition to planning permission. CIRIA (1994) goes on to suggest that there may be restrictions on demolition or alteration of certain parts of the building and may require the use of non-contemporary materials or techniques. Corroborating this view, Gorse and Highfield (2009) opined that where a building is listed, it is an offence under the provisions of the act, to carryout works of complete or partial demolition, alteration or extension without obtaining listed building consent. Indeed, it is on this basis that most developers find refurbishment of listed building to be difficult, with limited options in terms of refurbishing such buildings.

OPPORTUNITIES FOR BUILDING REFURBISHMENT

Buildings are considered a significant asset and their importance is such that it is required for generations to come as a means of providing shelter as well as producing goods and services. Indeed, it is almost impossible for buildings to complete its lifespan in good condition. As a consequence, due to changing standards of comfort, legislation and technological changes, buildings become obsolete and thus will require substantial improvement to meet current standard and regulation. It also appears almost impossible to demolish all aged buildings for new ones even after the life expectancy period thus, existing buildings below the required standards (in terms of energy and space requirements) will increasingly need to be refurbished in other to remain attractive to both occupiers and investors (GVAGrimley, 2010). However, aged buildings should be investigated to ascertain the extent of deterioration before any informed decision can be made whether they are worth refurbishing (Zavadskas *et al.* 1998). Elsewhere, Gorse and Highfield (2009) suggests that the decision to

refurbish and upgrade existing buildings in preference to new-build can be attributed to the potential economic advantages. Although this is not always the case as legislative constraints such as concerns about listed buildings and their alteration restrictions as well as difficulties with gaining planning approval for new build may force developers to opt for refurbishment.

Being essential from both economic and environmental perspectives (Marsh, 1983), opined that refurbishment is a quicker and lower cost means of extending the lifespan of existing buildings as well as reintroducing a building back into the market (GVAGrimley, 2010; Gorse and Highfield, 2009) as it is substantially cheaper than demolition and new-build. This action is usually motivated by a number of reasons some of which were identified as follows:

- The need to rearrange or organise space to new uses (Baker, 2009);
- The need to increase the value of the property (Corus, 2010);
- The need to improve quality (Baker, 2009; Gorse and Highfield, 2009);
- The need to replace degraded finishes and components (Baker, 2009);
- The need to increase rental income (Corus, 2010);
- The need to improve aesthetics (Corus, 2010);
- The need to make buildings more energy efficient (Caleb, 2009);
- The need to replace damaged building envelope (Corus, 2010; Marsh, 1983).

Corus (2010) suggests that buildings are refurbished as a result of change in ownership or use while CIRIA (1994) suggests that refurbishment may be considered on any existing building in good working conditions to accommodate new technology. However, whatever the reasons for refurbishment, there are numerous benefits and cost-saving opportunities. Indeed, Gorse and Highfield (2009) reported that in majority of cases, the completion of the building in a much shorter time is one of the proverbial advantages of refurbishing existing buildings over demolition and new-build. They further highlighted some of the financial benefits as follows:

- The shorter contract duration reduces the effects of inflation on building costs;
- The shorter overall development period reduces the cost of financing the scheme;
- The building is completed sooner, which often means that the client begins to earn revenue early.

Benefits associated with Building Refurbishment

There is a consensus among researchers that numerous cost saving opportunities exist in refurbishment schemes. Indeed, there are many instances where refurbishment offers a practical alternative to demolition and new-build. In majority of cases, opting for refurbishment can provide a finished building in only half to three-quarters of the time needed for demolition and new-build (Gorse and Highfield, 2009), thus providing considerable benefits in three areas as summarised below:

- Economic Benefits: The overall cost of refurbishment is considerably lower than the cost of demolition and new-build, as many of the building elements are already constructed (Gorse and Highfield, 2009), with subsequent savings in time and money (Corus, 2009).
- Social Benefits: When compared to demolition and new-build, refurbishment minimises disruption and offers sociological advantages from the social housing perspectives, demolition and rebuild of substandard housing usually

displaces established communities (Gorse and Highfield, 2009). With refurbishment however, improvements to aesthetics and the entire building envelop can be achieved thereby retaining established communities.

- Environmental Benefits: From the sustainable development perspective, it is believed that energy consumption in buildings has adverse implications. However, it is often believed that one of the many ways to minimise this and maximise environmental benefits of refurbishment is through re-use and/or recycling of existing material resources rather than replacing them (Gorse and Highfield, 2009). This would appear to corroborate with Baker (2009) who claimed that demolition and subsequent waste disposal creates carbon emission. On this basis, Zavadskas *et al.* (1998) were of the opinion that refurbishment supports excellent opportunities to reduce energy consumption in buildings. Indeed, re-use option of most functional parts of a building minimises the impact on the environment from both production and transportation.

CONCLUSIONS

Refurbishment can be regarded as a generic or umbrella term as it strands all activities associated with improving buildings from actual state to the acceptable standards. It has become part of the total building activity due to increasing need for improvement of existing buildings, lack of development finance as well as lack of undeveloped sites in many city centre locations which constraints the supply of new buildings.

To decide whether or not to refurbish and re-use existing buildings depends on the potential advantages. Overall balance of evidence suggests that, most often it makes economic sense to the owner and the environment if refurbishment is considered. A review of literature also suggests that when a building is recycled through refurbishment, a considerable amount of energy is saved by avoiding the need to extract raw materials for replacement. Furthermore, the ability to refurbish aged buildings to modern standards also represents a significant preservation of national asset as well as huge contribution towards sustainability agenda.

Although, demolition may be an option however; available evidence suggests that subsequent waste disposal creates carbon emission. Therefore, demolition should be considered where the cost of refurbishment is higher than the cost of demolition and new-build and/or where overriding reasons exist as in the case of listed buildings.

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FACTORS OF SUSTAINABILITY IN BUILDING DESIGN: ESTABLISHING THEIR RELATIVE SIGNIFICANCE

Denise Quigley[1 2], George Heaney[2] and Henry Odeyinka[2]

[1]*Dept of Construction and Surveying, Dundalk Institute of Technology, Dundalk, Co. Louth, Ireland*
[2]*School of the Built Environment, University of Ulster, Jordanstown, Belfast, BT370QB UK*

There has been a growing movement towards sustainable building in the past number of decades and in that time a variety of terms have evolved to describe this design ethos such as green buildings, passive buildings, carbon neutral buildings, low carbon buildings, all of which are different but all of which are striving for similar outcomes. For a building to achieve any of these status the design must take into account a number of different factors. The aim of this research is to establish the factors of sustainability relevant to the evaluation of sustainable buildings and to establish the significance placed on individual factors of sustainability in buildings. This was done by firstly identifying in a holistic manner everything which could be considered a factor of a sustainable buildings. These were then presented as a questionnaire to construction professionals with experience in the design and procurement of sustainable buildings who were asked to indicate the significance they have placed on each of the factors. The results of this exercise showed a) that while for many of the factors there was broad agreement as to their relevant significance, for others opinions varied greatly and b) not all factors are of equal importance with some being scored consistently lower than others. This suggests that amongst the group surveyed there is no overall consensus as to the significance to be placed on the factor contributing towards the design and procurement of a sustainable building.

Keywords: design, green buildings, sustainability.

INTRODUCTION

Since the World Commission on Environment and Development in 1987, a significant number of tools have been developed to assess and rate the sustainability or otherwise of buildings (e.g. BREEAM, Code for Sustainable Homes, LEED, EcoEffect, GBTool, CASBEE, HQE, VERDE, DGNB, SPeAR, EcoStar, SKA). These tools examine a range of issues related to sustainability, grouped into themes and measured in relation to certain criteria. Considerable research has been conducted into these assessment and rating tools and it has been generally found firstly, they do not take into consideration all the issues relevant to sustainability; secondly, they do not

[1] denise.quigley@dkit.ie

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measure the same criteria; and thirdly, in their calculations the tools do not place the same weighting on the individual criteria or the themes.

The aim of this research therefore is to establish the factors of sustainability relevant to the evaluation of sustainable buildings and to establish the actual significance placed on individual factors of sustainability in buildings in practice.

RATING AND ASSESSMENT TOOLS

Difference in criteria and weighting between the tools:

When comparing issues examined by different building assessment and rating tools the areas of social and economic sustainability are most often overlooked; Essa and Fortune (2008) found this to be the case for EcoHomes (and this appears not to have been rectified in the Code for Sustainable Homes (CSH) which replaced EcoHomes); Bartlett and Guthrie (2005) concluded environmental issues dominated the tools with little consideration given to economic and social issues other than users well-being and local stakeholders issues; Sinou and Kyvelou (2006) found the areas of economic and social issues were frequently overlooked. Table 1 highlights the apparently difference weighting placed on the criteria by the tools as well as the generally relatively small weighting placed on economic and social issues.

It should be noted the SBTool allows the user adjust the weighting given to each theme and therefore the weightings above (taken from an illustrative example on the SBTool website) are subject to change and within BREEAM and LEED there are also optional themes, not included above, which will change the weightings slightly. Notwithstanding this, the different weightings placed by the different tools are apparent.

Other criteria identified as under represented by different tools were supply chain issues, site selection and funding (Essa and Fortune, 2008), design aesthetics, transport and users comfort (Sinou and Kyvelou, 2006) and indoor air quality (Chuck and Jeong, 2011). When comparing BREEAM and LEED Papodapolous and Giama (2009) found although both appear to examine the same issues they are examined by different criteria, for example in pollution BREEAM considers insulants GWP, eco-labelling of goods and energy efficiency of internal and external lighting, none of which are examined by LEED. Even where similarities do exist, some assessment tools allow criteria to be added or omitted (GB Tool and LEED) to reflect local conditions (Sinou and Kyvelou, 2006).

Papadopoulos and Giama (2009) examining the rating of a single building using LEED and BREEAM found the tools gave significantly different results. Wallhagen and Glaumann (2011) conducted similar research looking at the consequence of using three different sustainability assessment tools (LEED, CSH and EcoEffect) in the evaluation of a single building. While LEED and CSH produced similar overall results this was judged a coincident as significant variation was present in *"the content of the tools, issues assessed, issue criteria, issue scores, aggregation and weighting of categories and issues"*. They also explored the adaptation to the design of the building necessary to improve the rating achieved by each assessment tools and found the adaptations differed considerably and its implementation would *"steer the case study building project in different directions."* Ultimately to achieve the highest rating in each tool, different buildings design solutions would be required.

Table 1: Assessment Tool Weightings by Theme.

Themes Grouping the Criteria.	BREEAM	SB Tool	CSH	LEED
Energy	19.00%			
Energy and CO2 emissions			36.40%	
Energy and Atmosphere				35.00%
Energy and Resource Consumption		20.50%		
Materials	12.50%		7.20%	
Materials and Resources				14.00%
Transport	8.00%			
Water	6.00%		9.00%	
Surface Water Runoff			2.20%	
Water Efficiency				10.00%
Waste	7.50%		6.40%	
Land Use and Ecology	10.00%			
Ecology			12.00%	
Pollution	10.00%		2.80%	
Environmental Loading		48.90%		
Site Regeneration and Development		13.60%		
Sustainable Sites				26.00%
Health and Wellbeing	15.00%		14.00%	
Social, Cultural and Perceptual Aspects		3.90%		
Indoor Environmental Quality		6.20%		15.00%
Services Quality		5.80%		
Cost and Economic Aspects		1.20%		
Management	12.00%		10.00%	
Total	100.00%	100.10%	100.00%	100.00%

From: BREEAM SD5073 -2.0, 2011; SBTool, 2012; Code for Sustainable Homes, 2010; LEED 2009

Difference in weighting applied by tools and designers:

Essa and Fortune's (2008) work on EcoHomes, asked those involved in social housing projects to indicate the importance they placed on each of the seven headings of sustainability identified by EcoHomes when designing. The ranking according to the tool was Energy, Health & Well-being, Land Use & Ecology, Pollution, Materials, Water, Transport; the ranking according to those surveyed was Energy, Materials, Pollution, Water, Health & Well-being, Land Use & Ecology, Transport. The most and least important were consistent, but respondents moved Health & Well-being down from second to fifth and Land Use & Ecology down from third to sixth, whilst Materials moved up from fifth to second. This demonstrates those involved (Architects, Quantity Surveyors and Housing Authorities) did not place the same relative importance on sustainability factors when designing as a building as a given assessment tool suggests they should, despite the UK government policy at the time requiring all such projects to achieve a "very good" rating.

Harmonisation of assessment tools:

Since 2005, CEN/TC 350 has worked on an internationally harmonised approach in the assessment of sustainable buildings. They have produced BS EN 15643, the aim of which is to *"enable comparability on the result of assessment"* and *"do*[es] *not provide valuation methods and do*[es] *not set levels, classes or benchmarks for any measure of performance"* (BSI, 2010). In doing this the results of an assessment are to be expressed in detail and without aggregation, for each of the indicator defined in prEN 15643-2, -3 and -4 (environment, social, and economic). BS EN 15643 gives no practical guidance on evaluation, stating *"valuation systems and related calculation rules for aggregation of indicators may be defined in the national standards or schemes"* (BSI, 2010). Consequently, within calculations carried out by different assessment tools, different weightings can be applied to various indicators. The standards also foresee not all assessment tools will consider all defined indicators, stating if a particular assessment method does not value a particular indicator this is to be shown as *"indicator not assessed"* (BSI, 2010). Therefore despite a move towards harmonisation of assessment tools, this is harmonisation of what should ideally be assessed, but not of what must be, or how it is to be or of what weightings should be applied. This is evidenced by the BRE, in New Construction, Non-Domestic Buildings, they (2011) state BREEAM incorporates *"the majority of environmental"*, *"a significant number of the social"* and *"some [of the] economic"* measures proposed by CEN/TC350.

In research to develop a new sustainability assessment tool for housing, Mateus and Braganca (2011) examined the work conducted by CEN/TC 350. While recognising this work as important progress towards standardization, they did not use it as a basis for their new tool electing instead to use the existing SBTool, which having been developed as an international tool allows users in different countries to reflect different priorities. Mateus and Braganca argue assessment tools, their indicators and their weightings must reflect the region in which the building is placed, identifying inflexible weighting as one of the most common weaknesses of existing tools. Ali and Al Nsairt's (2009) work developing a new tool for sustainable building assessment also emphasised the need for tools to reflect local cultural and environmental conditions. Both these works developing new assessment tools have been conducted since CEN /TC 350 commenced their work and since a great deal of their initial work was published. Yet in both instances those developing new tools concluded both the individual indicators and also the weighting to be placed on those individual indicators will be differ from region to region and therefore tools cannot be fully harmonised internationally. On the basis of this it seems reasonable to assume a variety of assessment tools will continue to be available for some time.

In summary, the literature shows despite moves towards harmonisation of what assessment tools should measure, the existing tools take into consideration different issues, measure them in relation to different criteria and place different weightings on those criteria in their assessment calculation and there is evidence to suggest this will remain so. The literature also shows that even when designers and clients are required to design buildings to achieve certain ratings as measured by a certain tool, it cannot be assumed they will place the same weighting on the individual criteria as is place by the that tool. The aim of this research is to establish the factors of sustainability relevant to the evaluation of sustainable buildings and to establish the actual significance placed on individual factors of sustainability in buildings in practice.

RESEARCH DESIGN

In carrying out this pilot study, a structured questionnaire survey of sustainability factors in building design was administered to building design team members. In order to establish the factors designers take into account when designing a sustainable building a number of areas of pre-existing research were examined, namely a) existing assessment and rating tools and the criteria they consider; b) published critical reviews of these tools; c) research into the constituent elements of sustainable buildings and d) research into sustainable development and sustainability generally. In completing this, the work listed in Table 2 was reviewed and to ensure the list was holistic and comprehensive each criteria identified was treated equally, regardless of whether it appeared in all documents or just one.

Table 2: Identifying factors of sustainable buildings

No	Author(s)	Date	Document Title
1	EcoHomes	2006	Ecohomes 2006 – The environmental rating for homes. The Guidance – 2006 / Issue 1.2
2	Code for Sustainable Homes	2010	Code of Sustainable Homes, Technical Guide November 2010
3	BREEAM (Non Domestic Buildings)	2011	BREEAM New Construction Non-Domestic Buildings. Technical Manual SD5073-2.0:2011
4	LEED	2009	LEED 2009 New Construction and Major Renovations with alternative compliance paths for projects outside the U.S.
5	SKA	2011	Ska rating. Good practice measures for offices, Version 1.1
6	SBTool	2012	SBTool Generic 06 Feb 12
7	SPeAR	2012	www.arup.com/Projects/SPeAR.aspx
8	ISO 15392	2008	Sustainability in building construction – General principles
9	BE EN 15643	2010 & 2011	Sustainability of construction works – Sustainability assessment of buildings. Parts 1 – 4
10	GreenStar	2012	www.gbca.org.au/green-star/technical-clarification-cir-ruling/documentation-guidelines/2086.htm Office v3; Education v1; Retail Centre v1
11	Bartlett & Guthrie	2005	Guides to sustainable built-environment developments
12	DETR	2000	Building a Better Quality of Life. A Strategy for more Sustainable Construction
13	SECBE	2009	An Introductory Guide to Best Practice in Construction
14	Presley & Meade	2010	Benchmarking for sustainability: an application to the sustainable construction industry
15	National Audits Office	2007	Building for the future: Sustainable construction and refurbishment on the government estate
16	Sinou & Kyvelou	2006	Present and future of building performance assessment tools
17	Braganca, Mateus & Koukkari	2010	Building Sustainability Assessment
18	Mateus & Braganca	2011	Sustainable assessment and rating of buildings: Developing the methodology SBTool PT-H
19	HM Government	2008	Strategy for sustainable construction
20	Kates, Parris & Leiserowitz	2005	What is Sustainable Development? Goals, Indicators, Values and Practice.
21	United Nations	2007	Indicators of Sustainable Development: Guidelines and

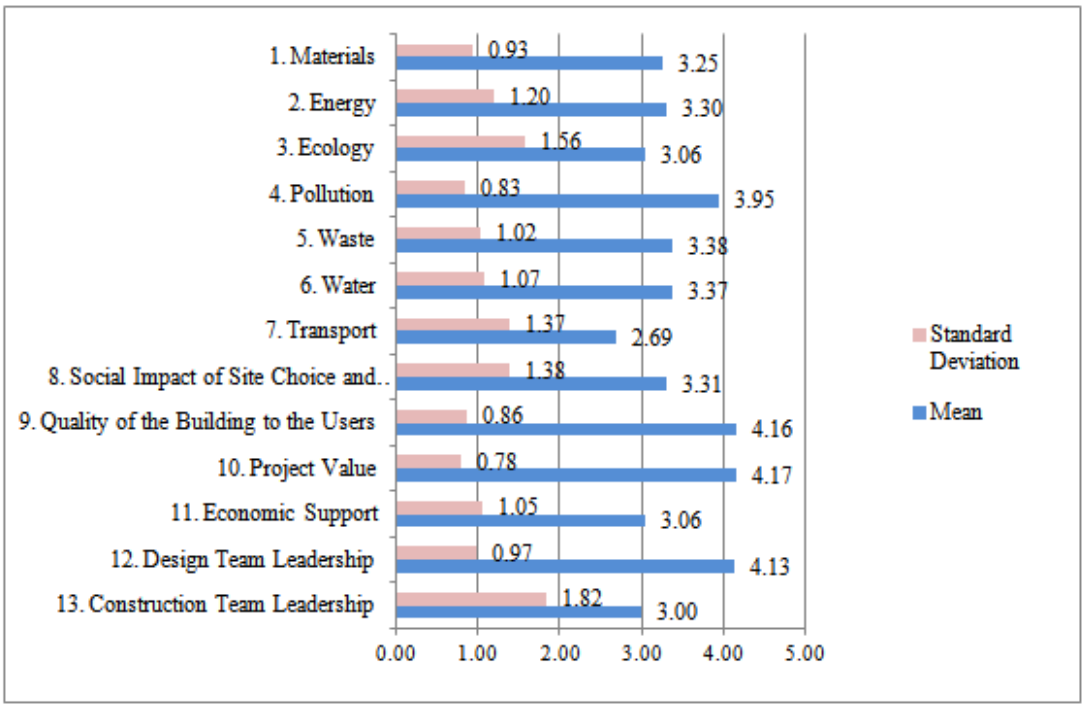
			Methodologies 3rd ed.
22	United Nations	2008	Measuring Sustainable Development
23	DEFRA	2010	Measuring progress. Sustainable development indicators 2010
24	Karl & Brunner	2009	Tools for measuring progress towards sustainable neighbourhood environments

This list of criteria was then organised into common themes, initially using theme headings frequently used by existing tools (see Table 1), then adapted and expanded as necessary to best reflect all factors identified, resulting in thirteen themes (see Fig. 1). Within these themes sixty-four factors were identified reflecting the essence of the individual criteria. Respondents were requested to score on a Likert type scale the level of importance they have placed on the identified sustainability factors in building design. The questionnaires were directed to designers from a range of disciplines with experience and expertise in sustainable buildings.

DATA ANALYSIS

As the research is currently at Pilot Study stage the number of responses was limited to twelve designers (five architects, three project managers, three building services engineers and one sustainability consultant); therefore data analysis is statistically limited at this stage. Each designer was asked to select a sustainable building of their experience and identify the level of emphasis placed on each particular factors making up each theme for their chosen building. In addition, information pertaining to potential independent variables was sought. The Likert scale had six points ranging from *"no emphasis"* to *"very high emphasis"* which were given values of 0 - 5.

Fig. 1: Emphasis place on each theme by Designers.

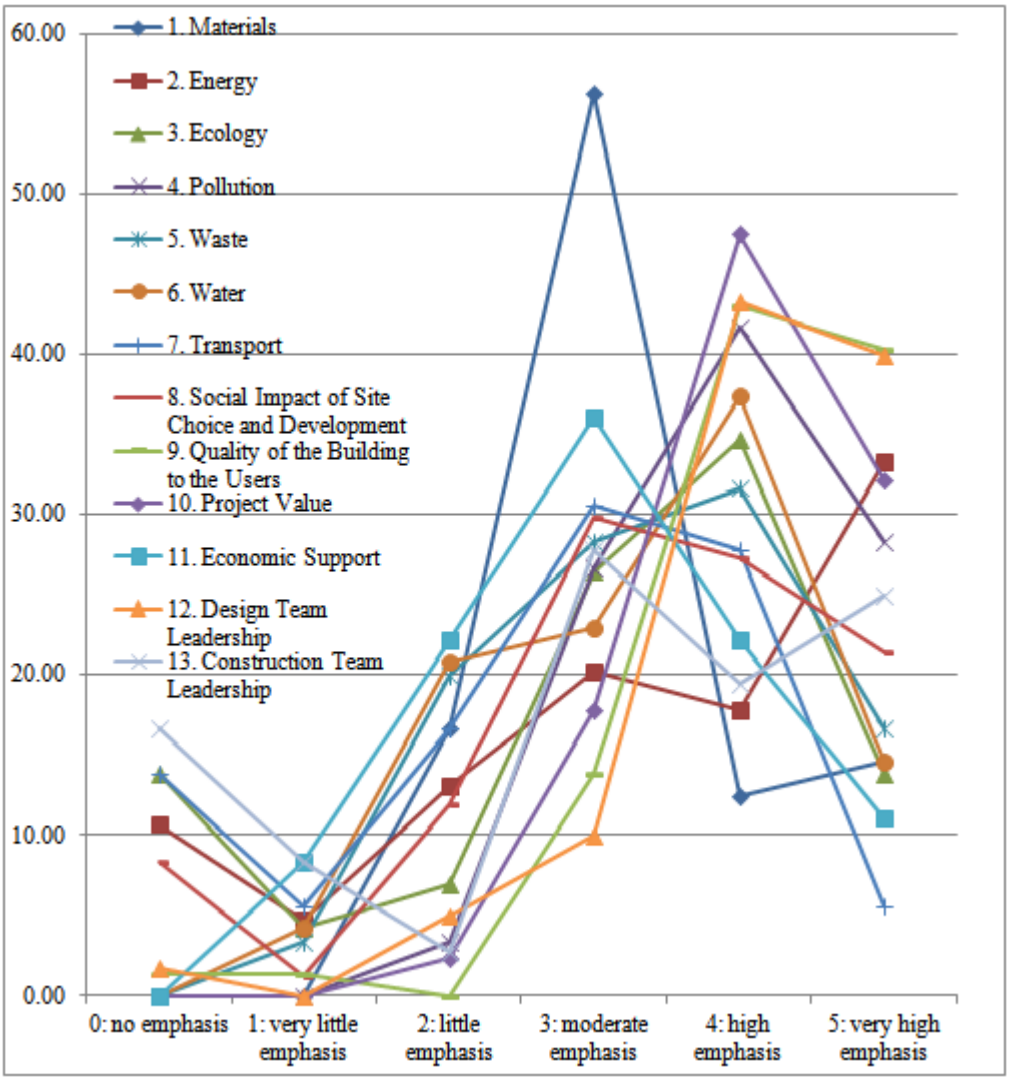


When the data was analysed for each of the thirteen themes, the means ranged from a low of 2.69 for *Transport* to a high of 4.17 for both *Project Value* and *Quality of the Building to the Users* (see Fig. 1). The majority (nine) of themes had a mean between 3 and 4, indicating designers placed between moderate and high emphasis on these

themes. Having examined the means of the thirteen themes, the means of each of the sixty-four factors making up those themes were addressed. In this instance the range was wider, the lowest mean significance placed on a factor by designers being 1.42 and the highest being 4.83 (both of these factors occur within the theme *Energy*).

The standard deviations of the themes varies significantly suggesting significant variation within these limited responses, also evidenced by the data shown in Fig. 2 and Table 3 (indicating the level of emphasis placed on each theme by the designers , as a percentage of all designers).

Fig. 2: Level of emphasis place on Theme by Designers, as percentage of all Designers



It can be seen from Table 3 that even for themes with high means (e.g. *Quality of the Building to the User*), some respondents placed little or no emphasis on the associated factors and similarly, for themes with low means (e.g. *Transport*), some respondents placed a very high emphasis on criteria within the theme. Of the thirteen themes, seven have responses at both the highest and lowest point in the scale; all thirteen have responses of the highest score. This range in responses is also evident in the data on the sixty-four individual factors making up each theme. On the six points Likert scale 29% of the criteria registered response on all six points, a further 14% registered on five and a further 31% registered on three of the six. 94% of the criteria had at least

one respondent who place *"very high emphasis"* on it; 33% had at least one respondent who placed *"no emphasis"* on it.

Table 3: Level of emphasis place on Theme by Designers, as percentage of all Designers

	Level of Emphasis					
	None	Very Little	Little	Moderate	High	Very High
1. Materials	0.00	0.00	16.67	56.25	12.50	14.58
2. Energy	10.71	4.76	13.10	20.24	17.86	33.33
3. Ecology	13.89	4.17	6.94	26.39	34.72	13.89
4. Pollution	0.00	0.00	3.33	26.67	41.67	28.33
5. Waste	0.00	3.33	20.00	28.33	31.67	16.67
6. Water	0.00	4.17	20.83	22.92	37.5	14.58
7. Transport	13.89	5.56	16.67	30.56	27.78	5.56
8. Social Impact of Site Choice and Development	8.33	1.19	11.90	29.76	27.38	21.43
9. Quality of the Building to the Users	1.39	1.39	0.00	13.89	43.06	40.28
10. Project Value	0.00	0.00	2.38	17.86	47.62	32.14
11. Economic Support	0.00	8.33	22.22	36.11	22.22	11.11
12. Design Team Leadership	1.67	0.00	5.00	10.00	43.33	40.00
13. Construction Team Leadership	16.67	8.33	2.78	27.78	19.44	25.00
Total	5.12	3.17	10.91	26.67	31.29	22.84

This range of emphasis is also shown in an analysis of the modes of the factors. While many are strong (50%+ of respondents agree on the level of emphasis placed on a given criteria) some are divided; multiple modes occur fifteen times and of these, non-sequential modes occur five time; e. g. as many indicated "minimising the quantity of potable water used during construction" is given *"little emphasis",* as indicated it is given *"high emphasis"*.

The standard deviation, the range and the visual information presented in Fig. 2 suggest the data pertaining to the themes does not have a normal distribution. This was examined statistically by the calculation of both Skewness and Kurtosis statistics and completing the Shapior-Wilk test (Table 4) although the reliability of these tests is limited due to the small sample size. Five themes have a skewness value of less than +/- 0.5 suggesting for them the distribution is symmetrical to moderately skewed; for the remainder the data is skewness and mostly negatively.

Five themes also have a kurtosis value of less than +/- 0.5 suggesting for them the distribution is normal; for the remainder negative figures indicate a flat curve rather than a bell curve. No theme has a significant value of Shapiro-Wilk greater than 0.05 implying no theme has a normal distribution, including *Project Value*, the only theme with both a skewness value and a kurtosis value of less than + / - 0.5. Similiar results are found when the sixty-four factors are examined in the same way; six (9%) have both a skewness and kurtosis value of less than +/- 0.5 and a Shapiro-Wilk significant value of greater than 0.05. Consequently, if similar results are found in the main study,

the majority of the data will be examined using non-parametric; if parametric tests are to be conducted data transformation will be first required.

Table 4: Distribution

Theme	Skewness	Kurtosis	Shapiro-Wilk Sig.
1. Materials	0.71	**-0.14**	0.000
2. Energy	-0.69	-0.62	0.000
3. Ecology	-0.86	**-0.27**	0.000
4. Pollution	**-0.27**	-0.71	0.000
5. Waste	**-0.18**	-0.77	0.000
6. Water	**-0.31**	-0.74	0.001
7. Transport	-0.62	**-0.46**	0.002
8. Social Impact of Site Choice and Development	-0.87	**0.37**	0.000
9. Quality of the Building to the Users	-1.83	5.60	0.000
10. Project Value	**-0.49**	**-0.26**	0.000
11. Economic Support	**0.02**	-0.54	0.013
12. Design Team Leadership	-1.72	4.45	0.000
13. Construction Team Leadership	-0.59	-0.92	0.000

DISCUSSION AND CONCLUSION

Given the factors and themes addressed in the research were identified through an examination of research carried out by experts in this field, and given the respondents were each reflecting actual behaviour in respect of buildings which achieved high sustainability rating, albeit assessed using different methods, it could be anticipated the data would show a) significant levels of emphasis being placed on each criteria and b) relatively homogeneous results.

The calculation of the means for themes showed all to be above 2.5, the mid-point of the range; in all instances an above average emphasis is place on the theme and for some the mean shows a high level of emphasis being placed on the theme. The initial analysis of the individual factors shows a more varied picture, with means for some factors of below 2.5. This will be explored in more detail in further research. Despite the relatively high means, there are a number of instances where "*no*" to "*little*" emphasis is placed on some aspects of sustainability during the design of sustainable buildings. The data shows there are fewer instance of "*very little"* emphasis, than instances of "*no"* emphasis suggesting either aspects are not considered at all or are given at least a certain level of attention. To establish whether or not this is a conscious decision made by the design team will require further investigation.

Whilst the data shows an above average emphasis is placed on all themes there is little consensus beyond this; the data shows considerable variation in the numbers placing "*moderate*", "*high*" and "*very high*" emphasis on the themes, with the exception of *Materials*, where the majority agreed "*moderate*" emphasis should be placed on that theme. The literature suggested rating and assessment tools overlooked economic and social aspects in favour of environmental aspects. While this may be true of the tools, the data indicates the designers place equal if not higher emphasis on economic and social aspects when compared to environmental aspects.

The results were not expected to have a standard distribution; positive skewness and positive kurtosis values indicating most responses at the high end was anticipated. While this was indicated by the means and the ranges, the results of the distribution tests showed significant level of negative skewness and negative kurtosis values indicating sizable amounts of data at the low emphasis end of the scale. This may be due to the poor reliability of these tests when applied to small sample sizes and this will be investigated further when a large sample size is available. Many potential external variable influencing these results exist, such as differences between the respondents and the projects they are reflecting. The effect of these variables could not be analysed in a meaningful way at this stage given the sample size, however they will be looked at in detail in a larger future study.

Upon completion of that future study it is anticipated a greater understanding of the emphasis placed on the individual factors of sustainability in buildings by designers will be achieved. This will be useful to clients in commissioning future buildings. It is also anticipated the factors which influence this emphasis, and the manner by which they do so, will be understood. This could then be used in the control and management of these factors.

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INTEGRATING RESPONSIBLE SOURCING IN THE CONSTRUCTION SUPPLY CHAIN

James Upstill-Goddard[1], Jacqueline Glass[2], Andrew R. J. Dainty[2] and Ian Nicholson[3]

1 Centre for Innovative and Collaborative Engineering (CICE), School of Civil and Building Engineering, Loughborough University, Loughborough, Leicestershire, LE11 3TU

2 School of Civil and Building Engineering, Loughborough University, Loughborough, Leicestershire, LE11 3TU

3 Responsible Solutions Ltd, Unit 12, The Office Village, North Road, Loughborough, Leicestershire, LE11 1QJ

Certification to industry standards is the most tangible means for a company to prove its commitment to sustainability issues. The construction sector is of particular interest, due to the huge impacts of its operations. Many companies operating within the sector have implemented environmental management systems in line with ISO 14001 although recently the industry has become focused on the concept of responsible sourcing (RS); the ethical management of sustainability issues associated with products and materials in the construction supply chain. An adoption of this concept can be evidenced by certification to BES 6001, the framework standard for responsible sourcing. Despite this, the number of accreditations is relatively low and knowledge and awareness of RS is still limited. This review paper explores the reasons behind the under-emphasis of RS within the industry, despite a continually increasing knowledge of the Corporate Social Responsibility (CSR) agenda. Currently, opinion is divided on whether CSR and RS represent a form of corporate philanthropy or a channel by which revenue can be increased. The issue is further complicated by the presence of engineered-to-order (ETO) products, which creates barriers to the enactment of RS and CSR principles. These are explored and possible explanations for their absence from supply chain management issues offered. Furthermore, the potential to extend the interpretation and application of the ISO 14001 framework to demonstrate the consideration of these principles is presented. Other certification schemes of particular significance to the industry and the problems for companies to achieve certification are also discussed; in particular, access to financial and other resources are identified as a key barrier to certification, especially for SMEs. Recommendations are made for future research that might enable SMEs to achieve sustainability certification more readily and to help the industry embrace the concept of RS more broadly.

Keywords: corporate social responsibility, engineer-to-order, responsible sourcing, supply chain, sustainability certification.

[1] J.D.Upstill-Goddard@lboro.ac.uk

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INTRODUCTION

Construction has a significant impact upon the environment, economy and society, due to the large impacts of its operations and its consumption of vast amount of resources and energy (Czarnecki *et al.* 2010; Dixit *et al.* 2010; Sev, 2009). However, recent studies have indicated that in terms of being sustainability driven, the sector is somewhat lagging behind other sectors (Glass, 2011). In addition to this, the industry has a major impact upon society across the life cycle of its operations (Murray and Dainty, 2009), accounting for around half of all greenhouse gas (GHG) emissions (Greenwood *et al.* 2011). It is clear that, for the sector as a whole, there is scope for improvement and by aiming to work towards international standards, organisations can begin to manage their sustainability performance more effectively and hence observe reduced impacts. There does however, appear to be no clear definition of what constitutes sustainable construction or any consensus regarding sustainability measurement, despite a growing field of new technologies which aim to minimise negative environmental impacts (Wallhagen and Glaumann, 2011). Certification to industry standards is the most tangible means for a company to demonstrate its commitment to sustainability issues. The concept of 'sustainable development' has been increasingly viewed as being at the forefront of business agenda, and global acceptance of this term has resulted in a heavy focus, both from industry and policy makers, to address the issue of depleting resources and climate change. It has frequently become the focus of standardisation (Schwartz and Tilling, 2009) and hence a number of national and international certification bodies now exist, and widespread adoption of the increasing number of published standards has been observed.

This paper presents a literature synthesis which clarifies the current position of the industry, the effectiveness of implementation of sustainability certification and the challenges confronting the sector in moving forward. A number of issues are explored to unravel these challenges; in particular the corporate social responsibility (CSR) agenda is considered in tandem with responsible sourcing (RS), and the effect that engineered-to-order products have upon it. However, RS is neither mandatory nor embraced outside of the UK (Glass, 2012), so the potential flexibility of ISO 14001 (BSI, 2004) standard for environmental management is also examined to determine whether this might offer an alternative route for RS implementation to yield greater adoption of the concept. Sources from academic research, industry and advisory bodies and government agencies are drawn upon to indicate the challenges in obtaining certification, particularly for those companies classed as small and medium sized enterprises (SMEs). The conclusion is that the answers may be found in research which examines the interfaces between current standards, supply chain behaviours and societal expectations on construction.

SUSTAINABILITY AND CSR PRACTICES IN CONSTRUCTION

CSR is key to both international and sustainable development and although there are an increasing number of publications on the subject from a variety of different perspectives, the lack of a commonly accepted definition for CSR is still apparent (Aßlander, 2011). Indeed, given the social, economic and environmental impacts of the construction industry and its significance as an employer through the provision of work, it has been argued that that it is the area where perhaps the greatest level of attention should be devoted (Murray and Dainty, 2009). Many large firms, including those within the construction industry, have begun to compile annual reports on their

sustainability performance (Glass, 2012), but the extent to which these address the three aspects of sustainability however, has been questioned. For example, Lozano and Huisingh (2011) find that in a sample of reports each aspect of sustainability is being addressed in a compartmentalised way. They argue that a more holistic approach should be adopted and that this should be integrated into corporate decision making. Similarly, Manetti (2011) finds that stakeholders are not engaged effectively in the decision making process of organisations, despite a number of international standards and reporting guidelines prescribing this stakeholder engagement as imperative (e.g. ISO 26000; BSI, 2010). Currently, debates on CSR see it as either a form of corporate philanthropy, or as a revenue opportunity, but much of the argument for CSR centres on morality and legitimacy; businesses should engage with it as it is seen as 'the right thing to do'. Yet Green (2009) states that neither profitability nor economic performance can be linked conclusively to CSR, which begs the question: why do organisations pursue with CSR policies when they do not appear to affect performance in a positive way? A fundamentally similar problem can be identified in the literature around environmental management; Heras-Saizarbitoria *et al.* (2011) find no evidence to suggest that financial performance is linked to EMS certification, but there is sufficient argument to suggest that the widespread uptake of the ISO 14001 (BSI, 2004) standard occurred due to a common belief that it was morally correct to take a proactive approach to environmental issues. However, it is also true that the expectation of customers and employees is that organisations will possess CSR policies. Hence, there is potential value in considering the role of standards (i.e. certification and management system standards), both established and emergent as a novel lens through which CSR in construction can be viewed.

AN INCOMPLETE TRIO OF SUSTAINABILITY STANDARDS

Industrial sectors began to realise the impact of their operations in the early 1990s; the response was the development of a number of environmental assessment tools and certification schemes, such as the International ISO 14001 (BSI, 2004) standard for environmental management. ISO 14001 (BSI, 2004) has, since its inception in 1996, become one of the most widely used certification standards, with close to a quarter of a million certifications globally (Marsden, 2011). Indeed this widespread uptake is indicative of a general consensus among global businesses that an ISO 14001 (BSI, 2004) certification is particularly coveted; the generic nature of its structure renders it applicable to any organisation. ISO 14001 (BSI, 2004) is recognised as a robust standard for proving environmental pro-activity; its core aim is to ensure that the EMS is integrated with business goals, but Curkovic and Sroufe (2011) also note that should an organisation be convicted of an environmental non-compliance, proof that an EMS was in place at the time of the incident can lead to reduced penalties. So, it could be argued that such an approach provides an 'insurance policy' for that organisation, but can it do more?

An environmental management system (EMS) compliant with ISO 14001 (BSI, 2004) makes up one third, along with ISO 9001, the quality management system standard and OHSAS 18001, the occupational health and safety standard, of a trio of sustainability standards that are now widely required, strived for and legitmised in industry. For many years, certification to these three standards was generally viewed as adopting a sustainable approach to business, with the framework provided by EMS implementation seen as taking a proactive attitude to improving environmental performance. Importantly, ISO 14001 (BSI, 2004) does not cover all aspects of sustainability, so in isolation does not completely address sustainability as a concept,

but has potential for extending to consider social issues. The framework enables an organisation to reduce its negative impact on the environment by ensuring compliance with all relevant legislation, minimising pollution risks and committing to continually improve environmental performance (NB: there is considerable overlap between ISO 14001 and section 3.4 of BES 6001 (BRE, 2009) which also covers a number of environmental requirements required ISO 14001 (BSI, 2004), such as emissions of greenhouse gases, use of resources, and waste management among others). However, it is the consideration of social issues which appears to be missing from both ISO 14001 and the other standards in the aforementioned 'trio'. This gap is clear to see; Henriques (2012) explains that, despite its not being a certification or a management system standard, in a bid to demonstrate social responsibility, many companies are claiming compliance with the recently created standard, ISO 26000 (BSI, 2010), even though it is not possible to do so. A recent focus upon ethical and social issues, accentuated by media interest in a number of high profile cases, has certainly caused organisations to be more scrupulous regarding transparency of their operations and traceability of their products and services, particularly for those operating within construction. Although OHSAS 18001 covers some social attributes, there is a notable absence of issues such as fair labour standards and working conditions (outside of ISO 26000), and industry has begun to require that this subject area is addressed. For instance, within responsible sourcing (RS), certification to a framework standard; BES 6001 (BRE, 2009), developed by BRE Global, can prove traceability and transparency in a product supply chain, demonstrate a proactive approach to sustainability and provide a means for a company to enhance its reputation (Robinson *et al.* 2011), as discussed in the next section.

RESPONSIBLE SOURCING: FIVE PROBLEMS

Good corporate citizenship is of significant benefit to an organisation's reputation, which itself will act to increase turnover (Green, 2009). From a supply chain management perspective, engaging in CSR and certification to standards has become particularly important, as demand for supplier traceability information has increased. This is particularly true of the construction sector, where many materials are imported from regions where corruption and poor working conditions and standards are still widespread. Responsible Sourcing (RS) concerns the management of sustainability issues within the supply chain, often considering ethical issues in detail (Glass *et al.* 2011) and has become a recent focus due to the published government target of 25% of all construction products to be sourced from RS schemes by 2012 (HM Government, 2008). Moreover, it is likely however that in future years, increasing numbers of building owners will demand RS certification in order to improve their confidence that their construction materials have been sourced with low ethical or legality risks (Glass, 2012). This can be linked to the CSR debate concerning the 'right thing to do' and given the number of high profile cases exposing large companies for using suppliers employing child labour and poor working practices, it seems rather apparent that adopting the RS framework set out in BES 6001 (BRE, 2009) should alleviate such fears and act as an additional method of risk-mitigation. RS thus appears to hold many benefits for organisations, yet the relatively low uptake of BES 6001 (BRE, 2009) is suggestive of the fact that there are potentially a number of issues with the standard.

First, RS has been somewhat under-emphasised and there has been very little research into RS as a concept; the absence of a focused research agenda has resulted in very little guidance for those operating within the sector and so evidence to suggest that

this relatively unchartered territory has any benefits is scarce. At present, there is a developing body of research focusing explicitly on RS and its reception within the industry. The Action Programme for Responsible Sourcing (APRES) network (see Glass *et al.* 2011) is a research council funded project which aims to develop a knowledge base on RS and create new research ideas that will provide the construction sector with guidance on meeting both government and industry targets.

Secondly, as a result, many industry professionals, although aware of it, are yet to become familiar with the concept. Clearly, there is a real need to develop knowledge and awareness in this subject. Given that the target year has now been reached and widely varying ideas of what RS actually is still remain, it seems unlikely that this target will be met. This is caused by the lack of purchase of RS within the industry, which has led to a poor level of awareness; further exacerbated by the rather sporadic research and education on the subject. Glass *et al.* (2012) report that 94% of respondents to a survey felt that further publicity and awareness raising on RS was required. Awareness of the importance of RS is a prerequisite to adoption of the concept and hence certification to BES 6001 (BRE, 2009). Without this, construction companies are unlikely to engage with a concept that will just appear at the outset to be a rather costly and time-consuming process.

Thirdly, corporate decisions of whether to engage with RS are also influenced to some extent by the perceived risk associated within the supply chain; CSR is seen by many as a risk-mitigation strategy to offset the likelihood of customers boycotting products (Green, 2009). However, companies whose products have a low risk of negative exposure through the supply chain are arguably less likely to engage with the concept than those whose products are sourced from countries where there is a poor record of fair working conditions and corruption, for example. All this is undoubtedly true of a large multi-national corporation, who are often much more focused in the media spotlight than SMEs, which brings us to the fourth problem, that of asymmetry. This works the other way for an SME; the financial and other resources that are required to gain certification may be perceived as taking a large risk, as it is likely that this strain upon staff resources may result in diminished attention being given to other work. Such resource issues are likely to be the main barriers to take up of the standard for SMEs. Results of a recent survey (Glass *et al.* 2012) indicate that in addition to the cost associated with certification to BES 6001 (BRE, 2009), a lack of interest and understanding from clients and customers forms a major barrier to its uptake, creating participation asymmetry.

Finally, there is a problem of going 'beyond philanthropy'. As a moral issue, exploitation of child labour, poor working conditions and corruption are deemed as problems that are important to tackle. However, it is rather alarming that the results of a recent survey (Glass *et al.* 2012) should suggest that moral concern only extends as far philanthropic values, and does not hold significant influence within the business. Furthermore, it could be argued that at the organisational level, idealised notions of how to enact CSR will be very difficult to realise in practice - for this reason, issues such as RS are commonly relegated to a secondary priority until they are demanded by clients.

THE ISSUE OF ENGINEERED TO ORDER PRODUCTS

A number of problems have been outlined which create barriers to the uptake of RS as a mechanism to enact CSR in construction. However, adoption of RS is further complicated by the presence of engineer-to-order (ETO) products, which are rather

noticeably absent from supply chain management debates, so here we consider ETOs in greater detail. Similarly to RS, there is a great deal of confusion and uncertainty surrounding the definition and strategy for the ETO sector (Gosling and Naim, 2009). The ETO supply chain is typically regarded as one where the decoupling point is located at the design-stage (Gosling and Naim, 2009). It is particularly relevant to this debate, as it tends to be associated with large scale projects in sectors such as construction. It is considered as a complex and time-consuming process due to the number of stages that must be completed after the product design stage, and often there is a necessity to source suppliers to co-develop the product (Amrani *et al.* 2010). Product designers are often under pressure to develop a broad range of design solutions to address customer-specific requirements, and as these variants tend to be individually developed on a project-to-project basis (Brière-Côté *et al.* 2009) they become a complex issue to manage. Finally, the high levels of customisation associated with ETO products leads to increased costs, higher risks and long lead times (Hicks *et al.* 2000) and Cheng *et al.* (2010) indicate the complex nature of construction supply chains and that they are typically made up of a wide range of participants. Indeed, such complexities are identified in Gosling and Naim (2009) as a root cause for the relative lack of research attention to ETO supply chains, when compared with those in the high volume, standardised supply chains, such as that of the make-to-stock (MTS) chain. As customers can specify customised options within ETO product lines, there are potentially a number of different sources that such custom products could be sourced which complicates the application of an RS framework, such as that of BES 6001 (BRE, 2009). It is thus significant that all the products that have been certified under BES 6001 (BRE, 2009) to date are from MTS supply chains; none are from ETOs which again indicates a further problem of asymmetry.

DISCUSSION

Robinson *et al.* (2011) suggest that engaging in sustainable practices is no longer viewed as complementary to a firm's corporate image or activities, but is seen as an increasingly integral part of doing business. Indeed, this supports the premise that CSR provides an increased revenue opportunity for organisations. In addition to this however, it is also true that the wider social good caused by the actions of an organisation can only ever be incidental to the interest in making profit, as companies are legally bound to maximise profits for shareholders. Two major points of departure have emerged thus far, which are set out here in the context of the SME.

First, in the case of SMEs, raising the initial financial resources to gain certification often represent a significant proportion of an SME's turnover and hence becomes rather a significant barrier. As a result, the number of SME certifications to key standards remains very low and those who do so are motivated because they feel pressure to do so from companies higher up the supply chain; they feel that financial benefits will be gained indirectly through maintaining the business links with larger corporations further up the supply chain. Interestingly, both RS and ETO supply chains have been found to be subjects with a great deal of uncertainty and neither has had adequate exposure and research. It is important to determine what creates supply chain buy-in in MTS and ETO scenarios; with regard to RS, an organisation can only be as 'responsible' as its weakest link in the supply chain. This is a particularly difficult trajectory for SMEs operating within the ETO sector; such is the variation of projects that they engage in and therefore variety of constituent materials.

Secondly, an extension of ISO 14001 (BSI, 2004) could render BES 6001 certification more straightforward; compartmentalisation of the aspects of sustainability is an issue that must be addressed and broadening such tools is the most appropriate mechanism to address this. This may be particularly relevant to an SME due to the resource issues they face coupled with reliance on informal procedures, rather than by adoption of a formal management system (Marsden, 2011). This is an example of a more social barrier; accreditation and quasi-accreditation are only part of the issue and may not overcome inertia in this area (e.g. a lack of adoption of such standards will not be completely resolved by making certification a more cost-effective process). Glass (2012) notes some fundamental problems with broadening the application of such tools to consider a more holistic approach, nevertheless, further research should be conducted to explore such opportunities (particularly given the informal adoption of ISO 26000 in practice).

CONCLUSION

Although the corporate social responsibility (CSR) agenda has been adopted in construction, the adoption of the RS framework standard BES 6001 has been very low, particularly among small and medium sized firms (SMEs), despite there being strong links between CSR and RS. Responsible sourcing is a particularly marginalised issue within the wider CSR agenda; it is yet to be embraced as a concept, thus it becomes a particularly interesting and important research topic. If improving image is becoming integral to the way in which business operates, then there is a particularly strong case to be had in engaging with the supply chain and integrating RS into common CSR practices.

Engineer-to-order (ETO) products have been presented as being of particular relevance to this debate, particularly as the construction industry tends to deal with a high proportion of ETO products. None of the BES 6001 (BRE, 2009) certified products fall into the ETO category, further accentuating the need for research, particularly given that the construction industry is becoming increasingly focused upon ETOs.

SMEs struggle to gain certification to standards and overall, there appears to be a reluctance of the construction industry to embrace and enact CSR for anything other than commercial reasons. This makes it problematic for standards such as BES 6001 (BRE, 2009) to have any real purchase within the industry. This, coupled with its apparent marginalisation has resulted in a poor rate of uptake.

Most fundamentally perhaps however, is to improve the current level of awareness of RS as this can almost be considered a prerequisite for adoption of RS as a concept. Extending the ISO 14001 (BSI, 2004) framework may be a solution to this, particularly for SMEs, as 'combining' these standards may enable easier certification for SMEs and may render certification more attractive.

We maintain that a new research nexus can be developed at the interface of current sustainability standards, emergent supply chain (moral) behaviours and broader, societal expectations on construction; this could lead to fascinating new insights for CSR and supply chain scholars.

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LOWERING CO_2 EMISSIONS IN THE NEW BUILD SOCIAL HOUSING SECTOR: A SPANISH CASE STUDY

Mark Downey[1]

School of Construction Management and Engineering, University of Reading, PO Box 219, Reading, RG6 6AW, UK

As part of a larger UK/Spanish comparative study, this research focuses on a new build social housing development in Spain, and examines the measures being adopted by those mandated to comply with the provincial planning laws as well as the relevant national building regulations which demand the inclusion of measures to lower CO_2 emission levels. Focusing on the socio-technical networks of the principal stakeholders involved, and utilising a multi-level perspective, the research aims to better understand how provincial planning and building regulation requirements are being met, both through fabric improvements and the use of low and zero carbon technologies. Emerging findings from the case study suggest the stakeholders involved in the delivery of social housing view the introduction of such technologies differently, and this interpretation may depend on their specific view of the technology being deployed and the role they perceive it to play within their working environment. Perceptions of the new technology and fabric upgrades demanded by the new regulations are generally positive, but there is disagreement regarding technological performance and misgivings regarding its introduction given the prevailing economic situation in Spain. Implications for practice may suggest better communication between suppliers and installers, as well as some additional technical support from the technology manufacturer to help bridge perceived performance shortcomings. For policy, given the difficulty encountered during the pilot study in identifying housing developments working to the CO_2 improvements mandated by the 2006 regulations, it may prove fruitful to tie future revisions of this legislation more closely to planning permission consents.

Keywords: carbon, housing, multi-level perspective, socio-technical networks, Spain.

INTRODUCTION

Low and zero carbon energy technologies for domestic use continue to be employed in a number of ways in new build housing (NHBC, 2012). The available low and zero carbon technology options for developers can range from community based schemes, which provide district heating for a number of homes, to individual energy generation on a home-by-home basis. However, concurrent with the development of these new technologies and their subsequent implementation are a number of innovative fabric performance improvements (NHBC Foundation, 2011; CTE, Technical Building Code 2009), as well as an emerging number of allowable solutions (Zero Carbon Hub - ZCH, 2011). This doctoral research seeks to better understand how housing

[1] m.downey@pgr.reading.ac.uk

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developers are meeting CO_2 emission targets specifically within the new build social housing sector using a case study methodology.

The Kyoto Protocol, which came into force in February 2005, set binding targets for thirty seven industrialised countries and the European Community for reducing greenhouse gas emissions (UNFCCC, 2010). These targets amount to an average 5% reduction against 1990 levels over the five year period 2008-2012. Additional market mechanisms agreed under the 2010 Cancún Accord and subsequently advanced at the Durban Climate Change Conference 2011, require industrialised countries to develop low carbon development plans and strategies, and assess how best to meet these, reporting their inventories annually (UNCCC, 2010; 2011).

It is against this low carbon agenda that European Union (EU) countries are committed to carbon dioxide reduction through EU directives which seek to achieve lower CO_2 emissions. The latest Energy Performance of Buildings Directive, 2010/31/EU (EPBD, 2010), has direct implications for the twenty seven nation states of the EU. This directive, now known as EPBD-2 (NHBC Foundation, 2011), follows consultation on the Recast of Energy Performance of Buildings Directive 2002/91/EC and attempts to clarify the targets for CO_2 reductions from buildings. EU member states are charged with fulfilling their obligations under directive EPBD-2 which seeks to achieve 'nearly zero energy buildings' (Article 9) in all new buildings by 2020. As the first EU country to make the introduction of renewable energy obligatory for all new dwellings (and major refurbishments) in 2006, Spain sought to utilise its solar resource and required all new dwellings to contribute between 30% to 70% of their hot water requirements from a solar energy source (CTE, 2006). The 30/70% variation depends on the geographical location of the dwellings and in which of the five climatic zones they fall (Fig 1), as well as the type of back-up energy used.

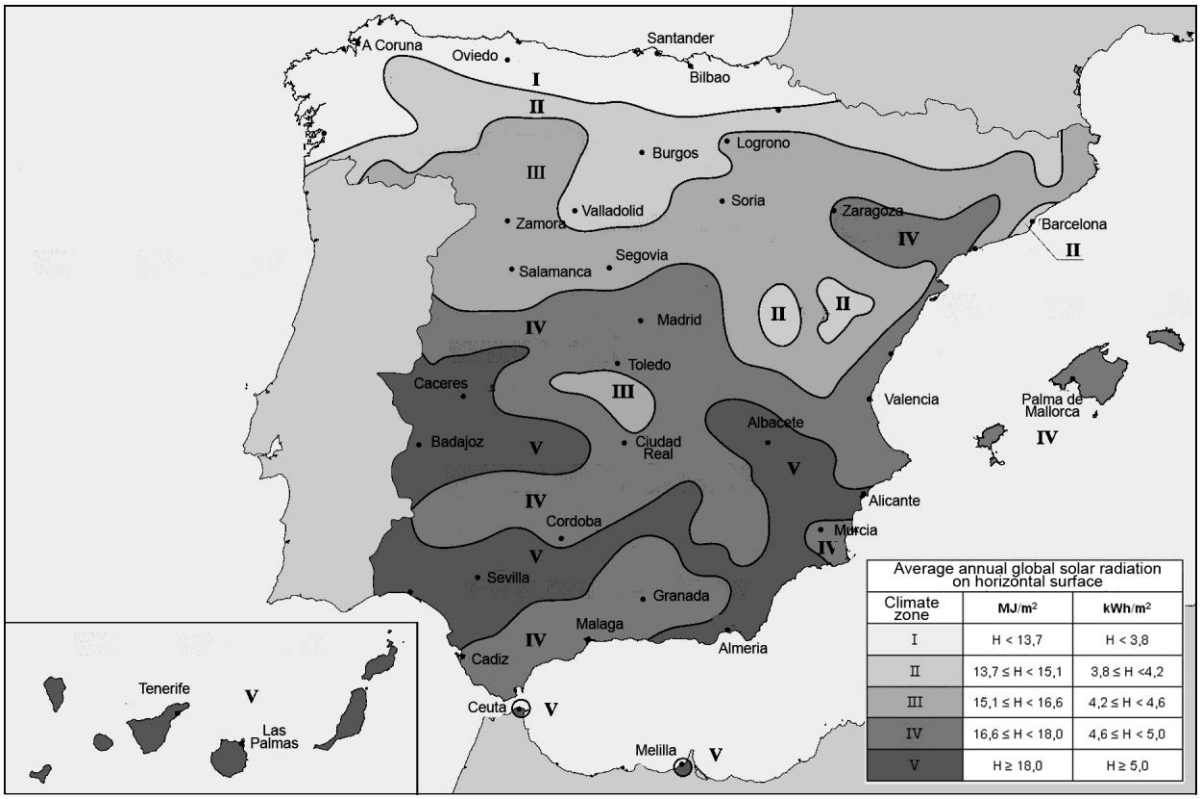

Fig 1 Map of Spanish climatic zones (CTE, 2006)

This case study was carried out in Andalucía (Zone V), which means the minimum solar hot water contribution from dwellings is 70% irrespective of the back-up energy system (oil, propane gas, natural gas or electricity). Although the 70% contribution is measured annually, there are a number of compliance stipulations which ensure there is a relatively even distribution of solar hot water production throughout the seasons (CTE, 2006).

The next section presents the case for this research and examines some of the drivers and difficulties in achieving low CO_2 emission housing. It includes a brief outline of the relevant legislation and the requirements of the Technical Building Code (CTE) relating to low carbon compliance in Spain. The methodological discussion covers the reasons for choosing the case study approach and gives the background to the case study, highlighting the data collection methods employed. The case study findings demonstrate how low and zero carbon technologies are being employed and include a diagrammatic representation of such deployment within this specific project. Finally, the discussion and conclusion section presents a summary of the findings and suggests how this research can be framed within the existing literature, highlighting its contribution within the Spanish context.

A CASE FOR IMPROVED UNDERSTANDING OF LOWERING CARBON EMISSION IN NEW BUILD SOCIAL HOUSING

European Union countries are obliged to meet demanding CO_2 reduction targets from buildings (UNCCC, 2010; 2011), and energy use from housing is estimated to account for approx 27% of all carbon emissions in the UK (DECC,2010), 20% in Spain (GBCE, 2011), and 25% of the overall emissions in Europe (EEA, 2011). Command and control regulation (Baldwin and Cave, 1999) through the introduction of the Spanish building codes (CTE, 2006), mandates the deployment of renewable energy technology for all new build housing. The introduction of this code ensured Spain was the first EU country to make the implementation of solar thermal energy obligatory in new and refurbished buildings. Along with the introduction of the government led Feed-in Tariff for photovoltaic installations in 2004, these policy incentives were intended to stimulate and consolidate supply chain integration, including job creation and investment (CNE, 2010). However, the results to date are inconclusive and Spain's initial gold rush has slowed considerably (Bloomberg, 2010; Heras-Saizarbitoria et al, 2011). In addition, the latest Renewable Energy Plan 2011-2020 (Plan de Energías Renovables 2011-2020) was introduced to provide a series of incentives for the production of solar thermal energy as well as additional methods of inspection and control throughout the various installation stages of the systems. This plan followed three consecutive years of contraction in the solar thermal sector (14% in 2009; 14% in 2010; and a forecast reduction of 28% for 2011) which largely reflects the significant downturn in the construction industry in general and the building of new dwellings in particular (Asociación Solar de la Industria Térmica, ASIT, 2012). However, despite this general contraction of solar thermal deployment in the construction industry, the 2006 building codes demand solar hot water provision in both private and social housing.

The Spanish social housing tenure is almost all owner occupied, with only a nascent renting sector (Hoekstra et al, 2009). The dwellings in the case study housing development were all social VPO registered (Viviendas de Protección Oficial -

Officially Protected Housing) from the general scheme category[2], and were all for sale, as opposed to being available for rent. This meant that their selling price was capped by the local authority (between 109.296E and 125.525E) dependent upon the m^2 of the dwelling. The right to housing is enshrined in the Spanish Constitution (Leal, 2004), and subsidised homeownership has been steered by a complex financial system in which both developers (through subsidies and soft-loans), and homeowners (through subsidies), received financial support from the government (Hoekstra, 2010). However, 'in the current context of decreasing house prices and decreasing housing production, such cross-subsidisation is not possible anymore' (Hoekstra et al, 2009 p137). Although social housing construction can account for anything between 20% and 50% of new developments (Shostak and Houghton, 2008), the developer within the Spanish case study suggested their current house building efforts were (by necessity) engaged solely on social housing. The lack of any cross-subsidisation therefore, means low carbon compliance has to be achieved within the strict cost boundaries of the capped social housing prices.

RESEARCH METHODOLOGY

Approach

A case study methodology was employed to examine some of the implications and challenges in achieving lower CO_2 housing emissions emanating from both the national legislation (CTE) and local planning requirements for social housing. Locating the research within a multi level context (Geels, 2002), a socio-technical network approach (Elzen, Enserink and Smit, 1996) was used as the theoretical and methodological lens to explore the existing situation and its dynamics while accommodating the actors and issues involved. This includes interactions between the actors, and their emergent understanding of the legislation, planning and technological requirements in meeting the challenge of low carbon emission housing. The research strategy was to select a housing development within the social housing sector that would permit access to site (including relevant project documentation), as well as access to key personnel charged with the deployment of low and zero carbon technologies within the social housing sector. The strength of the case study approach lies in providing vicarious experience in the form of full and thorough knowledge of the particular, and such understanding adds to the existing literature by extending the experience and comprehension gained through investigating particular cases (Stake, 2000). Although this case study is a bounded system (Fals Borda, 1998) and is limited by resources, it was chosen because it was consistent with the research strategy, and was considered most appropriate to deliver relevant, contextual information on low carbon housing.

Through the CTE, the deployment of solar thermal technology is a legislative requirement in this sector, and the research uses a socio-technical network analysis to examine this obligation through the complex interactions between people, institutions and technology within an empirical setting. In addition, by adopting a multi-level perspective (Geels, 2002), a range of considerations and influences on the choice and deployment of measures to achieve low CO_2 emissions in this sector are considered. Although primarily employed by Geels to investigate emerging technological

[2] The VPO comprises five categories, especial, general, municipal, a category especially for young people and a category to cover existing housing. All of these have a capped price and are destined to provide housing for those on low or limited incomes. (www.juntadeandalucia.es)

transitions, the multi-level perspective (MLP) for this case study is used to include some of the issues (CO_2 target reductions, code compliance, technological developments, planning policy compliance, construction education and training), which may impact on the deployment of low and zero carbon technologies, and which may best be explained from a generic model which can help to better understand these processes (Fig 2).

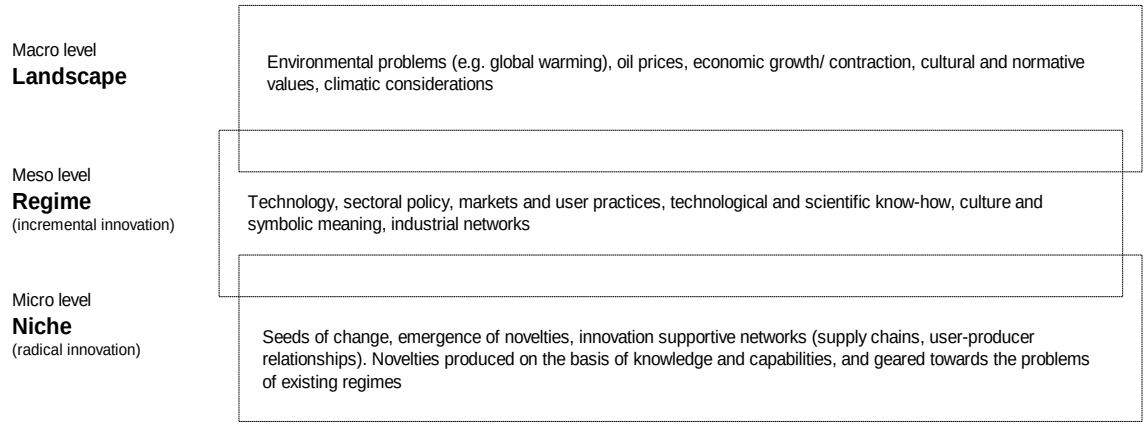

Fig 2 Multi-level perspective (Adapted from Geels, 2002 p 1261)

Utilising the MLP in conjunction with a socio-technical networks approach (Elzen, Enserink and Smit, 1996), has facilitated the examination of influences across the landscape, regime and niche levels of the MLP while identifying resilience within the network. The socio-technical analysis framework enables the tracing and analysis of factors that guide the various actors in their interactions, and acknowledges the identification of certain stable patterns whilst accounting for the different meanings that different actors attribute to the technology in question (Elzen, Enserink and Smit, 1996). A number of these influences are discussed within the actor interactions identified in this research.

BACKGROUND

The case study centred on a construction site of approximately 500 social dwellings where access was gained to both the works and the agents involved in its construction and the deployment of fabric upgrades and renewable technologies. The collated data included a variety of project specific information including project drawings, technical specifications, publicity documents, in-situ photographs from the site visit as well as a number of semi-structured interviews carried out with personnel at different levels. These included the architect, site manager, planning authorities, installers and manufacturers. Having previously conducted a pilot study, the interview questions were tailored to the building development selected, yet allowed a degree of contextual flexibility depending on the relevance of certain questions for individual interviewees. All the interviews were recorded with consent from the interviewees, transcribed verbatim, returned to each interviewee and subsequently translated into English. The transcriptions were then anonymised and only the job titles of interviewees remained identifiable. The transcripts were analysed qualitatively to identify any recurrent (including conflicting) themes arising from the discussions.

Spain has 24 million pre CTE homes (Asociación Solar de la Industria Térmica, ASIT, 2008), many of which are still under construction with planning permission gained prior to 2006. The site for the case study was chosen after preliminary investigations confirmed the development was subject to the 2006 building codes and

the local planning department required compliance with the energy saving measures contained in the legislation. As this case study is part of a larger comparative study, consideration was also given to identifying a comparable development in the UK with which to make a relative comparison. Further consideration was given to the economic situation (within the landscape of the MLP) that has particularly affected Spain over the last four years which has meant it is more difficult to find developments currently under construction (Asociación Solar de la Industria Térmica, ASIT, 2012). Targeting developer organisations based on the upper quartile of volume house builders in both Spain and the UK helped to identify suitable and on-going housing developments.

CASE STUDY FINDINGS

The case study included project specific information relating to the renewable technology deployed within this development. Although developers are at liberty to include a range of technologies within their dwellings, this development included CTE compliant fabric requirements, but restricted renewable provision to the installation of solar hot water panels which provide hot water to all 500 apartments. The development did not include any additional renewable technologies.

A typical socio-technical analysis for this development is shown in Fig 1.3 superimposed over the landscape, regime and niche levels of the MLP.

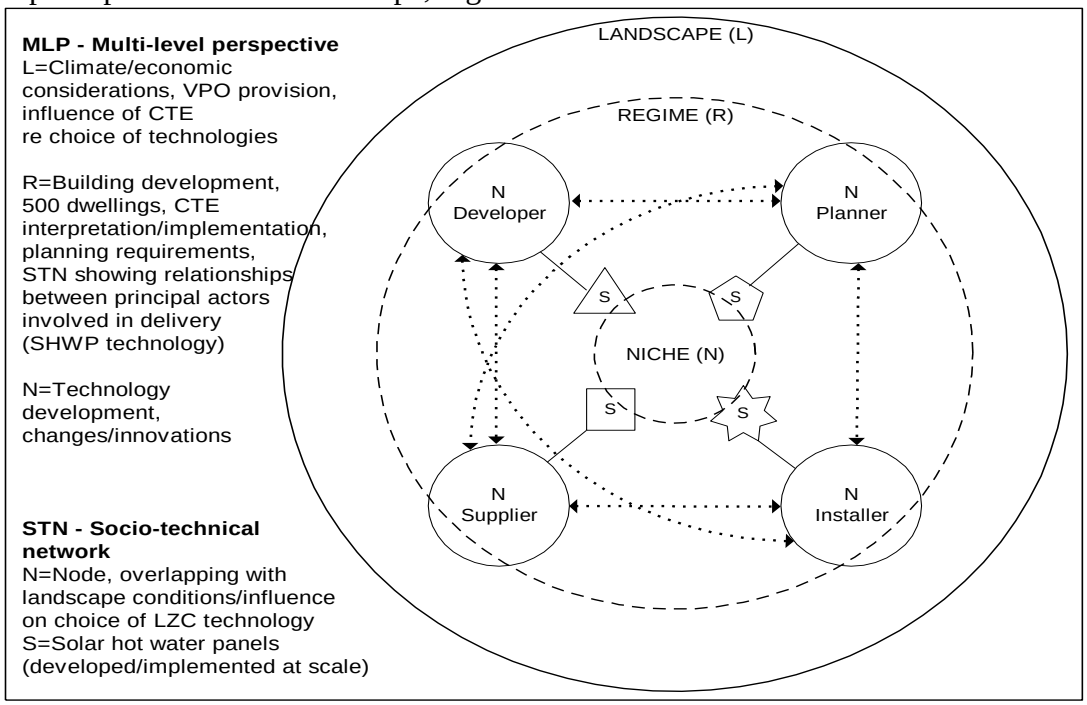

Fig 1.3 Socio-technical network (adapted from Elzen, et al. 1996 p 118) related to the landscape, regime and niche of the MLP (Geels, 2002)

The technology, in this case solar hot water panels, can move from one actor (such as the manufacturer/supplier) to others (such as the installer(s) and/or the developer) and in this sense is an intermediary. As with the social construction of technology approach (Pinch and Bijker, 1984), the socio-technical analysis recognises the interpretive flexibility of the artefact, and therefore the relevant characteristics of the artefact to that specific actor. In Fig 1.3, the actors (developers, planners, suppliers and installers) constitute the nodes of the network and the links represent the two way

interaction between them. The actors can be individuals or in the case of this development, organisations.

Whilst rooted within the regime level of the MLP, the nodes also overlap the landscape level as those actors interviewed during the case study cited the influence of climatic conditions in their region as well as the existing economic situation in Spain, which was seen as a significant influence on making the implementation of low carbon measures within such building projects so problematic at the present time. Interview respondents viewed the obligatory nature of the CTE as the main reason for deploying solar hot water panel (SHWP) technology in the current economic conditions in Spain; "…now, in this economic situation, we would not deploy the technology for sure, and the developers would remove them if it wasn't for the fact they are obligatory" (Interviewee code: Installer5 23). Such responses were typical despite the fact that all those interviewed suggested that the SHWP technology was the most suitable to deploy in the domestic setting given the climatic, as well as economic conditions within the Andalucian region of Spain; "Let's see, I think that today, with the problem you have with construction costs… if you had to choose between which is the most efficient, or sustainable, between photovoltaics, solar hot water, solar thermal, or any others, then the choice we've made is correct…in SpLocation1…that is solar hot water" (Interviewee code: Developer architect1 12). Within the socio-technical analysis, such environmental influences are an important part of the framework analysis. The landscape influences in this case are generally seen as providing a meteorological impetus, as well as a very difficult economic challenge for the actors charged with deploying the technology.

The interactions or intermediaries (Callon, 1992) that pass between the actors can be made up of contract documents, money, construction diagrams, etc., and can include the actual technology being deployed. The differing shapes of the SHWP symbols in Fig 1.3 represent the meanings, and attempt to show the interpretive flexibility of that artefact for each specific actor. For instance, the manufacturer/supplier recombines many of the raw materials, machines, manufacturing processes and individual components, to produce the panels to forward on to the installer. In turn, the installer recombines these artefacts with other installed components in order to successfully integrate them into this specific development.

During the interviews it became apparent that the interpretation of the SHWP technology, particularly in terms of any perceived design/performance gap or the functioning of the panels, differed considerably depending on which actor was interviewed. The manufacturer/supplier viewed the technology most positively and suggested any blame for performance under achievement did not rest with the manufacturer; "Now, going back to the question of whose fault it is if the system does not work well. I'd like to tell you something. We have to every year receive an inspection, an audit, we have to renew our certificate and they are done in a certified laboratory. So we do go through a check-up process and we do test 100% of our production. However ask an installer how often does he get an inspection from the public sector to check that his job is well done" (Interviewee code: Supplier7 14). However, in answer to how effective the technology was from various suppliers, the installer suggested the technology worked well, but within the social housing sector; "they are installing the basic, the most basic, the bare minimum requirement so that the panels function correctly" (Interviewee code: Installer5 4). Such comments from these actors demonstrate the differences in their perceptions of the deployed technology within the socio-technical network and generally reflected poor

communication between them. When it was suggested the manufacturer might provide some additional technical support to improve the technological systems being installed, it was stated this was not part of their remit and therefore was not considered part of their responsibility.

The developer liaises with both of these actors as well as the local planning department, utility companies, and the many other suppliers and tradesmen involved in the construction of these dwellings. For the developer in this case, the technology was seen as appropriate in providing building code compliance, allowing integration with existing provision, as well as future maintenance considerations (though there were some maintenance reservations given the newness of the technology). Consistent with the comments from these interviews, the technology employed on this development was generally considered the most appropriate given the climatic conditions, as well as the cost constraints imposed on social housing. Although there were misgivings regarding the introduction of new technology at such a difficult time, the legislation (CTE) was considered appropriate to ensure the region's natural solar resource was exploited within the domestic new build sector.

DISCUSSION AND CONCLUSION

This research set out to provide an improved understanding of the way low carbon targets are being met within the Spanish context and how the use of low and zero carbon technologies are being deployed in the delivery of social new build housing in Spain. Concentrating on one housing development, the collated data reveals how some of the principal actors involved in this delivery, view and interpret the technology and how it is perceived in their relationships with one another and within the wider economic and regional climatic context. The research forms part of a larger comparative study which looks to compare carbon compliance measures from two EU countries.

Given Spain's status regarding its progress in implementing its EPBD commitments (EPDB-CA, 2011) and given the recent moratorium called by the Spanish government on renewable energy subsidies (BOE, 2012), this research provides timely data on the implementation of the mandatory requirements of the CTE. Within this case study, the way the actors process and recombine the intermediaries shows that the relevant characteristics of an artefact may differ from one actor to another as in the case of the manufacturer and installer. This localisation of an actor-specific version of the artefact suggests that while there may be overlap in which characteristics are considered important by different actors, the actual SHWP technology being installed is reflected and interpreted in the variety of intermediaries sent out by the various actors within the network. However, the socio-technical network also revealed stable patterns of interaction between the actors. This is evidenced by the continued engagement of the installer or manufacturer by the developer, or by the planning authority engaging the developer from previous (presumably satisfactory) jobs. These stabilised patterns of interaction suggest actors behave in this network in ways which perpetuate their existing patterns of interaction and interviewee comments reflected the emergence of network resilience. The 'out-of network' interactions are also important in considering the interactions between the network and the environment, and for acknowledging the possibilities of technological change (Elzen *et al.* 1996).

The SHWP technology was considered the most appropriate renewable technology given the local climatic conditions, and the CTE was considered an essential legislative measure to ensure solar hot water take up and delivery within the new build

social housing sector. It was also recognised that the regulatory context is the subject of on-going development and is subject to change and evolve over time. Additional discussions highlighted concerns relating to future legislative revisions and how these could relate more closely to planning permission consent, particularly relating to the 'capped' rate for social housing, and for instance, in revisions which might mitigate the perceived northern European influence on ventilation provision.

At the time of conducting the interviews within this development, the solar hot water panels were not yet installed during the site visit. Whilst this meant it was impossible to get any in-situ photographs, by visiting an adjacent (and completed) apartment block by the same construction company, it was possible to record some photographic detail of a similar system, even though the chosen system for the new block differed in its back up energy design. The back-up energy system was discussed during the interviews and was considered important both for its system design and the subsequent and future performance of SHWP technology. Future contributions from socio-technical network analysis might include an examination of different back-up systems incorporating the views of the suppliers and installers in order to provide a comparison to investigate how such support systems influence either the choice of renewable technology, or the way such technology is viewed and incorporated into the development. Further research might also explore the policy reforms in greater detail and the way the CTE has shaped and is shaping technological development in this sector. This could be extended to examine alternative technology options for future provision.

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ENVIRONMENTAL ASSESSMENT TOOLS AND EFFICIENCY IN HOUSING AND OFFICE REFURBISHMENT

Ahmet Anil Sezer[1]

[1] *Department of Technology Management and Economics, Chalmers University of Technology, SE-412 96, Gothenburg, Sweden*

Most environmental sustainability assessment tools are focused on new construction while refurbishment of buildings presents a different picture. Short term, local environmental effects such as noise or dust are more frequent in a refurbishment process since both occupants and neighbours are affected whereas in new construction only neighbours might be affected. The purpose of this paper is to provide a framework in order to assess strength and weaknesses of environmental assessment tools for housing and office refurbishment projects, taking into account practical aspects, fundamentals of sustainability as well as conflicts between sustainability and efficiency. A review of literatures on sustainability, measurement systems in general and major environmental assessment tools confirms that these tools focus on energy consumption, heat insulation, air quality, light, noise, water efficiency and material consumption in new construction, but rarely in a refurbishment context. Short term, negative effects during a renovation process are not covered by current environmental assessment tools. The conflict between local and global effects of sustainable refurbishment, users' needs, workers' efficiency during the refurbishment process, problems caused by occupants and waste management should be reflected in a framework for indicators to be used in refurbishment projects. Since there are important effects on building users involved in most refurbishment processes, more attention should be paid to the relation between their productivity and both economic and social sustainability.

Keywords: environmental impact, measurement, productivity, refurbishment, sustainability.

INTRODUCTION

In Europe, the building stock is old and therefore the maintenance and refurbishment of the existing buildings are critical issues for sustainable building construction (Haapio and Viitaneiemi 2008). In order to satisfy financial, legislative and social demands, sustainable refurbishment in most cases seems like the best option, especially when the architectural heritage is intended to be preserved. Refurbishment also generates more waste than new construction and the content of this waste is less

[1] ahmeta@chalmers.se

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predictable in terms of what it consists of. Therefore the shift from new construction to refurbishment makes it necessary to look at the fundamentals of sustainability.

Sustainability is generally analysed in three categories: environmental, social and economic. However, authors from different perspectives deal with sustainability in different ways. A more traditional and anthropocentric economic view (Toman 1994) suggests that mainly environmental sustainability is based on two dimensions, intergenerational equity and substitutability of social capital. When it comes to the ecologist view, Passmore (1980) touches upon the difference between conservation and preservation. In conservation, aim is to save for future generations where intergenerational equity is pointed out. On the other hand, preservation means that species and wilderness must be kept in their present condition. These fundamental ideas which include the consideration of relations between humans and nature as well are coming mostly from ecologists (Baumgartner and Quaas 2010) and they highlight the issue of dealing with waste coming from refurbishment.

Refurbishment offers different challenges than construction of new buildings and most environmental assessment tools do not consider the unique challenges and conflicts of refurbishment. Short term, negative effects during the refurbishment process are not recognized in these tools. There are also other conflicts remaining such as sustainable refurbishment decreasing the energy costs while perhaps increasing rents and thus affecting social sustainability. BREEAM Refurbishment Domestic Buildings is the most recent (June 2012) and only environmental assessment tool that evaluates the refurbishment projects.

Earlier literature on environmental assessment tools (Crawley and Aho 1999; Cole 1998; Forsberg and Malmborg 2004; Haapio and Viitaniemi 2008; Kajikawa *et al.* 2011) usually compare them with each other through the indicators they have, however there has not been any study that analyses these tools in the refurbishment context. Thus, in this paper the fundamentals of sustainability, challenges and conflicts in sustainable refurbishment and essentials of the existing environmental assessment tools are in focus. Such an approach increases our understanding of these concepts and helps us to synthesize them in the practical applicability of tools for both designers and refurbishment contractors.

In particular, the relation between tools for environmental sustainability should be viewed also in an efficiency perspective that is related primarily to economic sustainability. The conflict between efficiency and economic sustainability should be pointed out since efficiency reflects the short term productivity (productivity during the refurbishment process) while economic sustainability refers to long term consequences. Therefore, the purpose of this paper is to provide a framework in order to assess strengths and weaknesses of environmental assessment tools suitable for housing and office refurbishment projects, taking into account both fundamental conflicts of sustainability and practical aspects.

METHOD

This deductive study is based on a literature review in areas of sustainability, measurement systems in general and earlier analyses of environmental assessment tools. The empirical base of the study is major systems of existing environmental assessment tools for (new) construction and the recent BREEAM Refurbishment Domestic Buildings.

SUSTAINABILITY AND THE CONSERVATIONIST DILEMMA

Dealing with sustainable refurbishment is more complex than sustainability in new construction since the environmental impacts of waste are more visible in refurbishment and requires more attention. Thus a few distinctions should be made between refurbishment and new buildings which requires a look at the ecologist perspective and its fundamentals. The conservationist view is one of these perspectives; Passmore (1980) starts the debate by clarifying the difference between conservation and preservation. He sees conservation as saving for the posterity whereas preservation is saving from destruction. His ideas are mostly based on consideration of posterity. Thus he suggests a differentiation between the terms pollution and exhaustion, where pollution is using the resources wastefully which will influence posterity's ability to civilize or in a worse scenario, survive. Hence the essential conservationist idea is to avoid pollution of air and water even though we have to decrease the present industrial activity.

Intergenerational equity and social capital are two dimensions that may provide a better understanding of the ecologist view. Substitutability between the services provided by natural capital (material resources, waste absorption, cultural values etc.) and services from other forms of social capital (buildings, knowledge, skills etc.) is the main concern of social capital dimension whereas the idea of saving for the sake of our posterity is an issue of intergenerational equity (Toman 1994). In that sense, the conservationist idea is more optimistic in terms of substitutability of social capital since the main concern is to achieve intergenerational equity. On the other hand, in preservation social capital is accepted as non-substitutable and the aim is to keep the species and wilderness as they are even if they are harmful to human beings. Therefore the main concern in preservation is the nature where intergenerational equity is totally disregarded. In that case issues such as resource use and waste management in refurbishment should be highlighted since they are expected to have bad influences on the nature (Passmore 1980).

From an economic viewpoint, Toman (1994) analyses the common views of sustainability in three categories: neoclassical presentism, neoclassical egalitarianism and ecological organicism. Neoclassical presentism is one of the most optimistic views where it is thought that natural resources are remediable through substitution and technical advance. In order to be sure that intergenerational equity is achieved, neoclassical presentism suggests using the present value. Neoclassical egalitarianism carries the same mentality as neoclassical presentism in terms of social capital; however in neoclassical egalitarianism, risks such as a potential shortfall in total saving for future are considered in the present value analysis. The first two categories are obviously based on the assumption that the price system can solve the problems related to sustainability. However there are minor issues remaining that should be considered in the refurbishment context such as that in neoclassical presentism, perfect knowledge is assumed to exist. But one should consider that in reality, knowledge among refurbishment clients is inadequate which explains why a client needs architects and consultants.

The last category, ecological organicism, is totally different from the first two views since it is claimed here that natural resources are limited. Moreover, this view does not only focus on individuals, instead it focuses on ecological systems and humanity as a whole, an approach which is related to the justice view of Baumgartner and Quaas (2010). The basis of ecological organicism is the idea of an ecological system

breakdown due to a chain of activities. In a refurbishment context it is unlikely that resource use might cause ecological system breakdown. However the waste from the refurbishment process might be different and more threatening from a system viewpoint.

SUSTAINABLE REFURBISHMENT

As stated, refurbishment presents different characteristics and challenges than new construction. This is mainly due to the stakeholders (occupants and neighbours) involved in the refurbishment process. Especially when sustainability is the focus in refurbishment, conflicts between the aspects of sustainability, in particular with social sustainability becomes more obvious. Therefore an understanding of these challenges is needed in order to address these issues in environmental assessment tools.

A number of authors have identified advantages associated with refurbishment. In one of the earlier studies, Keeping and Shiers (1996) present the major benefits of sustainable refurbishment as lower energy costs, lower maintenance costs and healthier buildings. Mickaityte *et al.* (2008) provide a longer list of expectations from sustainable refurbishment as energy savings, increase of comfort, healthy working environment assurance, increased building life cycle, economized usage and environmental protection. Yau *et al.* (2008) focus on the owners' perspectives and show that refurbishment increases the price of the properties. It is clear that concerns on energy consumption are considered as one of the main triggers of sustainable refurbishment. Increased energy prices are given as a primary reason that encourages energy saving refurbishment (Papadopoulos *et al.* 2002). Reed and Wilkinson (2005) add legislative reasons to the financial ones for energy saving refurbishment. The role of legislation is easily understood in the light of neoclassical market failures mentioned earlier (Toman 1994). The financial reasons in Reed and Wilkinson's (2005) list do not only concern decreased energy costs. These reasons also include an aspect of efficiency namely increases in staff productivity after refurbishment.

On the other hand refurbishment presents a greater challenge due to stakeholders particularly the ones present in the building during the refurbishment. This can be observed especially in office refurbishment projects where staff productivity is decreased temporarily due to disruptions such as noise and dust during the process. In an Australian study, Bullen (2007) presents a number of challenges that are primarily based on financial issues such as that owners do not see economic benefit in refurbishment, or adaptation problems such as that older buildings may not meet current sustainability standards. When we take a look at energy saving refurbishment, regulatory and financial problems are raised by Papadopoulos *et al.* (2002) as primary obstacles and it is shown that energy saving refurbishment sometimes creates unacceptable economic results.

These studies give a good overview of how different sustainability aspects such as environmental and economic ones conflict in practice. While one of the objectives of refurbishment might be to increase energy saving to reach an environmental and financial goal for the owner, it might lead also to rent increase which could influence the social aspect. Given all these complexities, one might ask how these challenges and conflicts can be managed in practice, especially as supported by environmental assessment tools.

ENVIRONMENTAL ASSESSMENT TOOLS IN PRACTICE

The first two influential studies comparing environmental assessment tools were written by Ding (2008) and Haapio and Viitaniemi (2008). Both studies analyse the existing environmental tools and identify the limitations of these tools, but they use different approaches. Haapio and Viitaniemi (2008) categorise the existing tools based on their classification systems and characteristics. Ding (2008) criticises the existing tools through their characteristics as well but she does not categorise them. Her analysis is based on eight aspects: usability as design guideline, usability for selection optimum project options, financial aspects, recognizing regional variations, complexity (input), evaluation of qualitative and quantitative data, weighting and measurement scales. Haapio and Viitaniemi (2008) formulate a number of limitations which are user based problems, reusability of the building products are not considered, a predicted service life is used, ambiguities in utilization of the results and, economic and social aspects of sustainability are not considered. Both studies assert the importance of environmental assessment tools on decision making in projects although Ding (2007) goes further and suggests a sustainability index for environmental building assessment. Her sustainability index includes four major principles: maximize wealth, maximize utility, minimize resources and minimize impact (on environment). While both studies are useful, they do not consider the specific challenges of different types of construction activities and instead analyse the existing tools in general rather than focusing on individual activities, such as refurbishment.

Because refurbishment is not yet covered by most environmental assessment tools, it may seem premature to develop a framework for assessing the tools themselves. Nevertheless refurbishment shares some problems with demolition and new construction which makes it interesting to see the limitations of existing assessment tools. In their pioneer article, Haapio and Viitaniemi (2008) provide a clear understanding of why these tools are created and how they differ from each other. The differences between the tools are: they assess different types of buildings, they emphasize different phases of life cycle, and they rely on different databases, guidelines or questionnaires.

The criteria behind the categorisation of assessment tools may give an idea about the range of tools and for which purposes they are created. Forsberg and Malmborg (2004) categorize the tools as qualitative and quantitative ones. They mention that qualitative environmental assessment tools such as BREEAM and LEED include some quantitative elements (e.g. energy use) while the rest is based on qualitative criteria. It may also be useful to show that different tools include various indicators to measure different aspects. However there remain some common areas that these tools focus on which are energy consumption, heat insulation, air quality, light, noise, water efficiency and material consumption. Obviously a wide range of environmental assessment tools exists and they show different characteristics depending on their essential principles which directly influence their application in practice.

Why environmental assessment tools?

One of the core issues related to environmental assessment tools is the question of why we need them or what makes them so important that many practitioners and researchers are engaged with them. The answer can help us to understand what is expected from environmental assessment tools, especially in the refurbishment context. In order to address this issue, one should understand the benefits gained from

environmental assessment tools. Environmental assessment tools' primary aim is described by Crawley and Aho (1999) as to help consumers to understand what is environmental and orient them towards buying such products or services. Moreover, in the absence of environmental design guidelines, environmental assessment tools implicitly provide guidance. In his pioneer article, Cole (1998) proposes a number of benefits of environmental assessment tools: they provide a common and verifiable set of criteria and targets, they gather and organize detailed information on the building, they can be used by building owners to identify priorities for future administration measures, they provide building owners a means to communicate to prospective tenants the inherent environmental qualities of the building, and they offer a means of structuring environmental information for new building designs and major renovations (note this!) in a rapidly expanding field of knowledge and provide a reference by which building owners and design teams can formulate effective environmental design strategies. The list he presents covers benefits from several processes such as design and operations and also different perspectives such as those of owners and users.

Problems and limitations of environmental assessment tools

Although environmental assessment tools present limitations in the refurbishment context, there might be other limitations that refurbishment shares with other construction activities. As we have seen, Cole (1998) published one of the earliest articles that analyse the environmental assessment tools and categorized limitations as structural or contextual. The structural limitations are given by him as:

- Ability to offer different levels of assessment
- Ability to acknowledge regionally specific environmental criteria
- Use of different measurement scales for different criteria sets
- Weighting of criteria
- Ability to be used as design tools
- Ability to link with other performance issues
- Ability to evolve as field matures
- Remaining voluntary in their application

Following on this early and extensive list of limitations of environmental assessment tools researchers have developed his approach. Todd and Geissler (1999) focus more on the regional limitations since regional differences such as having land or water as scarce resources influence the criteria. Although they stress the importance of considering regional differences, they conclude that having an international or universal tool is the best option since we live in a global village where gas emissions cannot be limited within the borders of regions.

Furthermore, Todd and Geissler (1999) propose partial flexibility in environmental assessment tools in order to solve the regional/universal dilemma. Hence they suggest that the criteria that have international impacts should be fixed such as the ones related to natural resources while the rest of the tool should give enough flexibility to modify the method for scoring performance on each criterion, as well as the method for weighting the importance of each criterion for a specific region.

Fairly recent articles are in coherence with the earlier ones and refine the argumentation. Soebarto and Williamson (2001) add that most tools do not consider costs while Kajikawa *et al.* (2011) present the use of a mixture of qualitative and quantitative measures as a further challenge. Haapio and Viitaniemi (2008) offer a deeper understanding of the limitations from the users' perspectives and claim that there are ambiguities remaining about the reliability of environmental assessment

tools. These ambiguities are assumed to explain low interest in assessment tools. Haapio and Viitaniemi (2008) also mention that users may promote a particular tool just because it gives better results for a certain type of building. Thus a user survey to see what makes users choose one environmental assessment tool rather than another is suggested by them as important.

Clearly, there are difficulties caused by the wide definition of sustainability. Cole (1998) thought that the aim of existing environmental assessment tools was to improve environmental performance by decreasing resource use and ecological loadings. However the concept of sustainability has expanded beyond environmental considerations and now includes two more aspects, social and economic sustainability. Haapio and Viitaniemi (2008) summarize this as the shift from green buildings to sustainable buildings and claim that transforming environmental assessment tools to sustainable assessment tools is still not on the agenda.

The widened concept of sustainability leads to further complications due to different perspectives and the range of actors involved in refurbishment projects. The perception of building performance differs among occupants and owners/investors as well as other stakeholders. While occupants may perceive building performance as air quality and other phenomena that influence their health and comfort, owners perceive building performance as economic performance (Cole, 1998). Therefore, the question of who will use the environmental assessment tools for which purposes becomes important. Environmental sustainability will be matched against (at least elements of) economic sustainability, which emphasizes efficiency.

PROPOSAL FOR A FRAMEWORK

In Table 1, criteria to assess the environmental assessment tools in different contexts are given under different categories. Within the environmental sustainability, an environmental assessment tool is expected to give enough flexibility to adapt criteria to local, regional and national differences. In that sense, it is clear that local effects are more visible in refurbishment than new construction and green buildings which make this criterion more important. The second criterion of the same category comes from the fundamentals of sustainability. Although refurbishment might not create extra problems in terms of resource use, waste should be highlighted as a greater challenge in refurbishment due to uncertainty and the problems often faced in recycling.

The conflict between efficiency and economic sustainability is more obvious in refurbishment since efficiency reflects short term productivity. Efficiency will most probably be lower in refurbishment due to the problems related to output measurement. As a consequence of the problem, output measurement this criterion may have a greater impact on refurbishment. When it comes to the second economic sustainability criterion, it is possible that the environmental assessment tools require excessive input including money and human resource which is a common problem of different construction types. Usability of environmental assessment tool for future operation and maintenance measures can be given as an example. So if the environmental assessment tool is useful for future operation and maintenance measures, stakeholders may be more willing to put more effort in certification.

When it comes to the social sustainability, greater challenges remain in refurbishment due to the stakeholders involved (both occupants and neighbours). Therefore adaptability to individual user needs may be more significant in refurbishment. A common problem in environmental assessment tools is that they are complicated.

While in new construction this might be a minor issue, in refurbishment occupants and workers might be involved in the whole process and thus need to understand the tool. It is also important that an environmental assessment tool facilitates the communication between stakeholders, especially with the current or prospective tenants. Hence an environmental assessment tool should be easily understood by the stakeholders. When it comes to the third criterion, user behaviour such as energy usage preferences of occupants should be highlighted. In refurbishment, since occupants usually are known, more accurate estimates can be made of user behaviour. However in green buildings and new construction, users are very often anonymous which makes this criterion a challenge.

Table 1. Framework for assessment of environmental assessment tools

Criteria	Green buildings	New construction	Refurbishment
1. Environmental			
1.1 Ability to adapt to local, regional and national effects	+	+	++
1.2 Threats to ecosystems (waste and irreversibility)	(-)	+	++
2. Economic			
2.1 Efficiency: consideration of resource use to obtain a given result	(-)	+	++
2.2 Effort in certification (input)	+	+	+
3. Social			
3.1 Adaptability to individual user needs	(+)	(+)	+
3.2 Ease of understanding for stakeholders (including workers)	(+)	+	++
3.3 Ambiguity (user behaviour)	++	+(+)	+
4. Sustainability in general			
4.1 Both process and product evaluation	(-)	+	+
4.2 Yes/No or graded (reliability)	+	+	+
4.3 Compatibility with national building codes, EU directives, standards	+	+	+

In the first criterion of sustainability in general, it is expected that an environmental assessment tool should be used as design guideline and refurbishment production planning. In detail, an environmental assessment tool should assist in identifying optimum project options which highlights the importance of having both process and

product evaluation as a criterion. In terms of product, providing robust technical solutions is important since environmental assessment tools use predicted service life. Hence if some products have shorter service life, it should be easy to replace them. Due to long term characteristics of green buildings, the end product is the important element to assess, not the process. Therefore this criterion is less important for green buildings than new construction and refurbishment.

The recently published (June 2012) BREEAM Refurbishment Domestic Buildings is the only environmental assessment tool that has been created to evaluate the refurbishment process. Refurbishment activities covered by BREEAM Refurbishment Domestic Buildings are alterations to existing dwellings, extensions, domestic conversions and change of use projects. Compared to earlier versions for new construction, more attention is paid to the energy section with 43 % weighting which agrees with the fact that the main intention behind most sustainable refurbishment applications is energy reduction. Sections such as waste, materials and pollution are given less weight than the earlier versions. Finally it should be pointed out that efficiency is partly included in the tool while thinking of refurbishment site waste and efficient use of resources (BREEAM Refurbishment Domestic Buildings 2012).

CONCLUSIONS

Intergenerational equity and social capital are fundamental ideas of sustainability, at least in an ecologist view. These ideas force us to think of our posterity in different ways, while some authors suggest a more pessimistic scenario whereas others are more hopeful about future. Basically the choice of alternative scenarios influence the way we apply concepts such as sustainable refurbishment.

The conflict between local and global effects of sustainable refurbishment is important. Although new construction creates some negative local environmental effects, the level of disruptions such as noise and dust is more obvious in refurbishment. It is primarily due to the fact that during refurbishment both neighbours and occupants are influenced by the negative effects whereas in new construction, only the neighbours, if any, are affected. Waste is one of the major local problems as well and once again, it must be acknowledged that new construction causes waste as well. However the waste from new construction is often easier to identify and recycle than the waste from refurbishment. It is probably so that the proportion between local and global effects is different in refurbishment.

Another conflict can be pointed out between economic and social aspects of sustainability. However this conflict is probably limited to housing refurbishment. In neoclassical economics, rents are supposed to reflect quality which means that after the refurbishment, rents might increase. So the attempts to decrease the costs associated primarily with energy usage result in an imperfect rental market as increases in rents and violate the social aspect. Once again such a conflict is unlikely to be observed in office refurbishment and new construction.

The link between economic sustainability and efficiency or productivity is complicated. Economic sustainability supports the idea of efficient resource use (materials and labour) where these two resources are used in traditional productivity measurement for renovation contractors. In further research, the negative local effects on staff productivity and the link to other sustainability aspects should be considered. A framework that covers principles for an efficient use of energy, heat, air, light, noise, water and materials is needed to achieve a sustainability/productivity balance.

Moreover, practical conflicts arising from the nature of refurbishment should be taken into account. Users' needs, and problems caused by occupants or the workers' performance are a few examples of these problems. It is also vital to remember that regional differences, a common problem shared by all construction activities, should be considered in environmental assessment tools. Thus these tools should give enough flexibility to some criteria to be modified according to region while the rest of the criteria that have global influences should be fixed. Weighting of these criteria should also be modified by considering the essentials of refurbishment.

In this paper, a framework is provided to assess the environmental assessment tools. Further research should investigate the conflicts deeper through case studies and take efficiency into account. Testing this framework in refurbishment context is important to see if the set of indicators work well in assessing environmental assessment tools in terms of different aspects of sustainability and efficiency.

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VARIATIONS IN THE MAINSTREAMING OF SUSTAINABILITY: A CASE STUDY APPROACH

Philippa Boyd and Libby Schweber*

School of Construction Management and Engineering, University of Reading, RG6 6AW, UK

The construction sector has a major role to play in delivering the transition to a low carbon economy and in contributing to sustainable development; however, integrating sustainability into everyday business remains a major challenge for the sector. This research explores the experience of three large construction and engineering consultancy firms in mainstreaming sustainability. The aim of the paper is to identify and explain variations in firm level strategies for mainstreaming sustainability. The three cases vary in the way in which sustainability is framed – as a problem of risk, business opportunity or culture – and in its location within the firm. The research postulates that the mainstreaming of sustainability is not the uniform linear process often articulated in theories of strategic change and management, but varies with the dominant organisational culture and history of each firm. The paper concludes with a reflection on the implications of this analysis for management theories and for firm level strategies.

Keywords: corporate sustainability, corporate strategy, neo-institutional theory, organisational culture

INTRODUCTION

The UK Climate Change Act (2006) and UK Strategy for Sustainable Construction (Berr 2008) reflect the UK's focus on sustainability and the low carbon agenda. There are increasing political, social and market pressures on the construction industry to play its part. At the level of policy, accelerated revisions to Part L building regulations, increasing demand for CEEQUAL and BREEAM assessments, guidelines for government procurement and the Code for Sustainable Homes have all helped to put sustainability on the agenda. Pressure from socially responsible investors and external stakeholders have led to demands for greater accountability and transparency, while attempts to document best practice have led firms to engage with advisory forums (e.g. Forum for Future, Tomorrow's Company) and benchmarking (e.g. Business in the Community, Times Green Companies).

As external pressure has increased, there has been a drive inside companies to develop sustainable policies and procedures. There is also a view that improving sustainability performance in terms of reducing waste and energy usage is a lever to reduce operational and project costs. The response of firms in the construction sector has been diverse. Firms vary in their framing of the problem, the location of sustainability

* l.schweber@reading.ac.uk

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within the firm, internal and external facing initiatives and the integration of sustainability into everyday practice. The aim of the research is to identify and explain variations in firm level strategies for mainstreaming sustainability. Research focuses on the framing of sustainability as a problem and on the institutionalization into the organizational structure and internal and external corporate strategies. The research does not assess the effectiveness of the different approaches, in part because, in two of the three cases, these strategies are relatively recent. However it does suggest guidelines for effective practice.

LITERATURE REVIEW

The call for corporate sustainability lies at the intersection of a number of policy agendas, including environmentalism, corporate social responsibility and modernisation of the construction sector. While much of the academic literature on corporate sustainability relies on practically oriented management theories, this research rejects that approach as overly simplistic and insufficient to account for variations between firms. Instead the analysis draws on neo-institutional theory.

Corporate Sustainability

The literature on corporate sustainability focuses on the integration of sustainability into core business objectives and operations and draws on theories of organizational and strategic change. Much of this work focuses on how to encourage corporate sustainability and the relation between environmentalism and competitive advantage. Three main approaches dominate this area: Stakeholder Theory, Resource Based Views and Stage Models.

Studies drawing on Stakeholder Theory (Sharma and Starik 2004, Benn and Dunphy 2007) explore the role of institutional investors (Mathews 2008, Sullivan and Pfeifer 2008, Reid and Toffel 2009), local communities and pressure groups (Baron 2003, Sharma and Henriques 2005), NGOs customers (Anderson, Daly and Johnson 1999, Delmas and Monitiel 2008) and employees(Mathews 2008) in driving corporate sustainability. While scholars generally agree that all of these groups potentially matter, they tend to be studied in isolation. Little is known about the interaction between these different types of demands and their effect on firms. Literature advocating a Resource Based View (RBV) suggests that the culture and capability of the firm are key factors in the successful integration of sustainability within the firm (Aragon-Correa and Sharma 2003, Buysse and Verbeke 2003). The effects of previous change patterns and acquisition history in the implementation of environmental strategies are identified (Ellis, Cordanok and Lamont 2002), but are not generally explored.

Literature on stage models includes linear models which focus on a stepwise approach to sustainability (Doppelt 2003, Hoffman 2006) and wave approaches where the firm's journey along the road to sustainability is characterised by different phases of momentum (Dunphy, Griffiths and Benn 2007). Like stakeholder engagement and RDV, this work is partially descriptive and partially prescriptive, laying out the steps which firms must take to become truly sustainable. This literature highlights the role of the champion within the firm and the importance of communication (Johnson 1990, Ginsberg and Abrahamson 1991). However, the approach tends to be a "one size fits all" analysis which identifies major step changes, but which does not address what it is about the firm that makes these prescriptions so hard to follow. In addition, few studies take into account regional or sector level variations.

In summary, the literature on corporate sustainability identifies a number of key factors, deemed crucial for the mainstreaming of sustainability. These include: stakeholder engagement, firm level resources, including capabilities, and the role of champions. While all of these factors are clearly important, this literature tends to be highly prescriptive. Little is known about how the different factors combine in specific firms or on variations in firm level trajectories. Nor does this literature provide the analytic resources to explain why different firms adopt different strategies, with varying outcomes. In contrast, sociological versions of institutionalism combine an appreciation of these different factors with a more coherent explanatory framework.

Neo-Institutionalism

This research draws on sociological versions of institutional theory to explain variations in the mainstreaming of sustainability across three firms. In general, institutional theory draws attention to the relation between the broader institutional context – including formal regulations and standards, societal expectations and dominant ways of working – and individual or firm level action (Scott 2001). While the theory initially focused on pressures for convergence across firms (isomorphism), recent developments explore firm level variations and agency (Delmas and Toffel 2012). A central focus of this literature is on the impact of dominant understandings of problems and associated rules and sanctions on firm level activities. While some firms conform to broader institutional rules, others may try to avoid the cost of change by decoupling their symbolic responses from their everyday practices (Hironaka and Schofer 2002). These observations draw attention to variations in how firms align institutional and environmental targets with internal strategies.

In the past decade, neo-institutional scholars have turned their attention to problems of corporate sustainability (Jennings and Zandbergen 1995, Bansal and Roth 2000, Lounsbury, Ventresca and Hirsch 2003). Key theoretical contributions include: a focus on institutional entrepreneurs and their role in shaping both firm level responses and institutional requirements (Larson 2000, Hall, Daneke and Lenox 2010), the role of organisational culture in inflecting firm level responses (Milstein, Hart and York 2002, Howard-Grenville 2006) and the importance of firm history in accounting for variations in firm level response (Levy and Rothenberg 2002, Sastry, Bernicke and Hart 2002). This research considers the nature and impact of all three of these factors in each of the three cases.

RESEARCH DESIGN

The research adopts an interpretivist approach, which fits with the neo-institutional concern for meaning and processes. It uses a small number of in-depth case studies and qualitative data to document variations in firm responses to external demands for sustainable construction. The case study method adopts a 'holistic' approach (Ragin 1992) to one or more (complex) units with the aim of "elucidating features of a larger class of similar phenomenon" (Gerring 2004, p.341). As such, it directs attention to the dynamic interaction between factors within a case. In addition, case study research focuses on causal mechanisms (Hedström and Swedberg 1996). As such, it is particularly suited to the study of strategic change and change management in complex organizations.

Three roughly comparable firms were selected as case studies. Two are large construction firms (with extensive engineering consultancy businesses), while the

smallest is an engineering consultancy firm. All three are multi-national firms and in all three the UK division has taken the lead in mainstreaming sustainability for the firm as a whole; research therefore focuses primarily on UK initiatives. Each firm underwent significant organisational change during the course of this research. While these were not driven by sustainability related concerns, they did provide the firm with an opportunity to strengthen, affirm or downgrade its commitments. Table 1 (below) provides a general profile of the three cases.

Data Collection

Data collection combined semi-structured interviews and documentary analysis of annual corporate reports. The former provided insights into the understanding and experience of employees within the firm, the implementation of formal strategies and the impact of entrepreneurial initiatives. The latter helped to document changes in firm level strategy and senior management support It also provided a historic record of changes in the importance and location of sustainability within the firm.

Interviews

Interviews focused on the professional services in each firm. This included a range of functions and roles including Sustainability CSR, Quality Control, Health and Safety, Finance, Marketing and HR. For each firm the sustainability champion and at least nine other individuals within the firm were interviewed. Interviews lasted between fifty and ninety minutes and were recorded, transcribed and anonymised. In total thirty four semi-structured interviews were conducted for this research.

Corporate Reports

Corporate reports are standard sources of data for the study of firm level change (Sastry, Bernicke and Hart 2002). By charting variations in discourse about sustainability, noting changes to the organisational structure and following leads suggested in the published reports, a history of the firm's mainstreaming of sustainability can be re-constructed. These documents reveal both the outwardly communicated message and the internal conflicts arising from firm culture and strategy. In the past decade all three firms began to publish specialised CSR reports alongside their annual report. In the past two years, all three have replaced these with a separate 'Sustainability' report. Twenty two Annual Reports and eighteen Sustainability/CSR reports were analysed for the research.

Table 1: Profile of Case Study Firms

	Firm I	Firm II	Firm III
Type	Engineering Consultancy	Construction & Engineering Consultancy	Construction & Engineering Consultancy
Approx Global Revenue	£450m	£10bn	£5bn
Employees	6,000	60,000	45,000
Main Business Units	Development, Natural Resource, Transportation	Infrastructure, Engineering, Consultancy	Infrastructure, Buildings, Business Services

Data Analysis

NVivo 9 software was used to analyse interviews. This software allowed transcripts to be analysed against a set of categories or nodes which had been derived from neo-institutional theory. These included: the location of sustainability in the firm's formal structure, formal strategy – including internal and external outreach, the location and activities of (formal and informal) champions, organizational culture and the history of the firm's engagement with CSR and sustainability related issues. Published corporate reports (both Annual Reports and Sustainability Reports) were analysed for evidence of firm experience and engagement with sustainability. Reports spanning the last decade were examined to chart changes over time in the way the firm talked about sustainability, how sustainability was measured, and the hierarchical position given to the sustainability champion.

FINDINGS

Data from the three firms was analysed using a neo-institutional framework to explain the variation in mainstreaming sustainability and to find ways of describing this. Three types of comparisons are discussed below. These include: frames, location and history and culture.

- Frames. This heading includes the way firms talk about sustainability and how it was seen to fit with firm strategy
- Location. This refers to how sustainability was organised within the firm. It encompasses the location of the sustainability champions, their 'fellow travelers', as one interviewee described them, and sustainability expertise more generally.
- The history and culture of the firm. This refers to those events and characteristics deemed essential to explain variations in frames and location.

Frames

Analysis of interviews revealed three distinct ways of talking about sustainability: sustainability as cul**t**ure, sustainability as an opportunity, and sustainability as risk.

A striking feature of the analysis concerns the consistency of these differences within firm specific interviews. Employees within each firm demonstrated a common understanding of the meaning of sustainability in their firm, with a sharp contrast between firms. A comparison of the statements by sustainability directors (Table 2) serves to illustrate this contrast. Table 2: Visions of Sustainability, as expressed by Formal Champions

Table 2: Visions of Sustainability, as expressed by Formal Champions

	Summary	Statement
Firm I: Sustainability as Culture	Sustainability as part of good design and project work	"….we embed sustainability within the way we do things, so to have a separate large sustainability (unit) would then be counter intuitive and would actually go against the grain..."
Firm II: Sustainability as Opportunity	Sustainability as a business opportunity (like all others).	"..If our clients want to be more sustainable then [we must] change the way we do work – it's an opportunity…"
Firm III: Sustainability as Risk	Sustainability as a dimension of good project management, comparable to Quality control, and Health and Safety.	"…Sustainability is part of risk management…..thinking about the negatives, managing the locals and giving something back all save time and money in the end – they are worth it…"

Location

Differences in the framing of sustainability between firms were paralleled by differences in the location of sustainability within the firm. Key dimensions include the position of the formal champion within the organisational structure and their access to both Senior Management and business units. These contrasts are summarised in Table 3.

Firm I: In 2007, the main board asked one of their members to oversee sustainability related activities and in 2008 they appointed a sustainability director from outside the firm. This formal champion was located in corporate services, with no leverage over business units and no single supporter at main board level. The champion was one of a team of two. His primary role was outward facing, while his colleague focused on internal initiatives. In terms of business unit buy in, the formal champion relied on persuasion. A sustainability group, consisting of the senior members from each business unit was formed; however there was no cost code for participation and attendance was sporadic.

Firm II: Sustainability was identified by a UK business unit in 2008 as an area of business opportunity and a small (sub-) business unit was set up to bring in sustainability-related work. Individuals within the team worked hard to grow it and to use business to develop and roll-out a firm wide policy. In 2010, the UK business was restructured and sustainability gained its own separate business unit. In contrast to the other two firms, formal sustainability roles were subject to billable hours – in line with other business units.

Firm III: The sustainability champion was an internal appointment. As in Firm I, he was located in corporate services. In contrast to the situation in Firm I, the original sustainability champion worked closely with the main board who were actively engaged in the ongoing development of the strategy. Because of his prior experience in business units, he developed an approach which mapped onto dominant firm level practices. In contrast to the other two firms, sustainability in Firm III was integrated into the firm's Integrated Management System (IMS). This, in turn, ensured a visible presence in every business unit and every project.

Table 3: Organisational Structure and Location of Sustainability Champion by Firm

	Firm I	Firm II:	Firm III
Recruitment	External	External/Internal	Internal
Location of formal champion	Group Services	Business Unit	Group Services
Main Board support	Weak	Weak (with strong UK support)	Strong
Internal engagement	Sporadic	Informal	IMS, Core strategy goal, Internal branding

History

Information from interviews and published reports was used to map histories of the three firms and to trace the introduction of sustainability into each firm. These findings are summarised in Table 4.

Firm I: In 2006, two developments helped to carve out a space for the subsequent introduction of sustainability into the firm. First, the main board decided that the firm should produce a CSR report in addition to the corporate annual report. Secondly, one of the business units introduced specialised sustainability services as a business offering. This initial offering was later expanded as part of a very ambitious overall growth strategy. In 2008, an external sustainability expert was recruited to deliver sustainability and was located in corporate services. His influence was somewhat limited as there were no channels for regular reporting to the main board. In addition, there was confusion over the division of functions between sustainability and CSR. This tension reflected a more general confusion in firm structure, arising from mergers and acquisitions and a culture of decentralisation.

Key internal sustainability initiatives included advice at bid level (which was limited to a small number of projects), benchmarking of office statistics (recycling, energy consumption etc.) and advertising individual project achievements in the firm's internal publication. Sustainability reporting was limited to office statistics and was not treated as a priority at senior level. Data collection was carried out by willing but under-resourced business unit volunteers who were allocated insufficient time and capacity to complete the task. The sustainability team devoted a great deal of time to internal promotional activities and to developing a firm specific comprehensive assessment tool, but at the time of the study it was just nearing completion and had not been rolled out. In 2009 the formal champion produced the first sustainability report for the firm, in lieu of a separate CSR report. In 2011, following restructuring along regional lines, the sustainability budget was cut and the specialised roles were abolished.

Firm II**:** In 2008 sustainability was recognised by a business unit senior manager as providing a revenue opportunity. A formal champion was brought in from outside the firm to develop this area. At the time of the initial interviews, sustainability was a sub-unit within a larger business unit and the team included 15 people, most of whom offered services such as BREEAM assessments and sustainability advice to clients. In 2009, the head office produced the firm's first sustainability report. As in Firm I, the official sustainability champion had no formal leverage over other business units and relied on persuasion to win support. This was helped by the corporate report which signaled the parent company's commitment. In Firm II this took the form of extensive internal networking around specific projects and bids. The champion organised

regular virtual meetings with colleagues across the multi-national firm to contribute to sustainability related business projects and shared learning. Reporting of sustainability was confined to office statistics and select projects and information was gathered by volunteers. This was partly in response to head office request. There were initiatives to measure and communicate sustainable value added to clients, however, at the time of the research, these had not been taken up in a systematic manner.

In 2010, following the UK Climate Change Act, sustainability was identified by international management as a potential growth area. Restructuring resulted in the creation of separate sustainability business unit.

Firm III: Following a major environmental incident in 1994 the company recruited an external committee to implement a sustainability review. Following a demerger, this committee was replaced by an internal champion and in 2002 the firm's first sustainability policy was published. Sustainability was declared to be a business objective in 2004 and benchmarking of progress began. The sustainability policy was aligned with government strategy at this time. A main board director was given responsibility for sustainability. At the same time sustainability was integrated into the central management system, with representatives in every business unit and on every project. In addition, a number of sustainability advisors were appointed to provide additional support to business units. Performance on sustainability was reported at board level. In 2007 internal branding was established as a means of raising employee awareness and buy-in. In 2010 there was a major re-structuring within the firm, but the integrated status of sustainability remained largely unchanged.

Table 4: Sustainability Milestones by Firm

	Firm I	Firm II	Firm III
First Sustainability Report	2006-CSR	2008	2002
Appointment of first Sustainability champion	2008	2008	2001
First mention of sustainability as a revenue generator	2006	2008	2004
First attempt at sustainability benchmarking	2009	2009	2004
Sustainability as a business objective	2009	2010	2005
Internal branding of sustainability	N/A	2008	2007
Reorganisation 2010	Sustainability budget reduced	Sustainability becomes business unit	Sustainability remains a central function

DISCUSSION

This research explores variations in the mainstreaming of sustainability across firms and the relationship between the framing of sustainability as a problem and implementation within each firm. In considering these findings, it is important to keep in mind that this research focused on firm level commitments to sustainability. As such, it says little about the ability of the firm to deliver highly sustainable projects when clients request them. All three firms are highly respected, all have the requisite technical capabilities and expertise and all have produced individual award winning, sustainable buildings and infrastructure. This research is premised on the assumption

that one of the main challenges facing this type of firm is to move from isolated flagship projects to the integration of sustainability into everyday practice across the firm.

All three firms appear to have made a commitment to sustainability, all have engaged in significant outreach to external stakeholders and all have adopted internal benchmarking; however they differ in their understanding of sustainability (framing), its location within the firm, and in their internal strategies (as shaped by their organizational culture and history). Employees at Firm I talked about sustainability in a diffuse way, describing it as 'something they already do'; this is described as a view of sustainability as culture. In Firm II employees talked about sustainability in terms of business opportunities and profit. In Firm III sustainability was presented as a source of risk. Three factors would seem to influence the content and effectiveness of sustainability strategies: organisational structure, senior management buy-in and the fit of sustainability and firm culture.

Large construction firms and engineering consultancies are heterogeneous, multi-divisional, complex entities which oscillate between centralising and de-centralising tendencies. Where they fall on this continuum influencesthe type of sustainability strategy which they adopt and its effectiveness. Of the three case studies, Firms I and II were more decentralized in their structure and practices; Firm III was more committed to centralization and standardizing practices across the firm. This, in turn, had implications for the location, content and effectiveness of internal sustainability strategies. In Firm I sustainability was located in corporate professional services; this limited the effectiveness of the sustainability champion. In Firm II, sustainability was located in a number of business units. Decentralization allowed for niche developments and entrepreneurship, but it impeded the diffusion of innovations across business units. In Firm III, centralization and the standardization of practices supported the integration of sustainability into existing management systems and supported its diffusion across the firm.

The importance of senior management buy-in is clearly evidenced in the contrast between Firm III on the one hand and Firms I and II on the other. In Firm III, the mainstreaming of sustainability was driven from the very top and benefited from continuity in senior management. In Firm I, sustainability was not a priority for the main board. It was not integrated into the core business strategy. Moreover the absence of regular reporting left it relatively invisible to its employees. This fits with more general observations in the literature concerning the importance of board level engagement (Hoffman 2006). Firm II offers a transitional case. In the course of the study, sustainability rose from a business unit activity to a clearly identifiable core strategy, although how this will be institutionalised remains to be seen. This shift in senior management buy-in is largely down to the skill of the formal champion and his team who very effectively used the firm's commitment to profit making to draw attention to their cause.

Finally, the comparison between the three cases underlines the importance of 'fit' between sustainability strategies and firm culture for the integration of sustainability across business units. In Firm I, sustainability champions were located in corporate services and did not have to bill their time. This was at odds with the dominant culture of the firm and undermined their authority. This lack of legitimacy, coupled with the absence of visible senior management support and the highly fragmented nature of the firm, severely restricted the roll-out of internally focused sustainability initiatives. In

Firm II, the location of formal sustainability champions in business units and shared billing targets, bought them a degree of credibility with fellow business units. Similarly, their strategy of winning business for the firm through sustainability services resonated with the firm culture and helped to change attitudes. The achievement of global management buy-in towards the end of this research attests to the success of this approach, although the roll-out of specific initiatives has yet to be fully realized. Finally, in Firm III, the more bureaucratic strategy of sustainability targets, measurement and reporting matched the firm's approach to quality assurance and health and safety compliance. These, in turn, reflected the firm's overall culture of risk avoidance. Employees uniformly recognize and embrace their firm's commitment to sustainability, although the impact of these 'core values' on projects still needs to be assessed.

CONCLUSION: 3 FIRMS, 3 RESPONSES TO THE AGENDA

Based on this research, large construction firms appear to be very good at the outer-facing work of engaging external stakeholders and of producing high quality demonstration projects. The challenge which they face is how to move from responding to client demand to developing a sustainable identity and culture. This research began from a criticism of the overly generic prescriptions which dominate the literature on corporate sustainability and a view that the mainstreaming of sustainability depends on a more nuanced understanding of variations across sectors and across firms. The aim of the research was to identify and explain how three construction firms have approached the challenge of mainstreaming sustainability. While the immediate aim of the research was not to document its impact on either firm practice or on the built environment, the assumption was that strategies will be improved by a better understanding of variations .

The research findings confirmed the initial assumption of variability across firms, thus challenging the adequacy of the type of generic prescriptions offered in government policies and in the literature on corporate sustainability. Analysis of the source of this variation suggested a number of factors, including the role of champions, senior management buy-in and organizational culture. While all of these factors figure in the literature, this study highlights the conditions which render them effective. Comparisons of the location of champions in different positions within the firm highlights the importance of giving champions the resources and authority essential to introduce change. It also points to the need for a 'fit' between the sustainability strategy and the dominant organizational culture. Research into senior management buy-in suggests that reporting and measurement are only effective when the information which they produce is fed up to the top and translated into a vehicle for recognition and reward across the firm. Stated differently, this research suggests that if the way a firm talks about and attempts to integrate sustainability is not in line with the firm's culture, de-coupling will occur. This is where what has been committed to and what can realistically be achieved are so different that mainstreaming cannot occur, and in extreme cases this results in a dramatic U-turn. Looking forward, this research suggests that mainstreaming sustainability depends on ensuring that champions have access both to senior management and business units, integrating sustainability related mechanisms into dominant systems and procedures and legitimating those commitments through visible senior management support and the alignment of incentive structures.

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OPTIMISING THE ROLE OF FACILITIES MANAGEMENT (FM) IN THE DEVELOPMENT PROCESS (DP): THE DEVELOPMENT OF FM-DP INTEGRATION FRAMEWORK FOR SUSTAINABLE PROPERTY DEVELOPMENT

Matthew Tucker [1], Mohd Rayme Anang Masuri and Mohd Nazali Mohd Noor

[1] *School of the Built Environment, Faculty of Technology and Environment, Liverpool John Moores University, United Kingdom*

The purpose of this study is to establish the critical success factors needed to optimise the integration of facilities management (FM) into the full development process (DP). This paper offers an initial finding towards development of FM-DP integration framework. An extensive literature review is provided, drawing critical links between FM, project management and property development and highlights the importance of integrating FM in the wider property life cycle. Differences in opinion with respect to the contribution of FM-DP integration to sustainable development are also highlighted. The paper found a broad understanding on the development process and different views on the most effective position of FM within the development process. FM aspects can be incorporated in four strategic areas in the development project namely the early stage (investment program, project initiation and planning and design stage), construction stage, operation stage (after handing over and occupational) and/or can be implemented throughout development process. The proposed FM-DP framework offers a new perspective on the role of facilities management in the full development process, and its wider contribution to sustainable development. This research provides new ideas into the current views on the importance of FM-DP integration. The framework provides social implications for the consideration of FM within the property and construction industry, and considers the critical factors required to fully integrate FM within this process.

Keywords: development process, facilities management, framework, optimisation, sustainable development.

INTRODUCTION

A review of related literature found that there are various elaborative descriptions and understanding of the property development process. Chodasova (2004) described the development process as a concept that involves various processes beginning with the project initiation, preparation of business case, design, construction proper, space utilisation, building operational and maintenance and business of the buildings.

[1] M.P.Tucker@ljmu.ac.uk

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Moreover, the development process comprises various expertise and skills in the management discipline inclusive of project management, construction management (Morris, 1988), briefing process (Yu, *et al.* 2010; Jensen, 2010), design management (Tzortzopoulos & Cooper, 2007), facilities management (Felten, *et al.* 2009), operational management (Quah, 1992), administration of property, service management, sustainability implementation, knowledge management (Blakstad, *et al.* 2010; Ruikar, *et al.* 2007) and space management.

Integration of facilities management (FM) in the development process is always a challenge to professionals in the property development and construction industry due to the complexity and multi-disciplinary professions in the construction project (Felten, *et al.* 2009). A number of studies have been carried out to harmonise multi-disciplinary knowledge and various experts in the early stage of development process (Jensen, 2006; 2008; 2009; Macomber, 2001). However, there is a lack of understanding and no real consensus on the importance of the integration of FM, to which there is a limited role of FM in the full development process. Even though FM is focused on the non-core service support to a business's core organisation objectives, the value added that FM could bring to the organisation should be taken seriously through strategic and systematic planning (Tucker & Pitt, 2009). It is argued that the integration of FM in the full development of a building will have a huge impact to the longevity of the building lifecycle, and have a positive influence on its sustainable development.

OVERVIEW OF THE DEVELOPMENT PROCESS

The development process is a concept that involves various processes beginning with the project initiation, preparation of business case, design, construction proper, space utilisation, operational and maintenance and business of the buildings (Chodasova, 2004). Building and facilities provided should serve its purpose of existence and satisfy the user's needs for its whole life cycle.

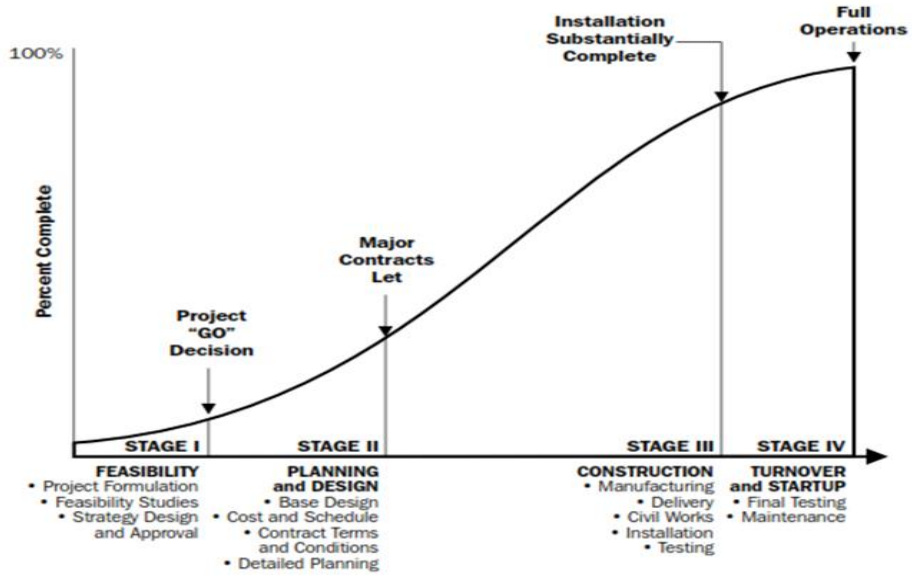

Figure 16: Life Cycle Stage

Morris (1988) illustrate that construction life cycle was divided into four stages. The diagram then was referred by the Project Management Institute (2000) which pointed out that contruction project life cycle consist of Stage I: Feasibility, Stage II: Planning & Design, Stage III: Construction and Stage IV: Turnover and Startup. Refer to

Error! Reference source not found.. Due to complexity and uniqueness of construction projects (Felten, *et al.* 2009), the Project Management Institute (2008) in its latest publication presented a new approach of the project life cycle with an "Overlapping Phases" concept in a new building project. This new understanding allows overlapping between stages (Wilkinson & Reed, 2008). Although it was regarded as an action of taking risks, conversely it encourages efficient coordination in the construction life cycle.

The construction industry is naturally linked to property development which is represented by sequential and structured construction activities and indirectly influenced by the economic environment (Wilkinson & Reed, 2008). The property development process is defined by Cadman & Topping (2002) as a process that involves changing and intensifying the use of land to produce buildings for occupation'. For further understanding, Wilkinson & Reed (2008) listed the development processes as consisting of eight (8) main stages as shown in Figure 17.

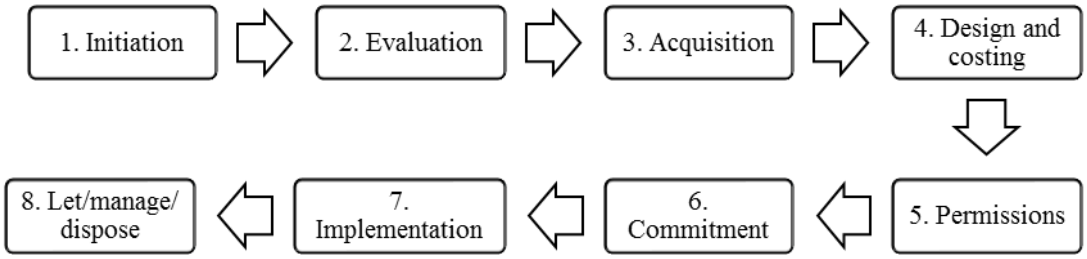

Figure 17: The Development Process

Further reading proves that the existence of differences in determining the levels of the development process. These differences indicate mixed views (Quah, 1992) from the stakeholders involve on the property development industry (Table 1). It is observed that FM was not considered important in the development process. This is in line with the view that FM is a non-core business that supports the organisation's objectives. (Lavy & Shohet, 2004; Shohet & Lavy, 2004; Lavy, 2008). However, FM should not be neglected at any stage of strategic planning as FM can increase the profile of organisation (Tucker & Pitt, 2009; Razali & Manaf, 2005).

In previous studies, there is very little discussion about the role of FM in the entire development process. FM is seen as vital at the operational level which is the final stage of the development process (Winch & Carr, 2001; Chodasova, 2004). This situation must be improved by placing FM involvement at all levels of the development process. Moreover, optimising the role of FM in all stages of the development process will contribute to the sustainability of facilities.

POSITIONING FACILITIES MANAGEMENT (FM) IN THE DEVELOPMENT PROCESS (DP)

The British Institute of Facilities Management (BIFM) define FM as the 'integration of processes within an organisation to maintain and develop the agreed services which support and improve the effectiveness of its primary activities'. Meanwhile, FM is defined by the International Facilities Management Association (IFMA) as 'a service provision that encompasses multiple disciplines to ensure the satisfactory functionality of the built environment by integrating people, place, process, technology and environment'. From the various definitions of FM, the key element that pulls the attention is the integration of the process in the organisation function. It is very common that FM related issues in organisations receive a lot of complaints from end-

users with regards to the dissatisfaction with the operational services of a building. The problem is often caused by lack of the coordination between the stakeholders involved during the planning and design stage (Chodasova, 2004). There is an argument to suggest that properties can therefore not meet their purpose as a result of neglecting the operational elements of the building in the design stages.

In the property development and construction industry FM is supposed to play a major role in the planning stages and should be able to forecast the performance of the building at the commissioning and utilisation stage in order to satisfy the end users for the whole life cycle of the building (Felten, *et al.* 2009, p. 116). Therefore, the facility managers must be allowed to involve in the strategic planning level and should be able to monitor the achievement. Even if the decision for long term forecast (two to five years) tend to be inaccurate, Nutt (2000) pointed out that the organisation is able to maximise the prediction accuracy for the building operation based on the short term trends and behaviour of the building.

Based on the literature, there are various arguments on the importance of FM to be positioned in the development process and its significant contribution to sustainable development. Havard (2008) discusses the development process from tactical aspects specifically in commercial and economic perspective. The 'market-demand project based' that he introduced was purely focused on the return of investment from the property. Based on his doctrine of property development, FM is only applicable if it suits to the method of procurement. Otherwise, FM can be neglected. Meanwhile, Hodges (2005) opined that FM integration during construction stage will extend its lifetime as well as solicit perceived satisfaction of users, increase productivity and reduce the damaging effects on the environment. On the contrary, Chodasova (2004) consider that the domain of the activities of FM is pertinent during the conceptual stage and utilisation of the buildings. Moreover, Shah (2007) contended that whole building life cycle needs for FM elements as early development process have a huge impact to end-users operation and organisation culture. In the case of existing buildings that were designed and constructed without FM consideration, FM is perceived to be the alternative to minimise the buildings vulnerability by complying with building regulation and shall be proven with end-users satisfaction (Wood, 2006).

IMPORTANCE OF INTEGRATION OF FM IN THE DEVELOPMENT PROCESS

Kincaid (1994, p. 23) appreciated Nutt's (1988) suggestion and his effort for inventing a simple definition of FM. Nutt (1988) defined FM is 'the management of facility resources and services to support the operation of an organisation'. It is affirmed that FM should be taken into account in the development process. An effective role of FM will enhance the performance of the organisations, flexibility in space use, efficient service delivery and offers sustainability to organisation's core business. As a result, FM is able to boost the organisation's major operations as well as maximise end-users' satisfaction and optimise profit (Razali & Manaf, 2005). Failure in knowledge management (Ruikar, *et al.* 2007) and design management (Tzortzopoulos & Cooper, 2007) has become synonymous with the construction industry. This situation is due to the absence of the techniques and technologies that can be tailored to the complexity of the construction industry. Continuation of knowledge or knowledge transfer (Jensen, 2009) in construction was divided into two situations (Figure 18). With the implementation of FM in the development process, the continuity of knowledge can

be ensured. This will increase the profile of FM in the development process. Indirectly, it contributes to the construction of long-lasting facilities.

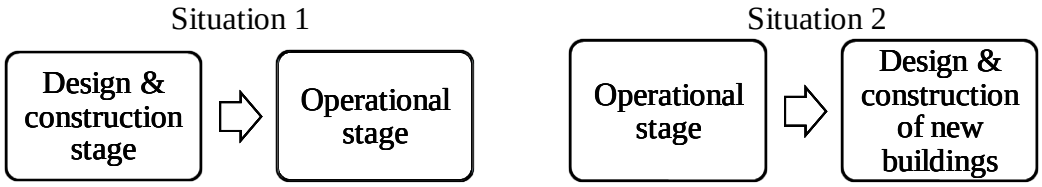

Figure 18: Knowledge continuity/knowledge transfer in development process

From the above arguments it shows that FM not only has a vital role to play in understanding and supporting the main activities of an organisation within the working environment (Amaratunga & Baldry, 2001; Junghans, 2011), but also in its contribution to the longevity of the buildings lifecycle. As Robathan (1996) states: 'Buildings-as property-are assets to be used to the long term advantage of the business. Indeed, it is only when organisations take the facilities director fully into the strategic planning process that the effect of the proactive management of facilities can be appreciated.' It is therefore apparent that FM knowledge should be formulated and implemented from the top down and it should be driven throughout the whole organisation by the encouragement of top management.

CONTRIBUTION OF FM TO SUSTAINABLE PROPERTY DEVELOPMENT

FM is in a strategic position to observe the activities in the development process and should be able to play a significant role in sustainable development. Considering the impact of the construction industry to natural resources and living environment, Khalil, *et al.* (2011) have revealed that there is a need for facility manager to play its role effectively in dealing with environmental issue. For years, sustainable development has become associated with the physical development that caused environmental deterioration.

Economic and social aspects are also an important issue in sustainable development (Hodges, 2005). Both aspects can be represented by facilities and human resources to demonstrate its impact to the sustainable development. Most organisations appreciate buildings from its tangible characteristics (Cooper, 1996) and considered building has less contribution to the organisation's core business. Conversely, Alexander (1996) claims that 15 per cent of organisation's turnover was spent to maintain and operate the facilities. Whilst, Hodges (2005) asserts that human resources are an organisation's largest expense and can count for up to 92 per cent of organisation's cost over its lifetime. Therefore, reduction in design and construction costs can have negative impact to the organisation's profit and working life. Hodges (2005) explains that facility manager can act as an advocate to sustainable development. He argued that sustainable development can be achieved through sustainable strategies initiated by facility manager. Deployment of FM knowledge can enhance sustainability value in the development process. Thus, optimising the role of FM is instrumental in achieving sustainable property development.

It is argued that FM can contribute in achieving the greatest environment, economic and social impact for a property development industry. It should also be stated that the success of sustainable property development lies in the capability of FM to optimise its role in the development process.

CHALLENGE TO INTEGRATE FM-DP FOR SUSTAINABLE PROPERTY DEVELOPMENT

Attending end-users complaints and carrying repair works on site is no longer appropriate for facility managers (Kincaid, 1994; Barrett & Baldry, 2003). The rapid evolution of technology have influence the users' needs. The needs keep changing and become more complex (Cigolini, *et al.* 2008; Jensen, 2010). Thus, the field of FM have to change and become more innovative in dealing with these challenges.

A study carried out by Elmualim, *et al.* (2005) found that the challenge for FM professionals to eliminate the vulnerability of the building design and operation is to enhance the efficiency of communication between facilities managers and other professionals. Inefficient communication contributes to the knowledge gaps (Elmualim, *et al.* 2009) that hinder the continuity of knowledge. Thus, the enhancement of communication in FM-DP needs to be improved. The field of FM is now occupied by various disciplines. This situation makes FM complex. A combination of inter-disciplines in FM should to produce better services and facilities. However, FM is exposed to the collision of professional interest (Felten, *et al.* 2009). Without mutual understanding, the project could suffer and even worse FM would be considered inappropriate in the development process.

FM is relatively new in the property and construction industry. Therefore, involvement of facility managers in the early stage of development process is perceived an alien. Conversely, the role of facility managers during operational is highly needed. This study contends that more can be done to drive these concepts into FM to better fit into the industry's culture and policy (Hodges, 2005).

MOVING FORWARD TO FM-DP INTEGRATION FRAMEWORK

As illustrated in the literature review, it became apparent that the role of FM in the full development process is critical, but the discussion about it is limited. It was therefore a need to develop a framework to optimise the role of FM in the development process which would in turn help enhance building design and usability. Due to lack of empirical knowledge about this area, a mixed methods approach was taken using 'sequential exploratory strategy' (Creswell & Clark, 2011). Refer Figure 19.

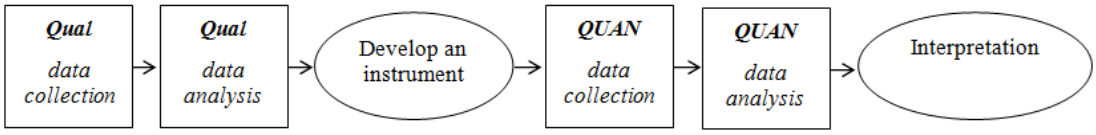

Figure 19: Sequential exploratory strategy with instrument development

A sequential exploratory strategy gives weight to the collection of qualitative data and to generate survey items and followed up by the collection of quantitative data in the second phase to help validate the initial qualitative findings.

CONCLUSIONS

The development process is complex because it involves various disciplines. This complexity creates confusion and gaps in the properties and facilities development implementation. Regardless of a generally wide understanding of development process, FM is not recognised except two common FM aspects: maintenance and operation. FM is acknowledged as a business support services in the organisation. However, if placed strategically in the development process FM can contribute to

increase the organisation performance in the form of operation output as well as corporate outcome. Continuous performance monitoring can be done through FM due to the ability of FM to fit into the organisation behaviour and culture. In the whole property life cycle, efficient FM service within the organisation will provide maximum return to stakeholders involved in the development process. FM is important to support sustainable property development. Ability of FM to extend the performance of buildings and facilities is an appropriate yardstick to measure the contribution of FM in the sustainable development. Challenges to integrate FM in the development processes have to be addressed and should be viewed as a success factors. Critical success factor is the approaches used to develop framework that will serve as a reference in optimising the role of FM in the property development industry.

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Table 6: Various Understanding of Development Process

Author	(Adams & Barndt, 1978)	(Morris, 1988)	(Winch & Carr, 2001)	(Chodasova, 2004)	(Project Management Institute, 2004)		(Macomber, 2001)	(Shah, 2007)
Stages of Development Process	Phase I: Conceptualisation Phase II: Planning Phase III: Execution Phase IV: Termination	Stage I: Feasibility Stage II: Planning & design Stage III: Construction Stage IV: Handover & Start-up	Define need Establish viability Conception Scheme design Detailed design Production planning Main trades Finishing trades Commissioning Facility management	Initial idea Conception Feasibility study Preparation of contract Origination of contractual obligations Construction works Completion and occupation Facilities management	Initial Phase Intermediate Phase Final Phase	Charter Scope Statement Plan Baseline Progress Acceptance Approval Handover	Formulation Design Construction Operations	Briefing Scheme design Detailed design Construction Operations Dismantling

Author	(Savolainen, *et al.* 2005)	(Wilkinson & Reed, 2008)	(Project Management Institute, 2008)		(Felten, *et al.* 2009)	(Jensen, 2009; Jensen, 2008)	(Barrett & Baldry, 2003)	
Stages of Development Process	Project Planning Design Construction Use	Initiation Evaluation Acquisition Design and costing Permissions Commitment Implementation Let / manage / dispose	Design Phase Construction Phase	Initiating Processes Planning Processes Executing Processes Closing Processes	Strategic planning Preliminary studies Project planning Invitation to tender Project execution Building operation	Decision Briefing Design Construction Occupation	Linear Process Planning Briefing Design Construction Occupancy	Cyclical Process Planning Briefing Design Construction Occupancy Evaluation

Author	(The Chartered Institute of Building, 2010)				
	CIOB Code of Practice for project Management for Construction and Development	**Office Government Commerce**	**British Standards BS6079-1:2000**	**British Property Federation (BPF)**	**Royal Institute of British Architects (RIBA)**
Stages of Development Process	Inception Feasibility Strategy Pre-construction Construction Engineering Services Commissioning Completion, handover and occupation Post completion review /project close-out report	Gate 0 Strategic assessment Gate 1 Business justification Gate 2 Procurement strategy Gate 3 Investment decision Gate 4 Readiness for service Gate 5 Benefits evaluation	Conception Feasibility Realisation Operation Termination	Concept Preparation of the brief Design development Tender documentation and tendering Construction	Appraisal Design brief Concept Design development Technical design Production information Tender Documentation Tender action Construction to practical completion Post-practical completion

DETAILED DESIGN ETHNOGRAPHY: ARCHITECTS EMBEDDING LOW CARBON PERFORMANCE

Gabriela Zapata Poveda[1]

Welsh School of Architecture, Cardiff University. King Edward VII Av. Cardiff, CF10 3NB, UK

The United Kingdom is aiming to enforce nearly zero carbon buildings by 2020. The plan has been set into three-year incremental periods to facilitate the transition to zero carbon. In 2008, the Welsh Government announced its aspirations to lead the low carbon pathway in the UK by enforcing higher reduction targets and adopting BREEAM as a planning application condition for new non-domestic buildings. It is anticipated that the building industry will experience changes in its working methods. However, the routine implementation of energy regulations by practitioners remains unknown. In this context, the detailed design phase was investigated to unveil how regulatory requirements were affecting routine architecture practice. The real-time development of a small number of non-domestic projects procured by design and build route was studied by ethnographic methods. The focus was architects' work during detailed design so to reveal how they adopted official tools to embed performance in the fluidity of the process. Architects were using the official assisted to different degrees by informal tools situated in the social context of practice. Architects working on detailed design were likely to transpose, follow and learn about the energy aspirations during low carbon problem solving. Official and informal tools could occupy central, peripheral and mediating roles in the design of low carbon; affecting the articulation of energy aspirations during detailed design and delivery. The in-depth understanding of how low carbon was embedded during detailed design provides insights about how practitioners coped with energy regulations and how low carbon design process could be improved.

Keywords: energy, design, building regulation, design and build, architecture.

INTRODUCTION

Energy regulations for carbon reductions in new buildings are urging practitioners to design and deliver better performing buildings. In the United Kingdom, the decarbonisation plan to zero carbon buildings by 2020 has been divided in three-year transitional periods to gradually enforce reductions and increase the understanding of the implications of more stringent energy targets. In 2010, new buildings were enforced to reduce their carbon emissions by 25 per cent. It is anticipated that the target by 2013 will be 44 per cent. Wales has the aspiration to lead the carbon reduction pathway so it is intending to aim for a 55 per cent reduction by 2013. The Building Research Establishment Environmental Assessment Method (BREAM), a

[1] ZapataPovedaMG@cf.ac.uk

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building rating system to assess sustainability, was adopted in 2009 as a planning application condition in Wales. Welsh non-domestic buildings of an area of 1000sqm or greater should be BREEAM Very Good and satisfy the Energy criteria 1, Reduction of CO2 emissions, to an equivalent of Excellent rating.

Official instruments have been made available to practitioners to comply with energy requirements. The key instruments are the regulatory standard and the calculation methodology to estimate performance. The British mandatory energy standard in new non-domestic buildings is the Approved Document Part L2A, Conservation of Fuel and Power which outlines the minimum targets. The compliance tool is the National Calculation Methodology (NCM) which has been translated to interfaces such as the Simplified Building Energy Model (SBEM). Proprietary simulations software aligned to NCM are also available for practitioners to analyse the building performance during the design process. The deployment of these tools is intended to enable the designers' understanding of energy matters during design, calculate energy performance and facilitate regulation compliance.

Despite the variety of official instruments available for practitioners to understand and evaluate low carbon and energy efficient design, there are significant discrepancies between as-design and actual building performance during operation, probably due to the processes and cultures in the industry (Zero Carbon Hub 2010). The process of developing skills, knowledge and supply of technologies and products to achieve the mandated carbon levels is estimated to take ten to fifteen years (ECEEE 2009). The building industry will have to upscale techniques and gain understanding of the practical implications of carbon reductions during the transitional periods towards nearly zero carbon (Häkkinen and Belloni 2011; Hamza and Greenwood 2009; Osmani and O'Reilly 2009).

Given the policy aspirations and the decarbonisation timeframe, there is a need to understand how the official instruments such as the regulations and the calculation methods are being used in the fluidity of the design process and how energy performance is embedded in routine design. This understanding might inform mechanisms to facilitate the adoption of energy regulations during the transition to nearly zero carbon buildings.

DESIGN AS A SOCIAL PROCESS

Social constructivist theories claim that reality is influenced by the social context where it is located (Berger and Luckman 1971; Law 1991). Action and behaviour is determined by the social structure. The individuals who are part of a social group create common frames of reference and meanings due to their daily interactions which result in typifications, habitualised actions, institutionalisation and legitimation (Berger and Luckman 1971). In the light of these theories, this investigation considered low carbon design as a process of social construction where shared repertoires and goals are negotiated in the social context.

Design could be regarded as a social process of negotiation of worldviews (Bucciarelli 1994) where the social aspects are likely to be a powerful means for knowledge and information exchange. Research undertaken in project environments has highlighted the importance of 'the informal' in the outcome of projects (Bresnen *et al.*t 2003) and the need to understand tools in their context of use (Brown and Duguid 1994). It has been suggested that this awareness may facilitate the provision of better informed and suitable tools as aids for practitioners. One of the limitations of design tools, aids and

official instruments is that they tend to be discrete and potentially limited for the use of a single professional or for a specific stage of the process. Both aspects might be detrimental to the continuity and common understanding necessary to solve energy matters. The social context of practice contributes to the understanding and learning as practitioners tend to develop internal routines and adopt informal strategies to achieve goals (Rowe 1987).

The social constructivist interpretation of design does not negate rational views or ideal models about the process. It acknowledges that the incorporation of official instruments may instigate conflicts or tensions within existing structures and patterns of practice (Suchman 1987). While analysing the incorporation of technology in practice, (Ihde 1990) raises attention to two flaw assumptions: that tools are merely instrumental and that they are completely determinative. He claims that both positions ignore the relativity of the relations human-technology and culture-technology. While technologies provide a 'framework for action', they are shaped by existing patterns, intentions and preferences.

The official tools for energy performance are intended to contribute to the application of low carbon in buildings though they could become a prescription imposed to practitioners if they do not get integrated as a natural part of the process. Little is known how designers are using the official in the context of periodic incremental changes. The enactment of low carbon policy aspirations by practitioners may be affected by routine patterns of practice. This research investigated how official, informal tools and patterns of practice contributed to embed low carbon performance during detailed design, with focus on the architects.

RESEARCH METHODOLOGY

The investigation adopted ethnography as a research tool to study how architects were embedding low carbon performance during detailed design since they are the practitioners likely to be involved during design and delivery phase. A detailed picture of the process was constructed by documenting the tools deployed by architects during routine project design. Four British architecture practices were recruited and four non-domestic projects were selected to study the design process during the 2010 energy regulation transition. The focus of the work was examining architect's work during conceptual and detailed design for buildings procured by design and build route, with emphasis on official, informal tools and routines for embedding low carbon design. This paper reports on the ethnographic findings of the detailed design, after the conceptual building design had been frozen and the planning application had been submitted. Detailed design corresponds to work stages E-K, according to the Royal Institute of British Architects (RIBA) Plan of Work, which is a British model of the building delivery process that outlines activities, deliverables and actors (RIBA 1998).

This study followed the contemporary ethnographic methods used in educational and medical research to investigate problems that overlap practice and policy dimensions which offer recommendations for interventions informed by the situated social context of practitioners (Delamont 2012; Hammersley 1992; Hammersley and Atkinson 1995) The data collection methods included semi-structured and opportunistic interviews, observational studies comprising non-participant observation in design and delivery team meetings and shadowing of architect's work, document analysis of project deliverables and informal documentation produced during design. Although the

architects were the main research participants, other team members of detailed design were included to construct a rich picture about the low carbon design.

The research design followed a generative research model where the early findings informed the development of further phases (Strauss and Corbin 1990; Coffey and Atkinson 1996). A grounded theory approach based on social constructivist perspectives informed the research, the data analysis and interrogation. The key aspect to investigate was the enactment of policy by practitioners, facilitated by the use of official tools in the social context of practice.

The researcher, being an outsider for the practices, did not impose her research agenda to the participants. The investigation documented and compared the real-time development of four non-domestic projects to find commonalities and differences in the processes. By comparing few case studies, reflexivity was encouraged to interrogate the data. No claim for generalisation is made. This research is bounded by time and circumstances. The researcher acknowledges the asymmetry of the ethnographic immersion as an inherent limitation of the method. However, by observing few low carbon design processes, rich information was obtained about the challenges and the enactment of regulations.

EMBEDDING LOW CARBON WHILE DESIGNING

Background

The case studies correspond to four non-domestic buildings; three of them located in Wales (case studies 1, 3 and 4) and one in England (case study 2). The fieldwork was undertaken between July 2010 and December 2011. Part L2A 2010 was the energy standard in all cases enforced from October 2010 and BREEAM 2008 the planning condition requirement for Welsh based projects, though all the projects aimed for BREEAM. The first regulatory gateway that practitioners faced was planning application, at the end of RIBA D. In cases 1, 3 and 4, the planning application required the commitment to BREEAM. In relation to low carbon aspects, Energy credit 1 comprised the achievement of an Energy Performance Certificate of 40. An approved calculation methodology was to be used to assess the energy performance. Due to planning application, the energy aspirations got inscribed as design requirements as part of the planning conditions. They became the energy aspirations to realise during detailed design and delivery. During detailed design, Part L2A 2010 was the regulatory instrument to be verified by building control authorities. It required a 25 per cent reduction of CO2 emissions. This improvement was calculated by comparing the estimated performance of a notional building and the building design. Additionally, Part L2A 2010 had 4 recommendations that include maximum thermal performance of building elements, solar overheating prevention, mechanical systems and ductwork testing and commissioning of systems. (Part L 2010)

Challenges in the process

The case study comparison suggests some potential problems arising during detailed design in relation to low carbon design and the enactment of the low carbon policy agenda. The critical instances where fragmentation was likely to occur were at the beginning of detailed design (RIBA E) and the transition between detailed design and delivery phase (RIBA J-K).

The architecture team must ensure the continuity of the energy aspirations and make the energy rational of conceptual design explicit to guide the subsequent phases. This

seemed critical in cases 3 and 4 where different architecture teams (within the same office) were involved during conceptual, detailed design and delivery phases.

The transition between detailed design and delivery is another instance prone to fragmentation when the design team had to transfer the ownership of the energy aspirations to the delivery team led by the main contractor. Architects and other members of the design team expressed their concerns about not achieving the energy aspirations from design because of the delivery team's different agenda. It was suggested that the delivery phase was driven by cost and time. Architects had the perception that the competing agendas of design and delivery phases could result in the lack or poor articulation of design aspirations and on-site drivers which undermined the achievement of low carbon intentions. Value engineering exercises were considered to be critical in reengineering the energy aspirations and drivers of the project. When the energy was not an explicit requirement, the value engineering could jeopardize the final energy targets. During delivery phase, only the minimum regulatory requirements were likely to be sought even though the initial design aspirations surpassed the minimum regulatory benchmarks. Architects claimed that the design aspirations might remain as good design intentions likely to be changed if the value engineering did not factor energy as an explicit requirement. If the energy performance was not a clear client requirement, pressing issues from the delivery agenda such as cost and time, could affect the continuity of the energy aspirations.

TOOLS TO EMBED LOW CARBON PERFORMANCE

A description of the tools used by the architects to embed energy performance during detailed design are presented and grouped in three categories: transposing, following and learning, corresponding to the low carbon problem solving activities, observed to different degrees in the case studies. There is no claim that these are the only or all the tasks necessary for low carbon detailed design. This classification is an aid to briefly document the cases studies. Each category has a table that outlines the use of the tools. In the following section some points concerning detailed development, simulation use and experience-based knowledge are further elaborated.

Transposing (RIBA E-F)

It is aimed to link design and delivery phases and facilitate the continuity and ownership of energy aspirations. It embodies the notion of forecasting and inscribing the energy requirements and connect them to performance, buildability, cost and site practicalities.

Table1. Transposing: tools to embed performance and their use

Tools	Use
Experienced based advice	To understand performance. Indicators: U-values of build-ups (all cases); G-value (case 1 and 3). It could start before detailed design though informal dialogue, workshops and meetings. The advice was given to architects by architects experienced in delivery, mechanical eng. and energy consultants.
Simulation (energy calculation tools)	To assess the detailed design and improve the accuracy of the model. In case studies 1 and 3, the model was factored against cost so to prioritise the more cost-effective low carbon strategies. In case 2 SBEM was used for compliance. In none of the cases architects deployed any quantitative method to evaluate performance, simulation was used by the mechanical engineers.
Dialogue with manufacturers and suppliers	To examine the suitability and compliance of specific details, related to thermal performance (all cases). However, the U-value might not be achievable when being delivered on site.
Details retrieval	To develop details, previous details were consulted informally. No general detailed documentation database was found in any of the cases.
Annotation on drawings	To clarify the performance of the elements in terms of U-values and G-values (case 1 and 4). Sequence of detail construction was included in case 4.

Tools	Use
Tender packages completeness	To prevent changes on site, rigour of information was necessary ('bullet-proof' information). The indicators were U-value (all cases), G-value (cases 1 and 3), airtightness (cases 1, 3 and 4). In case 4, 3D details were developed with a suggested sequence of construction.
Workshops to contractors bidding	To make the energy rationale explicit, inscribe the energy targets so to make the delivery team aware of the design aspirations (case 1, 3)

Following (RIBA F-K)

This could be developed during delivery phase when the architecture team gets novated and become part of the contractor's delivery team. It implies the assessment and monitoring the suitability of site proposals and changes to deliver the energy aspirations on site, as inscribed in the tender packages and specifications.

Table 2. Following: tools to embed performance and their use

Tools	Use
Experienced based advice	To understand performance in the light of buildability, cost, workmanship and delivery so to recommend or dismiss a site change. (all cases)
Simulation (energy calculation tools)	To articulate detailed design, energy aspirations and site work. It was invoked as a design aid to inform decisions (cases 1, 3 and 4); as a tool to negotiate with the contractor changes suggested by value engineering (cases 1 and 3) and as compliance tool to produce compulsory evidence for regulation (all cases)
Construction diary	To document the implementation of details and track changes on site, part of a specific investigation about thermal performance.
On site tests	To verify airtightness and mechanical systems performance (all cases). Results unlikely return to the architecture firm to inform the design assumptions made.

Learning

It implies the reflection about the process has the potential to contribute to learning and dissemination of practical low carbon knowledge based on experience. The

experience gained from designing could inform skills and enhance practical capabilities. However, this was unlikely to happen.

Table 3. Learning: tools to embed performance and their use

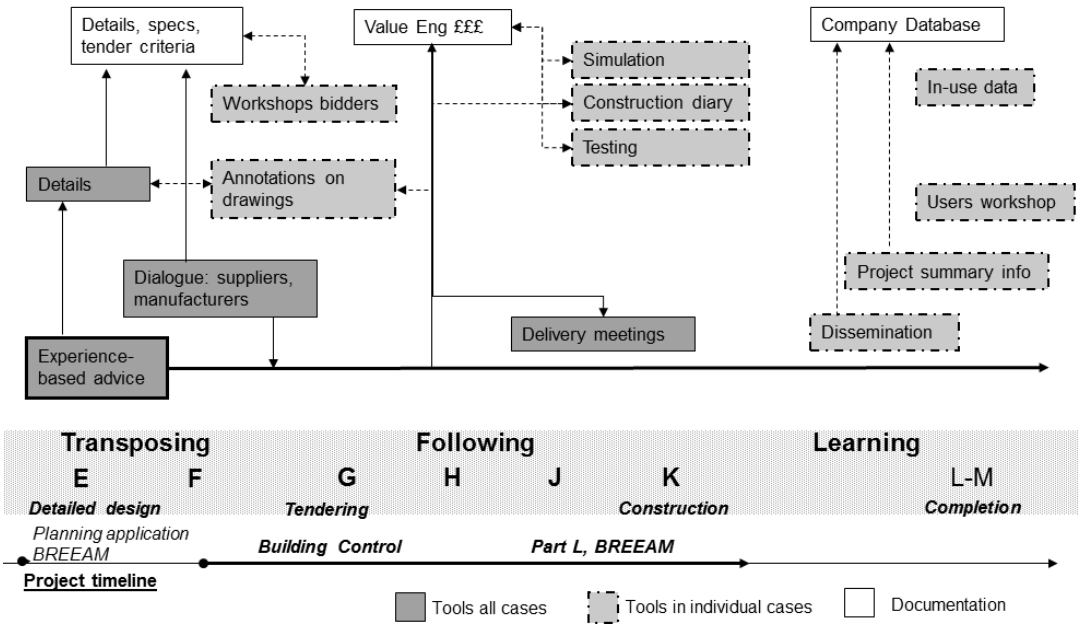
Tools	Use
In-house presentations	To disseminate information about targets and design experience in the office by presenting the projects to colleagues in the company (all cases)
Project summary info	To summarise information including energy aspects such as BREEAM rating, renewable sources, passive design. It was part of the database of projects.
In-use data (monitoring exercise)	To obtain the energy usage of the building. Only the clients in case 3 requested a specific target as contractual requirement (27kgCO2/m2year). In other cases, the metering reading was a referential value to record.
Users workshop	To inform about the operation of the building, use and maintenance of the systems. In case 3, there was an emphasis on educating the users about energy reduction. In all cases, a manual of operation was produced for the facilities manager.

Figure 1 illustrates the tools in their context of use. It is a 'snap-shot' of detailed design. It relates activities for low carbon problem solving, tools to embed performance, building delivery and regulation. It reads top-down and it includes:

1. Tools for embedding performance: The dark grey boxes represent the tools observed in all the case studies while the dotted light grey boxes represent the tools that were found in few cases. The white boxes represent the deliverables or documents produced by the time the tools were deployed. The arrows represent the relations between them. The tone of the arrow (dark, light and dotted) shows the role of the tool. The darker the arrow, the more central the tool was. The dotted arrows indicate the incipient use of the tools.

   1. Low carbon design tasks: transposing, following and learning;
   2. RIBA Work Stages referring to activities for project design and delivery
   3. Project timeline with corresponding regulatory gateways

Figure 1. Tools to embed performance during detailed design



DESIGN PRACTICE AND REGULATION

In this section, three aspects will be further discussed: the use of simulation, detail development and experiential knowledge and heuristics use during detailed design. They were selected to highlight the relations between simulation as the compliance tool and informal processes to develop detailed design and embed performance.

1. Use of simulation during detailed design

A rough model was available at the beginning of detailed design as evidence for BREEAM energy requirements due to planning application condition, however, design teams considered that this model based on conceptual design could be referential due to lack of the accuracy. As the detailed design progressed, simulations were invoked to produce evidence for building control compliance (Part L2A). Case study 2 only used SBEM to produce Part L2A evidence. In case studies 1 and 3, simulation was a design aid that aligned performance estimation, accuracy while factoring cost. In case study 4, although simulation was used during detailed design, it was intermittently invoked. Simulation was also triggered by the value engineering exercises that recommended changes in the design. In this circumstance, simulation enabled to understand the consequences of the changes and present evidence-based arguments to decline or support changes.

Architects expressed their distrust to simulation as a design aid due to the perception that it was an ‘academic exercise’ with limited accuracy, a time consuming task where ideal scenarios were represented but no certainty in the accuracy of the data input. The results were considered to be uncertain and probably ambiguous. For some, simulation was a regulatory requirement but not a design tool to estimate performance and inform the design. In such situation, simulation was regarded as an alien element that was not rooted in the process. If energy calculation tools and official tools to estimate performance were regarded as extraneous elements, their acceptance within teams did not seem to be based on their role as regulatory instruments. Calculation tools’ legitimacy seemed to rely in its position within the process. The social aspects underlying trust and partnering relations between architects who designed and mechanical engineers or energy assessor who created the simulation model had an effect on the regard of simulation by architects. When simulation was consistently invoked in the process as a design aid to monitor the aspirations and inform decisions, then architects seemed to trust the results. If simulation was only used to produce compulsory evidence for compliance, then results showing poor performance were criticised and simulation was perceived as a 'theoretical exercise'. The continuous use of simulation as part of the design process gave it legitimacy and trust.

2. Details development and details retrieval

Teams were prone to consult details used in previous projects as a basis for solving the new details. However, none of the case studies had an officially organised database to facilitate the detail retrieval or a repository of detailed documentation from previous projects. Unlike the widespread use of databases archiving project templates containing project summary information, no similar database was found for organising previous projects' details. The use of past details seemed to be central to detailed design but their retrieval was as an informal procedure. No official database or knowledge management system facilitated the reuse of details. Architects expressed that they consulted their colleagues who had worked in the past on similar projects to find out more information for details’ development.

Changing requirements seemed to be encouraging earlier considerations in the development of the details. Detailed design knowledge was invoked before detailed design during RIBA D to inform preliminary proposals and understand the possible energy performance. Although the details were unlikely to be developed before planning application submission; experience and technical knowledge about details informed the conceptual design and generally occurred before officially starting detailed design.

3. Experiential knowledge and heuristics

None of the architects in the case studies deployed any quantitative tools to assess performance despite all of the practices included in the study had expertise and experience in sustainable design. No evidence suggested that the energy calculation tools were part of the design aid toolkit used by architects. In order to understand performance, architects consulted colleagues to discuss about performance. This understanding was based on experience and feel for performance, encapsulated by rules of thumb and basic principles that had not been officially articulated nor tested quantitatively. Architects invoked experience based advice from architects and other team members such as the mechanical engineer and the energy consultants. Experiential knowledge also seemed to guide the analysis of simulation results. It was recurrently used to understand performance, even when energy calculation tools had been incorporated in the process.

CONCLUSIONS

It was observed that no design aids to quantitatively estimate performance were used by architects during detailed design. Architects relied on heuristics and experiential knowledge to assess the proposals while partnering up with the mechanical engineers to get feedback about the performance target achievement. Given the central and pervasive role of experiential knowledge and heuristics, they should be examined to assess their suitability to deliver the expected performance during delivery.

Additional detailed design tools could be available for the performance understanding during delivery. Embedding performance during detailed design might be incomplete and aspirations might not be achieved if the understanding is not informed by the actual performance obtained on site. Theoretical models, heuristics, experienced based knowledge linked to site test results might raise the practical performance understanding and enable the identification of discrepancies and limitations of design assumptions. The dynamic nature of problem solving where the official and the informal interact should be potentialised to contribute to the integration of the official in routine practice. The informal could mediate the adoption of the official in the fluidity of the process so the official is not imposed as a compulsory element.

Information related to details and site delivery does not tend to return to the studio to inform architects' detailed design and delivery assumptions. Design changes that occur on site are unlikely to be documented comprehensively. The chain of changes is rarely tracked, reducing the opportunities to learn about the design in the light of delivery phase evidence. Intended learning and reflection to link different stages of design and delivery remain peripheral in the process though experiential knowledge and heuristics were central to understand performance in the fluidity of the process. The lack or poor reflection could be detrimental to learning. Increasingly higher energy regulation targets demand teams to understand the possible performance earlier

in the process and embark on a learning process that connects different stages of development.

Further areas of work include the provision of mechanisms that facilitate intentional learning and the identification of key indicators and instances in the process to learn from designing. Such mechanisms should be part of the process to not disrupt design tasks nor interrupt the process.

While official tools contribute to low carbon design, they could become prescriptions to the process if they do not get appropriated in routine practice. The informal tools and the social context of practice might have a supporting role for the uptake of the official and the design of low carbon. Although simulation might be the central tool for compliance, it might not be incorporated in the design process as a natural part of it. The lack of integration undermines the effective deployment of simulation on the relevant instances of the process where the energy aspiration is understood and negotiated within the design teams. Embedding performance is not only matter of calculating the energy target. It is a process of negotiation where tensions and potential fragmentation has to be overcome. If simulation is only deployed as a regulation tool to produce compulsory evidence, then the tool is unlikely to inform low carbon design. Informal tools and social practices could support the understanding, negotiation and achievement of energy aspirations as mediators in the process. The social context where the process is situated is likely to affect the adoption, acceptance, integration, trust and tacit legitimacy of official calculation tools, such as simulation, that otherwise may be considered elements prescribed in the process.

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A CRITICAL REVIEW OF THE CONCEPT OF FACILITIES MANAGEMENT IN COMMUNITY-BASED CONTEXTS

Mohammad Tammo[1] and Margaret Nelson

Faculty of Advanced Engineering and Sciences, University of Bolton, Deane Road, Bolton, BL3 5AB

The concept of Facilities Management in a Community-based setting is derived from understanding the social value of community facilities and the management of community assets, which include people, buildings, voluntary groups and organisations. This research forms part of a PhD study, which aims to critically review the concepts of FM and translate knowledge into the community setting, in order to develop new thinking and demonstrate the added value of FM in the regeneration context. For the purpose of this paper, a critical review is undertaken to identify the key characteristics of FM in the community-based setting emerging from literature. Further analysis is then undertaken to demonstrate the potential contribution of FM to community development. The research identified five areas in which FM had the potential to make contributions in a community-based setting, namely: service management, social inclusion, strategic development, environmental and economic sustainability. These covered all the different aspects of the existing concepts and models, bringing together community and organisational issues.

Keywords: community development, facilities management, service delivery, urban FM, social enterprise.

INTRODUCTION

Facilities Management (FM) was first used as term in the early 1970s. It was introduced by academics and practitioners as a young profession with a very large portfolio (Varcoe, 2000) because of the diverse scope of functions it covers. Though older as a profession, FM still encompasses a wide range of functionalities from operations & maintenance, real estate, technology, auxiliary services, and planning, to finance and budgeting. The multi-disciplinary approach of FM has challenged researchers both in terms of subject and funding. FM research pioneers such as Alexander (1996) highlighted how early development of FM had its roots in practice. Others argue that FM does not have a research agenda and is more practice oriented (Mclennan and Nutt, 1992). It becomes clear that there is tension between FM at practice and academic levels, with practice more focused on the operational side of FM and its relation to the strategic possibilities, which has been the subject of much research (Lilliendahl *et al.* 2011). However, the absence of critical thinking and

[1] M.Tammo@bolton.ac.uk

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research in FM is supplemented by the diversity of FM research. Practitioners' perspective of FM focuses on the physical and economical factors such as information technology, the cost of effective workplace, globalisation, and user satisfaction. In which the social factors are missing such as integration with communities, sustainable development, and community engagement (Varcoe, 2000)

Gibson (2005) stated that "reformed public services need better community buildings" and "sustainable communities need sustainable buildings." This and the need for a new approach to effective public service delivery have led to the development of research into the added value of FM in a community-based setting. In this research, community facilities represent more than buildings to be used by residents; they are the main springboard for engagement and accessing local services. In addition, there is value to be added in terms of translation of FM approaches and principles from the corporate real estate sector to public service management, and a role to be played by community members in service delivery through social enterprises.

Both FM and sustainability have been researched in detail as separate topics. The concept of sustainable FM has only recently been highlighted by practice, but there is a gap in research knowledge. This paper aims to critically review the literature available on existing concepts and models in FM in a community based setting, to identify current position and gaps for future research to address. This will support the on-going research aims to clarify the role of FM in sustainable development and regeneration in order to translate the knowledge and practice from the corporate to the public sector, and to introduce new directions in the evolution of FM in public service management.

FACILITIES MANAGEMENT DEFINITIONS

Various definitions of facilities management by researchers and practitioners illustrate the broad magnitude of the discipline. Price (2002) articulated that FM was still debating its status as a profession and field of academic inquiry. Tay and Ooi (2001) suggested that the task of creating a common platform for the theoretical development of FM is faced with a barrier of multi-definitions. This view was supported by Smith and Pitt (2007), and further by Drion *et al.* (2012) who suggested an absence of any agreement on what Facilities Management means as a coherent body of knowledge. So ten years down the line from Price, we are still debating FM's status as a profession and field of academic enquiry.

Alexander (1996) approached FM as process by which organisations can deliver their service in a quality environment to meet their strategic needs. Barrett and Baldry (2003) viewed FM as an integrated approach to maintenance, improvement, and adaptation of organisation's facilities to meet its primary objectives. Others defined FM as an integrated profession that ensures services are tailored to suit people and places, though mainly as a reactive and technical approach (Kelly & Hunter, 2005). Smith and Pitt (2007) on the other hand defined FM as a stable balancing act between the competing pressures of time, cost and quality; whereas Hudson and Kasim (2006) had earlier proposed that the social and financial aspects of FM come together in one multi-disciplinary approach of FM involving not only the management of the organisation’s core business, but also the delivery of quality services to the users. Lilliendahl *et al.* (2011) proposed that unlike the previous approaches of FM which are most likely driven by an emphasis on business, social drivers come into play leading to the consideration of FM as “the science and practice of dealing with people, places, and societies”.

This is not an exhaustive list of definitions for FM, and there are even more definitions from FM associations and international networks including, from South Africa, FM as "an enabler of sustainable enterprise performance through the whole life management of productive workplace and effective business support services" (SAFMA, 2005). The European Committee for Standardisation (CEN) defined FM as "the integration of processes within an organization to maintain and develop the agreed services which support and improve the effectiveness of its primary activities (EuroFM, 2006). This definition has been adopted across Europe by national standards agencies and professional institutions. The International Facility Management Association (IFMA) defined FM as "a profession which encompass multiple disciplines to ensure functionality of the work environment by integrating people, space, process, and technology"(IFMA, 2008).

Drion *et al.* (2012) suggested that "organisations that treat FM as a commodity overhead will be at a significant strategic disadvantage" moving into the future. This implies that an advantage is achieved through approaching FM as an integral part of organisations' strategic plans. They further stated that at operational level, effective FM provides a "safe and efficient working environment, which is essential to the performance of any business whatever its size and scope". FM in the community setting therefore becomes crucial in translating strategic plans into effective operational reality. The traditional FM approach focussing on tangible factors concerned with design, construction and operations of buildings would need to make way for a shift in focus to productivity, effectiveness, and efficiency with consideration of the social implications of FM (Lilliendahl *et al.* 2011). For the purpose of this research, Community-based FM is defined as the integration of people, processes and place, to develop, manage and sustain effective and efficient services, which meet the socio-economic and environmental objectives of the community.

FM APPROACHES IN THE COMMUNITY SETTING

Community-based Facilities Management is a concept exploring opportunities for the development of a socially inclusive approach of FM (Hasbullah *et al.* 2010). It is "an emergent term that identifies the role that facilities and their management play in community life" (Heywood & Smith, 2006). This role is defined by the affiliation to the core of community business in which success is measured by the scale and quality of support to enable the community meet its objectives (Hasbullah *et al.* 2010). Several authors have coined new terms for this concept of FM including urban FM, FM as social enterprise, CbFM, Sustainable FM, and Community-based Asset Management. The first four are examined at this stage of the research.

Urban FM

Roberts (2004) saw Urban Facilities Management as an "idea that community management can be wholly externalized to professional service providers". He defined urban FM as a "logical extension of the need to reinvest in community facilities and system, and provide a flexible platform in which agencies and the private sector can come together in new and innovative setting for the benefits of the community". Urban FM was seen as a mechanism for developing a sustainable scheme for managing and operating public facilities (Tobi & Amaratunga, 2010). It is however based on the concept of outsourcing provision of public services in order to leverage knowledge and advantage of private sector FM experience. Urban FM can play a dynamic role in constructing positive changes in local neighbourhoods as well as facilitating innovative improvements for corporations (Lilliendahl *et al.* 2011). Its

philosophy lies in the use of social enterprise to create a model for managing public facilities (Steel *et al.* 2003); and create the right environment for economic and social growth in cities (Lilliendahl *et al.* 2011). However, this is subject to how communities or organisations approach social enterprise. Florida (2003) suggested a manifest shift away from traditional hierarchies towards open type of network organisation in the economy; moving from government to more networked governance and business minded new public management (Lilliendahl *et al.* 2011).

Roberts' (2004) perspective of urban FM was to rebalance the dominance of business imperative and shareholder value, by realignment of FM to the public interest and stakeholder value. He outlined two notions of broadening and deepening engagement between the private and public sectors in the provision of community services; and pulling together agencies responsible for social, health and voluntary services, and community and media. This is closely aligned with the current government's position, creating the right environment for adopting this approach. Roberts (2004) saw urban FM as a solutions provider for the public services sector with advantages of efficiency improvement to public services, greater level of services, and customer oriented public services. He further suggested that the integration of public service and community support could make a significant contribution to the principle of putting people first and meeting best value objectives. The ambiguity will be located in the private sector side, if social enterprise is business with primarily social objectives, the question will be whether this will meet its financial strategy. He also highlighted that if FM wishes to overcome its challenges in the public sector realm, it needs to shift from the traditional approaches towards a new model based on public interest. This was further emphasised by Tobi and Amaratunga (2010) with the need to move away from the traditional service provider approach in which local communities are faced with increased costs of managing, operating, and sustaining their public facilities.

FM as Social Enterprise

The former Labour government proposed social enterprise as the model for maximising the public good through business (DTI, 2002). Social enterprise was defined as "a business with primarily social objectives whose surpluses are principally reinvested for that purpose in the business or in the community, rather than being driven by the need to maximise profit for shareholders and owners" (DTI, 2002). FM as social enterprise was defined as a "new way of thinking on how to integrate organisational support services and the community support services" (Kasim and Hudson, 2006). The root of this definition dates back to the UK concept of social enterprise, which emerged from community investment activity. Community enterprise is seen as a need to identify factors concerning FM practice in the community context (National Housing Federation, 2005), including: engagement with local communities to promote local economic development and improve employability, and generation of employment to raise local communities' living standards.

In relation to FM, social enterprise has the potential to engage the community to participate significantly in the provision of community services. Kasim and Hudson (2006) debated that the future of FM lies in FM alignment to social community interest, which can be done by changing priorities and improving FM practice to support local communities. They saw social enterprise as promising for the development of Community-based FM; and argued for its unique role in helping form sustainable and socially inclusive economies, creating opportunities for people

working in them and for the communities they serve. Furthermore, they discussed the ability of social enterprise in offering alternative solutions for deprived areas. The level of autonomy in social enterprises makes it a viable business model to deliver the Big Society (Knox, 2011). This contribution may be addressed through the characteristics of social enterprise in engaging with local community, enabling individuals to participate in regeneration, and creating new models of service delivery (NRDA, 2005).

Community-based Facilities Management (CbFM)

Alexander and Brown (2006) further developed Robert's (2004) and Kasim and Hudson's (2006) ideas of urban FM and FM as social enterprise respectively; suggesting that social enterprise can be used as a ' new economics'. Their approach was to identify the involved processes and responsibilities in practice, then explore the opportunities for development of socially inclusive facilities management (Alexander & Brown, 2006). They debated that FM has the ability to add value by delivering social and environmental benefits as well as increasing economical viability. These benefits have been acknowledged by corporate shareholders and Price (2002) felt it was time to be extended to the community. CbFM is "the management of facilities and the delivery of services that reflects the community and environment in which they reside and operate" (Alexander & Brown, 2006). It aims to consider the impact and effect facilities place on the existing environment, empower local communities and spread economic profits to improve quality of life; and promote local economic development and offer more value to the community under corporate social responsibility.

CbFM is a toolkit developed by the Centre for Facilities Management to assess organisational responsibility by evaluating their process transparency. Alexander and Brown (2006) suggested that FM "can assume a central role in local partnerships for regeneration"; and assess the organisation’s engagement with customers, employees, services and the community, in order to manage the social, environmental, and economical impacts. The original CbFM model focussed on four areas of impact assessment namely, environment, workplace, social, and economic, alongside three key dimensions of governance, socio-economic development and environmental focus (Alexander & Brown, 2006). The current version has six areas of impact assessment, adding accessibility and resilience. Alexander and Brown (2006) labelled the development of corporate social responsibilities in FM as ‘social enterprise’; arguing to create a role for FM in community development, as they saw FM at the heart of urban policy and neighbourhood regeneration. Their approach to the community as an economic multiplier enables FM to play a wider role in regeneration.

Sustainable Facilities Management (SFM)

SFM views sustainability as a core component of FM. Many FM practitioners and researchers build their research and community of practice on the three main components of sustainability - economic, social and physical/environmental. Shah (2007) had previously stated that the integration of sustainable development in facilities management is not new. Furthermore, he posited that organisations have moved to the second stage of proactive engagement of sustainability linked to the provision and delivery of services. The Danish Centre for Facilities Management (DCFM) developed this concept through investigating the role of FM in sustainable development on a societal level (Nielsen & Galamba, 2010). In this approach FM is discussed and defined in terms of its relation to sustainable development, and its aim

to build a strategy for FM to act sustainably, enhance the environmental management practice, and construct a communication strategy (Nielsen & Galamba, 2010). The definition is biased "towards technical and system solutions for isolated environment problems" (Nielsen & Galamba, 2010).

METHODOLOGY

A qualitative enquiry approach is used in this research with a variety of data collection and analysis tools and techniques including literature review, interviews, content analysis, documentary analysis and thematic coding. Interviewees' were selected by using a purposeful sampling strategy. The first phase of the research focused on the critical review and analysis of diverse literature, approaches for community based FM, and examples of these approaches' application where used. Analysis included SWOT, content analysis, and cross analysis of objectives against concepts.

RESEARCH FINDINGS

The literature and document review helped to understand the theoretical background of FM in the community context. Although there was plenty of literature on FM in the corporate real estate sector, there was very limited literature on FM in the community context. Most of the literature available also discussed theoretical concepts (Roberts, 2004; Kasim and Hudson, 2006; Nielsen and Gambala, 2010). The focus on sustainability within FM was identified as one of the key issues driving the adoption of FM in the community setting, as was the development of the concept of sustainable business practice. In addition, new initiatives such as PFI and PPP raised questions about the contribution of community facilities to community life (Heywood & Smith, 2006). Community facilities can play symbolic roles in their communities, and their effectiveness and sustainability carry a clear message about the community values. The role of community facilities in community life may vary from provision of services to creation of job opportunities, and the creation of spaces to support community activities to their impact on the sense of belonging through engagement and occupation; which are some of the main challenges for community development. Heywood &Smith (2006) suggested that community facilities are capable of greater contribution to community life than just being accommodation, a view which still needs to be demonstrated. The coalition government's drive towards the development of social enterprises as part of the 'Big Society' agenda also created new opportunities for FM in the community in terms of job creation and engagement of community in public service delivery.

However, the lack of implementation and application of community based approaches proved to be a real challenge in analysing the value added by the concepts to the community; as only the CbFM concept (Alexander and Brown, 2006) has been developed into a model, and applied in assessing community facilities. Comparative analysis (table 1) of the concepts showed similarities and differences between these approaches according to themes derived from the literature review. Table 1 shows the characteristics and objectives of each approach. Urban FM and FM as SE are still in the conceptual stage and are yet to be implemented in practice, or evaluated. Both approaches did not adopt the environmental aspect of community development which is a significant component of sustainable development. Some critics of Urban FM suggest that it is a platform based on outsourcing service provision to professional providers with priority given to the private sector to lead, and with no guidance on how this platform will work (Tobi & Amaratunga, 2010). Although, Roberts (2004) did not give any guidance, he clearly illustrated without any given priority how

agencies and private sector can work together in an innovative way for the interest of community.

Table 1 Critical review and analysis of FM approaches in the community setting

	Urban FM	FM as SE	CbFM	SFM
Level of intervention	Strategic, operational	Strategic, operational	Strategic, operational	Operational, technical
Target of intervention	Communities, Local service delivery	Communities, Local service delivery, local economics	Communities, Local service delivery, local economics	Organisations, Local service delivery
Unit of analysis	Management of community facilities	Management of community	Management of facilities in the community	Management of organisations
Alignment of FM	Public interest	Public interest	Public interest	Private interest
Drivers	Social	Social	Social	Environmental

Urban FM and FM as SE have similar advantages in that they are socially driven for the benefit of the community and public interest. They also have similar challenges, which should be considered in any new thinking of FM in the community setting, some of which are: the internal capacity of the community may lead to poor performance; and applying the concept requires high level of managerial skills which will affect the quality of the final product. The need for work to be done to distinguish between social and community enterprise was also identified. In contrary, CbFM as a model has been applied in evaluating different contexts and communities. Analysis of these evaluations identified an advantage over other related concepts in the consideration of social, environmental and economic components of sustainable development. The main disadvantage is that the model does not address the strategic planning stage of community development.

Table 2 Critical analysis of CbFM evaluations of community facilities

	Example 1	Example 2	Example 3
Functions	Education & enterprise	Education	Health & entertainment
Integrated dimensions	4	3	3
Community engagement	Negative	Positive	Positive
Accessibility	Negative	Positive	Positive
Good location	Positive	Positive	Positive
Community awareness	Negative	Positive	Positive

Further analysis of the CbFM model evaluations (table 2) highlighted that a maximum of four out of six dimensions have been identified in use in practice, with two cases demonstrating only three dimensions. This flexibility of implementing whatever dimensions are applicable might be considered as an advantage; though on the other hand it could be a disadvantage as it is therefore difficult to measure the success of the model. It also highlighted that although the facilities' location played a major role in terms of accessibility, this has to be combined with community engagement and awareness to show a positive result. The results appear to confirm Gillespie and

Murty's (1994) supposition that analysis of the service delivery system provides useful insights on the impacts of various community linkages.

The SFM concept differs from all others in that it is focussed on the organisational and operational issues related to the environment, whilst others are focussed on communities and the strategic issues related to social drivers. The SFM is also aligned with private organisational interests rather than the public service interest. The thematic analysis of the literature identified five perspectives for FM in the community setting as follows:

1. Service perspective: FM in the community setting should provide facilities that enable effective delivery of services in response to local needs.
2. Community perspective: Management of community facilities should include social objectives and involve community members. The management process should empower the community and support the development of confidence and skills, and their ability to shape relations with all public bodies. The facilities should create a platform for engagement, and this is closely linked to the facilities' accessibility.
3. Strategic planning perspective: A strategic FM approach to community facilities would enable facilities managers analyse the urbanism context, and apply principles of engagement with public space such as integrated instead of segregated, invite instead of repel, and open up instead of closing in (Gehl 1980). This approach should enable FM to be fully engaged in urban planning and participate in decision making from the early stages; planning strategically for future needs instead of reacting to issues due to poor management.
4. Environmental perspective: Facilities should be eco-friendly and environmentally sustainable, and awareness of environmental issues raised with the community, including behavioural change.
5. Economical perspective: Facilities should be economically viable and sustainable, and services affordable by the community. The development of social enterprises would create opportunities for members of the community to set up their own businesses and create local jobs.

These five perspectives form the elements of a community based approach to Facilities Management in which all the previous concepts will be presented. Those perspectives will be examined in order to enable this approach to act as new service delivery model in managing communities' facilities. Table 3 shows the links between each approach and these five perspectives.

Table 3 Mapping exercise shows the excluded & included perspectives in each concept

	Urban FM	FM as SE	CbFM	SFM
Service perspective	Included	Included	Included	Included
Community perspective	Included	Included	Included	Excluded
Planning perspective	Included	Excluded	Excluded	Excluded
Environmental perspective	Excluded	Excluded	Included	Excluded
Economical perspective	Included	Included	Included	Included

CONCLUSION

FM in the community-based setting aims to contribute to the creation of sustainable communities through a stakeholder approach to the management of community

facilities. As we have seen, community facilities have a vital role to play in supporting communities, and FM is positioned to make contributions leading to improvements in quality of life, sense of belonging, and providing affordable local services. FM in a community setting is a people-based approach, which could act as an economic multiplier with emphasis on social objectives involving multiple stakeholders. Integrating stakeholders into public service management and delivery processes will significantly improve the facilities use and the benefits to the communities that serve. FM also has a role to play in facilitating and managing the relationships between the multiple stakeholders in community development. Moreover, findings from the analysis of existing literature indicated that research on the added value of FM in a community setting is not yet clearly defined. This may however include providing quality and cost effective services and enhancing community efficiency, enabled by the multi-disciplinary approach of FM to service management.

Analysis of existing concepts identified that the first three concepts were focused on FM's role and contribution to community development, promoting local economies, and were socially driven; whereas the fourth focused on organisational interests and was environmentally driven. Apart from the CbFM model, the other concepts of FM in the community setting reviewed were conceptual and had never been applied nor evaluated in practice. This led to the inclusion of a case study on a community facility geared towards the business community in order to test the principles in the public and private sectors. The five perspectives demonstrate FM's capability to contribute to community development. They address the values that can be added to the public and private sectors in terms of service delivery, environmental performance, economic growth, sustainable development, and socially inclusive communities. These perspectives will be reviewed and updated in light of further case studies currently being undertaken.

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THE DOMESTICATION AND USE OF LOW AND ZERO CARBON TECHNOLOGIES IN NEW HOMES

Tim Lees[1] and Martin Sexton[2]

1 Transition Pathways to a Low Carbon Economy Research Group, School of Construction Management and Engineering, University of Reading, Whiteknights Campus, Reading, RG6 6AW.

2 School of Construction Management and Engineering, University of Reading, Whiteknights Campus, Reading, RG6 6AW.

Changes in the Building Regulations are demanding higher levels of environmental performance in the products of house builders in the United Kingdom. New approaches are being deployed, including incorporating low and zero carbon (LZC) technologies, in order to meet this challenge. It is recognised that the use phase of buildings is responsible for a significant majority of the energy consumption and therefore carbon emissions. A corpus of literature exists focusing on the technical potential of individual technologies but there is a relative dirth addressing the role that the end users (or occupants) play in the use of these technologies in the domestic setting of the home. If the overall objective of lowering carbon emissions is to be realised it is therefore critical that a more in-depth and nuanced understanding of the interaction between homes equipped with new LZC technologies and users is developed. Case study data from two households in a new development using solar thermal technology is analysed from a domestication theory perspective. The results show that the households had little knowledge of, or interest in, the technology prior to moving into the houses. The 'market pull' of consumer design or imagination for the solar thermal technology was absent - they were passive consumers. However, once in the houses, the meaning ascribed to the technology and the household practices emerging from user-technology interaction were significantly different in each of the two households. The findings contest the prevailing technical rationality notion that LZC technologies are uniformly absorbed and used by a homogeneous set of households.

Keywords: domestication, housebuilding, low and zero carbon technologies, socio-technical.

INTRODUCTION

Recent and planned changes in Part L of the Building Regulations, driven by the broader UK Government zero carbon homes agenda, is challenging housebuilders to comply with ever increasingly high levels of performance in terms of carbon

[1] t.j.lees@reading.ac.uk

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emissions. In response, some housebuilders are selecting and incorporating low and zero carbon (LZC) technologies into their products. The term LZC technology is used as to include any technology, additional to the fabric of the building envelope, which recovers or generates energy. Establishing the technical potential of individual technologies has spawned a still growing body of research (see for example Entchev *et al.* 2004; Mithraratne 2009; Bashaj and James 2007 and Hinnells 2008) and work has begun to address which LZC technologies housebuilders have selected and the rationale for their selection (Sexton and Lees 2012). To date, most effort has been expended on the production side: understanding, from a technical perspective, the business model and design and build challenges of low carbon homes.

In contrast, little research has been conducted on the consumption side: what happens to these LZC technologies once handover to the home occupiers has occurred? The cultural and media studies literatures have asserted that technologies must be culturally appropriated through consumption to become fully operational (for example, see Oudshoorn and Pinch 2005). From this lens, the physical technological assemblage of the home (with its LZC technical components) must move into the consumptive domestic realm and that this translation process may (or may not) result in 'successful' operational outcomes. In effect, the physical home becomes a socio-technical system, within which the occupiers domesticate the LZC technologies with meaning and practice which may be far removed from the designers abstracted view of users' interpretations and uses of those technologies. A better understanding of these domestication processes and outcomes, which are idiosyncratic to individual householders, is an important prerequisite to increasing the appetite for and appropriate use of these technologies.

This paper seeks to achieve two tasks. First, broaden the prevailing literature on LZC technologies in new housing by drawing on the domestication literature (Silverstone 1994) to consider user - technology interaction and emergent meanings and practices. Case study data from two households in a new development using solar thermal technology is analysed. The results show that the households had little knowledge of or interest in the technology prior to moving into the houses. The 'market pull' of consumer desire or imagination for the solar thermal technology was absent - they were passive consumers. However, once in the houses, the meaning ascribed to the technology and the household practices emerging from user-technology interaction were significantly different in each of the two households. The principal moderating influence was the different working patterns of the households. The constraining effect materially affected the efficient use of the solar technology. The findings contest the prevailing technical rationality notion that LZC technologies are uniformly absorbed and used by a homogeneous set of households. Second, as a result of applying domestication theory to LZC technologies with new homes, we comment on potentially fruitful avenues to extend the theory from its original focus on discrete technologies towards an accommodation of integrated technological assemblages.

BACKGROUND AND THEORETICAL FOUNDATIONS

The cultural and media studies approaches to user-technology relations are interested in the way technology and its appropriation is defined and moderated by consumption (Bourdieu, 1984). An important contribution to this agenda is the concept of domestication which seeks to explain and understand the adoption of the technology from a perspective that embraces the technology within the context of the household. The domestication discourse has its origins in the household integration of media

technologies such as television, radio and the internet (see for example Silverstone and Haddon 1996; Livingstone 1992 and Haddon 2006). In this perspective the household is seen as a dynamic, transactional system with its own 'moral economy' (Silverstone 1994: 122). The moral economy of the household is capable of actively engaging with the products of the wider formal economy both culturally and economically. Domestication considers how the products of the formal economy come to the attention of household, move into the household, are ascribed meaning and value and become part of the cultural context of the household both in terms of meaning and routines and practices. The process of consuming a technology is taken to be non-linear, rather it is a cyclical and dialectical 'cycle' of consumption.

Silverstone (1994) identifies six phases to the consumption of technology. These six phases are commodification, imagination, appropriation, objectification, incorporation and conversion. One possible configuration of the stages of consumption is shown in Figure 1.

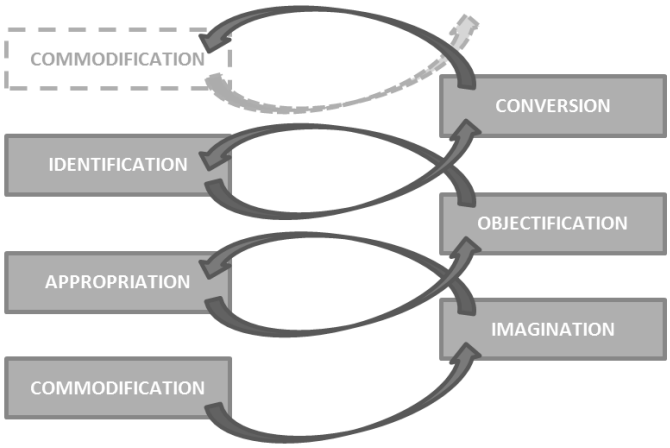

Figure 1: The six phases of the cycle of consumption.

Commodification is the process by which material and symbolic artefacts are created, opened to the influence of the consumer and brought to sale in the formal market economy. The process of commodification permeates the consumption cycle, artefacts (symbolic and material) move between commodification and non-commodification as they develop different material and symbolic forms. The movement between commodification and non-commodification can also constitute part of the interaction between the moral economy of the household and the wider formal economy beyond.

The imagination phase is where goods are desired and coveted. Advertising creates social meaning for a technology with the aim of instilling consumer desire for the object. Consumers can actively engage in this construction of social meaning through the process of imagination. Goods can begin to influence the moral economy of a household well before they enter materially as individuals engage with the social meaning being constructed in the wider economy. Imagination allows symbolic meaning to develop before ownership is established.

Appropriate is the point at which a product is bought by the consumer. Appropriation is easily imagined when considering material objects but is as relevant to messages. Through appropriation a product can leave the formal economy and become possessed and therefore owned by an individual or household. Whilst appropriation embodies ownership and acquisition, objectification is physical usage. Households can seek to express their identities through the physical arrangement, and environment in which

this occurs, of the object. Technologies can be functional but not always in the way that designers intended them to be. This is the process of identification. Identification is the functional use of a technology, rather than its physical placement through objectification. Objectification is the physical acceptance of the technology into the household's moral economy whereas identification is its integration into the routines of everyday life. Objectification and identification are not always unproblematic. Struggles can emerge around the physical location of an object or its incorporation into daily routines. These struggles can be between individuals within the household or between the household and the object. Through negotiation these struggles can be alleviated and stabilised.

If an object enters the household through the process of appropriation, and the household makes sense of it internally through objectification and identification, then conversion is the reaching out of the household back across the internal-external boundary. Conversion is the process of taking the meanings ascribed to the object and communicating them back to the wider society. It is as this point that we come full circle and the process of commodification can pick up the signals of conversion to inform and influence future development.

This cycle does not happen once or in a linear fashion. The process of consumption is not quantum or isolated but dynamic in the sense that the technology, and the meanings ascribed to it, pass backwards and forwards between the internal moral economy of the household and the wider society and formal economy. Each influencing the other and both informing the uptake of a technology and influencing if it is successful or not.

METHODS

The data used in this paper is from one housing development case study in an ongoing larger multi-case project. The goal of the larger project is to establish the day-to-day lived-in experiences of occupants relating to the low and zero carbon technologies. The project employs a number of approaches, including this domestication study, in order to establish the occupants' understanding and use (or non-use) of the technologies contained within their homes.

The interviewees participated through self-selection. A letter from the research team was sent to all the tenants of the housing development, through the housing association, inviting them to participate in the study. The letter outlined the purpose of the research and invited them to contact the research team by phone, e-mail or letter if they were interested in participating. Two out of the three homes on the development volunteered to take part in the study.

For each household two interviews of sixty minutes in length were conducted. The interviews were conducted in the participants' homes and were open in structure allowing the participants to direct the conversation towards aspects of their new homes and new technologies that they felt important. The conversation was guided by the interviewers by asking the participants to talk through their purchase of the property, a 'day in the life' of the household and seasonal differences.

The interviews were supplemented with photographs and notes taken on 'walk arounds' the house. During the walk arounds the participants were asked to demonstrate how they interacted with the technology and to elaborate on points made earlier on during the interview.

Recordings were made of the four interviews which were then transcribed, anonymised and thematically coded using NVivo 9 software (http://www.qsrinternational.com/). The coding of the transcripts allowed themes to emerge from the data which were coded as nodes in the data. Nodes were grouped and split in an iterative process until the researchers were confident in the themes that had emerged.

RESULTS

The findings of the research are presented in this section. A brief description of the case study development and case study households is given. This is followed by quotes from the interviews structured around the phases of the cycle of consumption.

The development

The two case study households live on a development of three terraced houses on a brownfield site. The houses were developed for a housing association as part of a larger local portfolio they manage in a village situated eight miles outside of a small city in the South East of England. The development was located between existing housing and access to the site was restricted by the width of the road running between two buildings. The access restrictions encouraged the housebuilders to use a traditional approach to construction as delivering frames onto site would not have been feasible. To alleviate the potential concerns of the local residents a significant local engagement campaign was run by the housing association and housebuilder. This was targeted more at providing information about the build to the current neighbouring residents rather than sales information to prospective tenants.

One of the requirements of the housing association was that the homes achieved Code for Sustainable Homes level 3. As part of the solution to this each house contains a solar thermal system which supplements a gas central heating system and an electric immersion heater. Solar thermal systems use solar collector panels to absorb solar radiation. This energy is used to heat water which is circulated through the hot water cylinder to pre-heat the water in the cylinder. The pre-heating of the water in the cylinder means that less energy is required to bring that water up to a usable temperature which displaces energy generated from non-renewable sources and lowers energy bills. As the radiation from the sun is subject to daily and seasonal variation so is the output of the solar thermal system. The system is most effective if the greatest amount of hot water is drawn off before midday when the solar radiation is at its greatest.

Household A

Household A is a single parent family with one young child of nursery age. The family has strong ties to the local area. They have lived in the property for ten months. The young child attends a nursery each work day morning. The occupiers rent the house from the housing association. Four generations of the family live within walking distance of the development in properties managed by the same housing association. The housing association has begun a programme of retrofitting the same solar thermal technology throughout its existing local stock.

Household B

Household B comprises two adults and two young teenagers who are social tenants in a three bedroom end-terrace property which is owned and managed by a housing association. The family has lived in the property for ten months. Both adults work,

one full-time and the other part-time. Household B does have loose family ties to the local area but not as many as Household A. Household B has moved back to the area after a period of first living abroad and then some distance away on the South coast.

Consumption of the solar thermal technology

The cycle of consumption is used below to structure and analyse the data. Each section has a short narrative describing the phase and a series of indicative quotes from are given to illustrate the issues raised. In some cases these quotes are in conflict with each other demonstrating the diverse, often opposing, views of occupants to the same LZC technology on the same development.

Commodification

Commodification is taken to be the process by which the low and zero carbon technology came to be incorporated into the homes and was made available to the tenants through the housing association. There is no evidence that either household influenced the design or production of the homes, including the selection of the solar thermal system. The commodification phase was dominated by two sets of interests: the housing association's interest to rationalise their local housing asset portfolio and achieve Code for Sustainable Homes level 3; and, the housebuilder's interest to meet the client brief in a commercially viable fashion.

Imagination

Household A, through their local family ties, was very involved in the local regeneration-orientated consultation process surrounding the development. Household B was disconnected from this process. Both households did not incorporate the solar thermal technology (and its potential benefits) into their imagination to a significant extent before moving into the property. Imagination was constructed through post-appropriation processes. Household A, when talking about their understanding and imagination of the solar thermal technology noted that:

"I just assumed – I mean, it was – I think I just assumed it was just for your water. I didn't realise I was going to reap benefits from my heat, you know, from my heating bills, not at all, because I was absolutely gobsmacked when I received that cheque back into the bank. It was, like, whoa, Jesus Christ." (Household A)

Household B were unable to articulate any expectation or understanding of the solar thermal system originating from before appropriation.

Appropriation

Appropriation of the solar thermal technology was not a separate, discrete episode divorced from the house. The technology was structurally integrated into the house and, therefore, the technological assemblage of the house as a whole (including the solar thermal system) was appropriated.

For both households the appropriation was driven by the location of the development. The solar thermal technology played no part in the decision to acquire the property (and therefore the technology). Household B was not even aware that solar thermal technology was installed in the property until they moved in:

" ... it was only on the day that we got the house, really. We didn't know anything about it up 'til then." (Household B)

Objectification

Objectification is physical placement and use of the solar technology system within the home. The household had no input into the physical location of the technology in the house. The solar thermal system was already located within the house when they moved in. The system for all intents and purposes is immovable. The solar thermal technology was integrated within the constraints of the standard design of the housebuilder. There was a loss of amenity as a consequence in both houses, as the cylinder was placed where normally the airing cupboard would be.

Identification

The solar thermal technology was ascribed different meanings and affected the routines and practices of the two household in different ways. Both Household A and B were told by the housing association during the handover to try and use most of their hot water during the mornings to maximise energy efficiency and save money.

Although both households received similar instructions the different routines of the households constrained or enabled their capability to response to this direction. Household A, not restricted by work patterns, have far greater opportunity to alter their daily routines around the requirements of the technology than the working couple making up Household B. Household A has shifted as much of their hot water consumption to before midday in an effort to maximise return from the technology.

"...I'm finding I'm trying to do everything in the morning, sort of, especially with little 'un, like her bath and that 'cause nothing worse in the evening when it's cold you have a, sort of, lukewarm bath." (Household A)

In contrast, the working patterns of Household B constrains it discretionary capacity to align behaviours to the solar thermal technology: "[we] can't …because we're at work, aren't we?" (Household B).

The difference in opportunity for the two households to accommodate the solar thermal technology into their daily routines is manifest in their level of awareness of the financial returns of the technology. Household A was much more enthusiastic and aware of the benefits of the technology than Household B: "...my gas and electricity bills compared to where I've lived in the past have been absolutely fantastic here." (Household A)

In both householders unfamiliarity with the operation of the solar thermal technology and the inaccessibility of the user manuals led to minimal use of the control settings, restricting the configurability of the technology to each household:

"Idiot proof information would be grand [laughs]. I like things very simplified. I don't like – you know, I've learnt from my dad telling me off enough times that I don't touch something that I don't know what I'm doing." (Household A)

Conversion

Both households are supportive of the solar thermal technology, but appear to not have channels to feedback to the formal economy. The housing association and housebuilder have not sought feedback on the technology. Both appear to have become keen advocates of the solar thermal system and both would and have recommended them to friends and family.

[about solar thermal] "I tell them if they can afford to do it go ahead and do it most definitely, most definitely." (Household A)

[about solar thermal] “Yes, I would recommend it and if people could get it installed then, yeah, great.” (Household B)

DISCUSSION

The analysis of the interview data using a domestication lens has begun to reveal some interesting insights into how low and zero carbon technologies are consumed. Like Silverstone (1994), it is not intended to suggest that the phases are discrete well defined periods that progress in a linear fashion, far from it as these are 'fuzzy' processes which are cyclical in nature.

Domestication theory has allowed us to consider the adoption of LZC technologies in the social context of the households in which they are being used. It enables us to engage with the different social routines of a household and how this affects the physical (objectification) and temporal (identification) acceptance and use of the new technology. Perhaps the most obvious example of this is that Household B's routines are dominated by coming and going to work whereas Household A's is not. This allows a greater freedom to Household A in identification with the technology. Household A has flexed their usual routines to consume most hot water in the morning, following guidance from their housing officer and maximising their benefit from the technology. Household B does not have the same level of flexibility and this advice has been rejected.

The application of the cycle of consumption to LZC technologies in new homes has begun to hint at some interesting differences to its original use. When considering consumer electronic goods, such as televisions, in a material sense it is relatively easy to comprehend the processes of commodification, imagination and appropriation. This becomes more complex in the case of low and zero carbon technologies in a new home. Firstly, in Silverstone's (1994) discussion of consumption it appears as if the household, although dynamic, is well formed and in a stable but changing configuration. The new technology is adding to the formed moral economy of the household. For LZC technologies, in this case solar thermal, in new homes the routines and practices of the household have already been significantly disrupted through the change of home. The new technology is entering at a time when many things are changing simultaneously.

It is also clear from the interviews conducted so far that none of the households were significantly influenced in their decision of which home to chose by the technology it contained. The location of the home (to work or family) seemed significantly more important. In the two households studied here, the cycle (or spiral) of consumption of LZC technologies began with the commodification and imagination processes playing out on the technological assemblage that contains the technology (the house) rather than the technology itself. Once some time has been spent in the new homes the solar thermal system was ascribed more of a meaning in itself, either through changes in performance (with solar thermal typically seasonal), cost savings or problems.

This way of conceptualised how technologies are consumed has potentially interesting consequences for the way that homes perform once lived in. The effort expended by the housebuilders in marketing and selling their products begins the journey of the households in creating a meaning for the LZC technologies and incorporating them within the moral economy of the household (both materially and temporally). It is possible that a lack of focus on the technology in sales and marketing creates a void in meaning for the technology in which the occupant is left to negotiate the tensions unguided. This will require further investigation as the work develops but is of

potential significance to the way housebuilders market, sell and handover their products to their customers.

CONCLUSION

The central problematic of this paper was to start a response to the dearth of research into the consumption of LZC technologies in new homes and, in so doing, contribute to an urgently needed rebalancing of the agenda to consider and integrate production and consumption. The paper has contributed in two important respects. First, case study data from two households in a new development using solar thermal technology was analysed through a domestication theoretical lens. The key findings demonstrated the broad utility of the cyclical and dialectical 'cycle' of consumption. It was found that the households had little knowledge of or interest in the technology prior to moving into the houses (the imagination consumption phase). The 'market pull' of consumer design or imagination for the solar thermal technology was absent - they were passive consumers. However, once in occupation in the identification consumption phase the meaning ascribed to the solar thermal technology and the household practices emerging from user-technology interaction were significantly different in each of the two households. The principal moderating influence was the different working patterns of the households. The constraining effect materially shaped the routines enabling efficient use of the solar technology. The findings contest the prevailing technical rationality notion that LZC technologies are uniformly absorbed and used by a homogeneous set of households.

Second, the empirical setting of the technological assemblage of a house in which LZC technologies are integrated systems is not accommodated by domestication theory which considers discrete technologies (such as televisions) which consumers have the discretion to purchase or not purchase. The majority of new homes in the UK are produced by volume builders and, for a variety of regulatory, planning and commercial reasons, consumers are not given the choice of LZC technology system at the time of purchase. The development of domestication theory for integrated technological assemblages would be a useful endeavour, particularly in the appropriation and objectification phases. On a broader level, the need for research to not treat LZC technologies as discrete entities, but as an integral part of the socio-technical system of the home, is reaffirmed.

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SUSTAINABILITY – (THEORY AND DESIGN)

OPTIMIZING EMBODIED ENERGY OF BUILDING CONSTRUCTION THROUGH BIOCLIMATIC PRINCIPLES

Sattar Sattary[1] and David Thorpe

Faculty of Engineering and Surveying, University of Southern Queensland, Springfield, Brisbane 4300, Australia

Climate change and global warming are major issues in sustainable development, with the building sector being responsible for more than one third of global greenhouse gas emissions, and in many countries being the largest source of these emissions. It is believed today buildings are responsible for more than half of the energy consumption worldwide, significantly contributing with the carbon dioxide emissions they are responsible to the very cause of climate change. The knowledge gap that exists with respect to how emissions from built environments can be reduced and mitigated, how buildings and components can adapt to shifts in global and local climate must be filled (Altomonte 2008). A significant proportion of the energy consumed by the building over its life cycle is the embodied energy in building materials and construction processes. The intergovernmental panel on climate change estimated that around 30% of the base line carbon dioxide emissions in buildings projected for 2020 could be mitigated in a cost-effective way globally, at no or even negative costs, if bioclimatic principles were considered in material selection and construction stages of buildings, thus reducing their embodied energy. There are three major ways to reduce energy consumption: reducing building energy use, replacing fossil fuel with renewable energy, and increasing energy efficiency. Therefore, reducing embodied energy in buildings has come into focus as one of the issues in reduction of carbon dioxide emissions and global warming. Reducing embodied energy of buildings by using bioclimatic principles to achieve optimum embodied energy use can improve energy efficiency, and importantly reduce costs and lifecycle energy use. The paper discusses the use of bioclimatic design techniques to identify criteria that can be used to decrease the embodied energy used in building materials and construction processes. The criteria can assist with developing a model and checklist to apply for an optimum embodied energy of actual building which includes both pre-construction and construction stages.

Keywords: optimum, embodied energy, energy reduction, construction management, sustainability, environmental construction process.

INTRODUCTION

The construction process includes all the onsite work done in building or altering structure, from land clearance through completion. It includes all the activities of workshop and construction site to provide construction elements, transporting (raw material or other elements) to the site, and all the activities on the site during construction, moving the site people and using local facilities, services. The life cycle

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of buildings consists of four stages: pre-construction (Stage I); during construction (Stage II); post-construction (Stage III); after demolition (Stage IV). See Table 1.

Table 20: Life cycle model of building

Stage I	Stage II	Stage III		Stage IV
Before Operation Phase		Use Phase - Operation		After Use
-Extraction and production processes of Materials -Assembling of construction components and elements in manufacturing sections	Site preparation Construction processes of building on the Construction Site Cleaning and auditing services	Operation of building Incorporated services Operation of Other Appliances	Maintenance Repair and refurbishment	Demolition Reuse, Recycling Final Disposal

Source: Adapted from Lawson 1996; Sattary2007

EMBODIED ENERGY

"Embodied energy is the energy consumed by all of the processes associated with the production of a building, from the mining and processing of natural resources to manufacturing, transport and product delivery". Transportation is a major element of embodied energy of construction materials (Edwards 1999; Technical Guide 2010).

Research in Australia and elsewhere has shown that the embodied energy of a building is a significant multiple of the annual operating energy consumed (Overbay 1999; Technical Guide 2010). It ranges from around 10 for typical dwellings to over 30 for office buildings (CSIRO 2000). Making buildings such as dwellings more energy efficient usually requires more embodied energy, thus increasing the ratio even further. In the construction sector, however, experience has shown that as the energy efficiency of buildings increases, the impacts of embodied energy on the overall building footprint become more conspicuous, because the ratio of embodied energy to total energy consumption increases. Not surprisingly, as more and more investors and tenants scan the property markets looking for verified indications of green performance, arguments for reducing the embodied energy in commercial buildings are becoming more compelling.

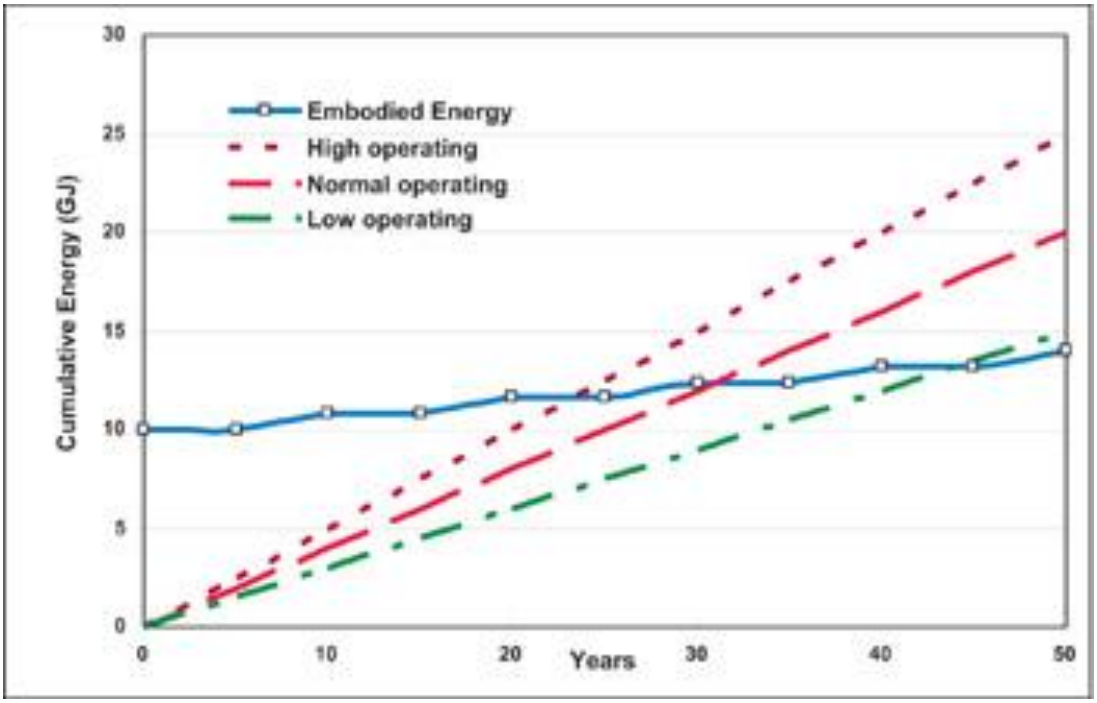
CSIRO research shows that the average house contains about 1,000 GJ of energy embodied in the materials used in its construction. This is equivalent to around 15 years of normal operational energy use. For a house that lasts 100 years, this is over 10 percent of the energy used in its lifetime (CSIRO 2000).

However use of the embodied energy figures in construction should be cautious, and must be considered in context. For example, transportation can affect embodied energy: thus a material manufactured and used in Melbourne has a different embodied energy if the same material is transported by road to Darwin. Recycling of some materials is also possible, and can decrease the impact over their lifecycle. For example, aluminium from a recycled source will contain less than ten per cent of the embodied energy of aluminium manufactured from raw materials; stainless steel can also be recycled many times (Your Home Technical guide 2010). Another consideration is definition. For example, in Canada architects only consider non-renewable energy sources in embodied energy. It can thus be seen that there are several factors to be taken into account when considering potential areas for reducing embodied energy levels of buildings (Canadian Architects 2010).

As buildings have become more energy efficient, the ratio of embodied energy to total energy consumption has increased. Clearly, for buildings designed to be 'zero-energy' or 'autonomous', the energy used for construction and disposal is significant (Canadian Architects 2010).

It can be seen then that as the energy efficiency of buildings and appliances increases, embodied energy is becoming increasingly important (CSIRO 2000). See Figure 1.

Figure 1: Cumulative life cycle energy of an office building



Source: (CSIRO 2000; Recovery Insulation 2010)

Assessments of embodied energy levels for common building materials have to also take into account other factors including the energy used in transporting materials from production point to construction site and, as energy savings with recycling can be significant, whether source materials are raw or recycled. Materials with the lowest embodied energy levels such as concrete, bricks and timber, are usually consumed in large quantities, whereas those with higher embodied energy content levels such as stainless steel are often used in much smaller amounts. Construction techniques crucially determine the mix of embodied energy from low or high embodied energy level materials (CSIRO 2000; Timber Building In Australia 2010). This means that if embodied energy in buildings is to be assessed, designed and managed it has to be calculated and accounted for within an 'assembled building element or system'. Besides materials and assembly inputs to embodied energy, there are also the recurring contributions made up by "the non-renewable energy" used in the maintenance, repair and refurbishment of the building over its entire life (Canadian Architects 2010).

Bio-climatic design characteristics also have to be considered. Such analysis should enable the identification of what can be done to achieve a reasonable reduction in energy use by retrofitting (Liu 2010; UNEP World Business Council for Sustainable Development 2010).

Government guides and industry experts point to the re-use of building materials commonly saving about 95 per cent of embodied energy that would otherwise be

wasted (Milne and Reardon 2008; Technical Guide 2010). The embodied energy savings to be made by recycling of materials will vary according to materials (CSIRO 2000; Milne and Reardon 2008).

RE-USE AND RECYCLING OF BUILDING MATERIALS

Re-use of building materials commonly saves about 95 per cent of embodied energy that would otherwise be wasted (Commonwealth of Australia ; Geoff Milne 2008). There are significant energy savings to be made by recycling of materials, though this is variable – for example, as can be seen in Table 2, recycling of aluminium can save up to 95 per cent of energy used in full production, but only 5 per cent of energy can be saved in recycling glass due to the energy used in its reprocessing (CSIRO 2000). For example, lessons from research and experiences in USA shows for a typical building, an energy star window will save $126 to $465 per year when replacing single-pane windows and $27 to $111 per year when replacing double-pane windows. (Energy star 2010).

Table 2: Potential energy savings of some recycled materials

Material	Energy required to produce from virgin material (million btu/ton)	Energy saved by using recycled materials (percentage)
Aluminium	250	95
Plastics	98	88
Newsprint	29.8	34
Corrugated Cardboard	26.5	24
Glass	15.6	5

Source: (Home Energy 2010)

BIOCLIMATIC PRINCIPLES

The design process brings together disciplines of human physiology, climatology and building physics (Olgyay 1963; Hyde 2008). Building on this ‘bio mimetic’ metaphor – where the flexible cooperation of several constituents contributes to the metabolism and well-being of living creatures – the proposal here is to develop a design method based on the integration of specialized and interconnected competences (Altomonte 2008). Bioclimatic issues in architecture were identified by Olgyay in the 1950's and developed into a process of design in the 1960's (Olgyay, 1963, Altomonte 2008). This design process brings together the disciplines of human physiology, climatology and building physics; it has been integrated within the building design professions in the context of regionalism in architecture, and in recent years has been seen as a cornerstone for achieving more sustainable buildings (Hyde 2008, Altomonte 2008).

Pereira (2002) believes that building design should be inspired by nature, and aim to minimize environmental impact. In order to do this, issues that must be considered in design include health and well-being, energy and sustainability.

Energy saving may be achieved through attention to such bioclimatic design principles. This has been shown in research which has found that appropriate bioclimatic design can reduce energy consumption in a building by five to six times as compared to a conventional building (Jones, 1998). As the energy efficiency of buildings increases, the relative contribution of embodied energy to total energy consumption becomes increasingly important, as does its reduction through

bioclimatic principles or other method. The term 'bioclimatic' refers to a process where savings in energy are achieved through use of bioclimatic design principles in building.

Energy reduction in the Australian building sector is a priority both for the federal government and also the city councils of Australia (City of Melbourne 2008; Green building concil Australia 2010). However considerable progress in reducing the energy consumption of new buildings has been achieved through use of modern bioclimatic techniques. Attention has now turned to reducing the energy consumption of existing buildings. By use of appropriate technologies and techniques of bioclimatic retrofitting, it is possible to significantly reduce the energy consumption of buildings, perhaps by a factor of up to five times (Hyde 2008). Other benefits of such energy reduction include improved health and productivity of workers, and reduction in costs of building (Birkeland 2002). Australian cities are beginning to act in this area – for example, the Victorian Government and City of Melbourne aim to retrofit more than two-thirds of Melbourne's commercial buildings with the aim of improved sustainability and reduction in environmental impact (City of Melbourne 2008).

There are two main aims in bioclimatic construction – first, to ensure that the constructed building is able to function satisfactorily within current and future climatic conditions; and second, that the environmental impact of existing building is reduced through reduction in its energy use and GHG emissions (AIBS 2008).

In summary, by using the proposed model through bioclimatic principles the following can be achieved:

- Minimize energy consumption in mining, processing, equipment, pre-assembling, assembly in manufacturing. Criteria measured are reduced energy in mining, processing, equipment and services of construction materials.
- Minimize Transportation in whole stages of the processes. Criteria measured are reduced energy in transportation for professional workers in preassembling, site workers and materials to the site and suppliers.
- Minimize using resources, achieving waste reduction by facilitating reuse and recycling possibility. Criteria measured are reduced energy by recycling and reusing of materials and elements.
- Minimize pollution by reducing carbon dioxide emissions.
- Maximize use of renewable energy. Criteria measured are replaced energy in mining and construction (preassembling, professional's transportation, site process, site worker transport, materials transportation).

There are numerous data and criteria to measure and consider for materials and construction processes to identify optimum embodied energy that needs lifecycle monitored energy consumption that time consumer and vary for each individual materials and elements therefore the proposed model is based on achievable, reliable and collectable data from the five aspects of quality data resources.

CRITERIA TO OPTIMIZE EMBODIED ENERGY OF BUILDING

The proposal is to develop a model based on integration of specialized method and construction processes to decrease embodied energy of all the processes associated with the production of a building, from the mining and processing of natural resources to manufacturing, transport and product delivery, see Table 3.

Table 3: Life Cycle Stages (1, 2) of Building and Consumed Energy

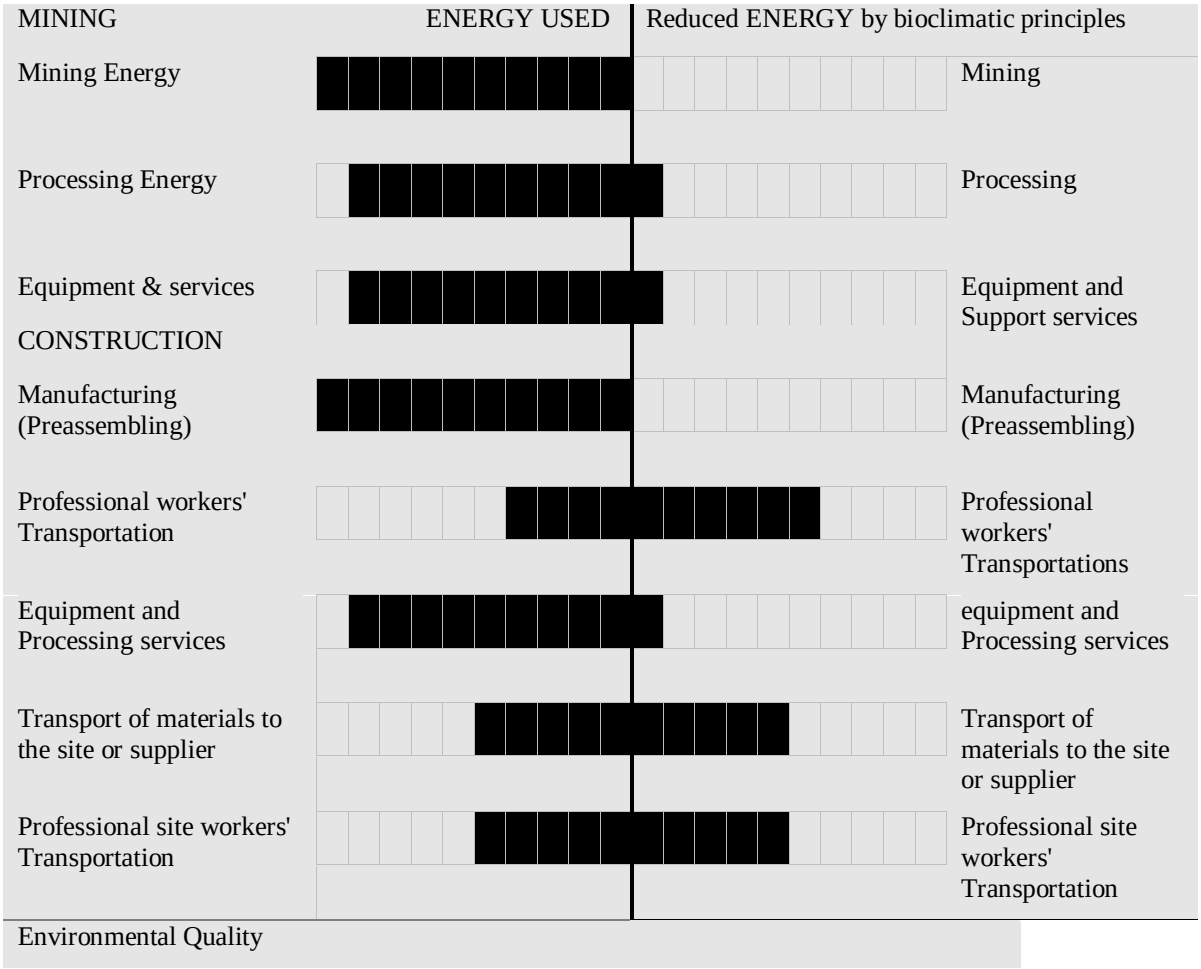
Life Cycle Stage I	**Life Cycle Stage II**
Production and pre-assembling	**Construction processes on site**
- Energy consumed in extracting - Energy consumed in production processing - Energy input for transport of workers, site people and equipment - Energy consumed by equipment and support services - Energy consumed for transportation of raw materials to building site or supplier - Energy used for preassembling of building components, elements - Energy input for transport of workers - Energy consumed for transport of components and building elements to building site or supplier	- Site preparation and fencing - Energy input for transport of the workers and site people - Energy consumed by machineries and support services - Energy input to transport the equipment to building site - Energy consumed input in the construction processes of building - Energy consumed by equipment - Energy consumed for transportation of raw materials and elements from supplier, production or preassembling - Energy input to the workers and site people

Source: (Lawson 1996; Sattary 2007; UNEP SBCI Sustainable Buildings &2010)

Research by the Steel Construction Institute in the European Union suggests that the key to lifecycle assessment of environmental impact is in the relationship between manufacture, transportation, use of materials of construction and the transportation is a major element of embodied energy of construction (Edwards 1999). The following categories and criteria can be used to decrease embodied energy to identify optimum embodied energy through bioclimatic principles: Site & Climate Analysis, Flexible & Adaptive Structural Systems; Renewable & Environmental Building Materials; Modular Building Systems; Building Envelope Systems; Renewable & Non-conventional Energy Systems; Innovative Heating, Ventilation & Air Conditioning Systems (Altomonte 2008)

A proposed model to analyze the energy consumption in pre-construction and post-construction, in order to identify the optimum embodied energy of the construction is presented in the following two tables. The first table (Table 4) identifies reduced energy in the stages of the production and construction processes. In this table and the following table (Table 5), the length of the bars in each column represents the amount of energy relevant to the particular item discussed in that column.

Table 4: Energy Consumed from the mining and processing to manufacturing, transport and product delivery



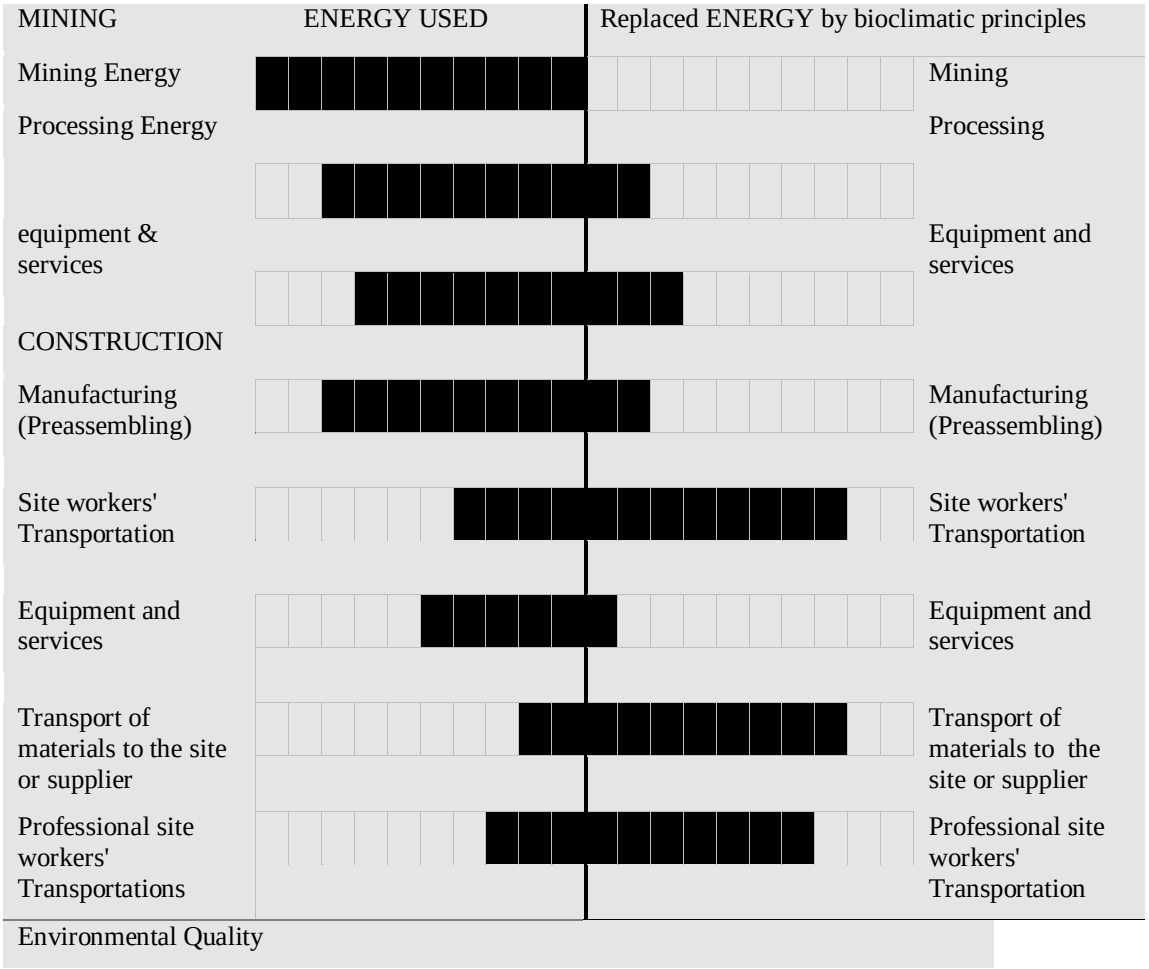
In the second step, the saved energy replaced renewable energy or produced renewable energy in whole stages of the production and construction processes are identified. Table 5 shows what can be replaced and reviewed in selected actual sustainable building projects in pre-construction and construction stages in Australia.

PRODUCT ASSESSMENT AND GREEN SPECIFICATIONS

Green materials rating systems and specifications are broad guides to the environmental performance of the materials and systems used. Attention is now turning to more product-specific assessment to form the basis of green specification systems for construction. One problem with the proposed model is validating the environmental performance of the products and systems. Five aspects of quality data, which are used to develop the criteria for the proposed model, have been identified:

1. Eco-label (Australia and international);
2. Life-cycle assessment;
3. Independent verification;
4. Manufacture's declaration, certified by the company under trade practice legislation
5. Expert assessment Ecospecifier 2003 (Hyde 2008)

Table 5: Renewable Energy Consumed from mining and processing to manufacturing, transport and product delivery



The proposed model, with the collected data from the five resources described above, will be used to identify "Optimum Embodied Energy" of the construction systems and building elements will make possible to identify and complete a table similar to that shown in Tables 6, 7.

Table 6: Assembly embodied energy of some construction systems

MATERIAL	Original Embodied Energy MJ/kg	Reduced Embodied Energy in Mining and Construction per MJ/kg	Renewable Energy Used in Mining and Construction per MJ/kg	OPTIMUM EMBODIED ENERGY MJ/kg
Single skin AAC block wall	440	a- Percentage of reduced energy	b- Percentage of replaced energy	440 - (a +b)
Steel frame, compressed fibre cement clad wall	385	a- Percentage ...	b- Percentage ...	385 - (a +b)
Cavity clay brick wall	*860*	*a- Percentage ...*	*b- Percentage ...*	*860 - (a +b)*

Source: Buildings, materials, energy and the environment (Lawson 1996), the figures for the amount of embodied energy come from Lawson, and table created for model

Table 7: Assembly embodied energy of some building elements

MATERIAL	Original Embodied Energy MJ/kg	Reduced Embodied Energy in Mining and Construction per MJ/kg	Renewable Energy Used in Mining and Construction per MJ/kg	OPTIMUM EMBODIED ENERGY MJ/kg
Elevated timber floor	293	a- Percentage of reduced energy	b- Percentage of replaced energy	293 - (a +b)
110 mm concrete slab on ground	645	a- Percentage ...	b- Percentage...	654 - (a +b)
Roofs				
Timber frame, concrete tiles, plasterboard ceiling	251	a- Percentage ...	b- Percentage ...	251 - (a +b)
Timber frame, steel sheets, plasterboard ceiling	330	a- Percentage ...	b- Percentage ...	330 - (a +b)

Source: Buildings, materials, energy and the environment (Lawson 1996), the figures for the amount of embodied energy come from Lawson, and table created for model

CONCLUSIONS

Energy reduction in the Australian building sector is a priority for all levels of government in Australia. Embodied energy and achieving optimum energy is recognized as one of the main issues in sustainable construction and development. Key areas in reducing this energy use and saving greenhouse gas emissions are building development, construction processes and management. While the on-going energy used in the post construction (operations) phase of the building life cycle continues to be significant, the increasing trend to reduced or zero emissions means that reducing energy use in the pre-construction and construction phases of the building life cycle takes on increased significance. A major component of energy use in this phase is the embodied energy of building materials and relevant energies, such as transport, equipment, processing and replacing renewable energy.

A model has been proposed to identify optimized embodied energy in pre-construction and construction phases of buildings that take into account decreased and replaced renewable energy in preconstruction and during construction processes, saved energy in transportation by localizing of whole two phases and reduced energy from reusing and recycling of the materials that can be significant.

Therefore, reducing embodied energy in building materials through processes like selecting suitable materials, recycling materials, balancing the use of materials, selecting materials for durability, localizing the manufacturing process, and similar measures is expected to make a considerable improvement in the efficient lifecycle energy use of buildings, There is considerable potential to achieve very low lifecycle energy use over the coming decades.

Further study and research in this area can facilitate achieving benchmark and criteria to achieve 'optimum embodied energy' and 'optimum embodied energy construction' in the building that is not far from belief for the building through bioclimatic principles to reducing embodied energy of the construction process.

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THERMAL PERFORMANCE OF BUILDINGS AND THE MANAGEMENT PROCESS

Christopher Gorse, Anne Stafford, Dominic Miles Shenton, David Johnston, Ruth Sutton and Dave Farmer

Centre for the Built Environment, Leeds Sustainability Institute, Leeds Metropolitan University, Leeds LS18AJ

From the limited information that exists on the thermal performance of dwellings there is growing evidence of a significant gap between that which is predicted and the built product. Such differences between the intended and actual measured performance are not accepted nor tolerated in other industries. The differences in the performance can be considerable, with some buildings experiencing deviation from designed thermal transmittance resulting in twice the heat loss expected. This does not bode well for the industry when new dwellings are expected to achieve zero carbon standards by 2016. Although some of the problems are related to inadequate design, many are attributable to construction processes. Using the technical reports and feedback from researchers engaged in forensic investigations of building performance, this paper presents some general observations and some re-occurring problems associated with the management of the construction process. Specific areas of concern include the interface between design and construction, sequencing and planning of works, quality of workmanship and build, and lack of quality control systems. Due to current environmental and energy concerns, emphasis has been placed on improving the efficiency of the building system to ensure the gains expected are delivered. Much of this relies on the production of quality building fabrics that provide passive solutions, which maintain thermal comfort and reduce the level of service intervention.

Keywords: building quality, coheating tests, thermal performance, workmanship and zero carbon standards

INTRODUCTION:

Producing Zero Energy buildings

Meeting the standards set across Europe to deliver low and nearly zero carbon buildings is not going to be easy. The building stock in Europe is substantial, with 22 million homes in the UK alone (CLG, 2011a). And although recent production of new homes has fallen from the 2009-2010 output of 128,689 to 121,200 units during 2010-2011, the production of 120,000 units per year in the UK is substantial (CLG, 2011b; UK Statistics Authority, 2011). Thus, any changes to individual elements of the new building stock can have a significant impact on CO_2 emissions and energy consumption. For example, by reducing the party wall heat loss to values close to zero giving savings in excess of 10,000 tonnes of CO_2 per annum are not unrealistic. The party wall research and observations by Lowe *et al.* (2007), Wingfield *et al.* (2009; 2010) and general observations by the CeBE group reports would suggest the

Gorse, C; Stafford, A; Shenton, D.M; Johnston, D; Sutton, R and Farmer, D (2012) Thermal performance of buildings and the management process *In*: Smith, S.D (Ed) *Procs 28th Annual ARCOM Conference*, 3-5 September 2012, Edinburgh, UK, Association of Researchers in Construction Management, 1413-1422.

reductions in CO_2 could be much greater (LSi, 2012). Achieving zero carbon in reality means heat loss mechanisms need to be identified, accounted for, reduced or eliminated.

Identifying the less obvious areas of heat loss and close the gap

It should be noted that the areas of significant heat loss are not always obvious; prior to the discovery of the party wall bypass the general assumption was that heat energy was not lost within or through the party wall. Thus, the recognition of unknown heat loss mechanisms can significantly reduce the energy required to heat the building. Furthermore, producing buildings to enhanced thermal performance standards without knowing the building's actual ability to resist heat flow is like using a bucket for carrying water without checking if it leaks. It is essential that heat loss mechanisms and building behaviour are properly understood, if buildings are to be produced that perform.

The general nature of the building fabric remains relatively unchanged for most of the building's life. Thus, improvements to the building fabric have greater longevity than most other energy saving measures. As long thermal barriers perform, the savings are continuous, operating throughout the building's life. Thus, it is important that the building actually performs.

Underperforming buildings will only achieve desired thermal comfort by consuming more energy than expected. Currently, the additional costs due to underperformance are transferred and accommodated by the consumer. Although, the enhanced energy efficiency measures, that are now promoted when selling buildings, must be changing client expectations, the complaints about a buildings actual ability to reduce energy demand have not yet manifest. The 'grand designs', which stress the importance of thermal performance, must be also be contributing to the general awareness of how buildings should or could perform. It cannot be long before the public ask whether there buildings are working and question whether they have been given what they have paid for. It is questionable whether the industry can offer 'energy efficient buildings' if few of the designs are tested to see if they work. If the industry is to adhere to its own low and zero energy mantra then there is much work to do to ensure performance is achieved in practice. Building designs should be tested to ensure functionality is achieved. Quality control systems should be extended to cover thermal performance and feedback mechanisms introduced to improve building standards and ensure client satisfaction is achieved and maintained. The aim of this paper is to highlight some of the reoccurring construction problems encountered that affect thermal performance.

AS-BUILT PERFORMANCE AND MANAGEMENT

Generalising about the building stock can be problematic with dwellings varying in age, design, size, characteristics, components and materials to name just a few factors to consider. Whilst there is much to learn about the building stock and the effects of the different factors, there are some overriding issues that can affect buildings, almost regardless of type and design. The management and control processes are known to influence the nature of the building product and the way it performs (Fryer, *et al.* 2004). While there is considerable focus on the design of low carbon buildings relatively little attention is being placed on the processes necessary to realise the low carbon product, with some very noticeable consequences.

Figure 1 shows some of the studies conducted by Leeds Metropolitan University over a six year period. The seminal work that emerged from Lowe, Bell and Wingfield (Lowe, Wingfield, Bell and Bell, 2007; Zero Carbon Hub, 2010) has developed into a growing body of evidence of underperformance.

The team have now conducted more than 40 co-heating tests on 25 individual buildings to determine actual thermal performance of the dwelling compared with that intended. Most of the tests are on new builds, however in some cases multiple interventions were introduced to existing buildings, with performance tests before and after the change in order to determine the effectiveness of the change.

The graph below shows the results of 33 tests (conducted on 21 individual properties), identifying the percentage difference between the intended performance and that measured using the coheating tests. In the studies of new build and modifications to existing buildings the research team were able to observe the construction process and consult with site operatives. Thus, the feedback from those directly involved in the management of the construction process and the observations from site visits were useful in identifying potential contributions to difference in performance. While, it is not possible to determine the extent that the process contributed to the variation in performance, what is apparent is that the actions, changes and events on site are directly linked with performance.

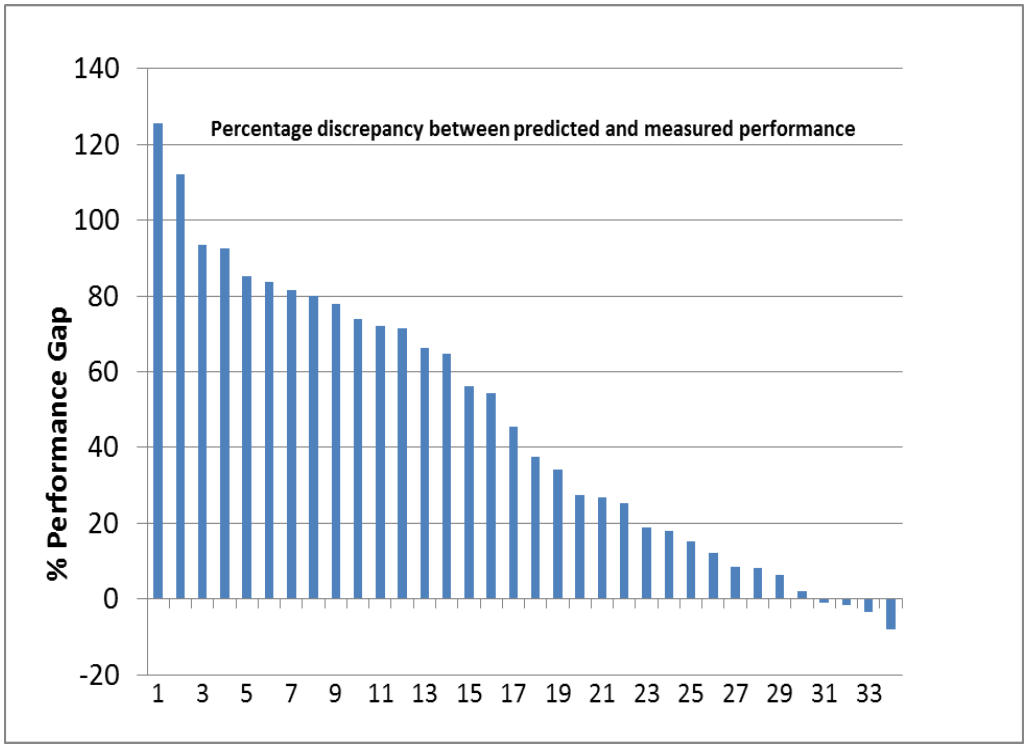

Figure 1. Whole House Heat Loss data – Percentage discrepancy between Measured and Predicted Heat Loss (built on the initial data set reported in the Zero Carbon Hub, with additional tests 2010; Stafford et al. 2012b. 21 individual buildings studied)

Supporting Information for figure 1

Calculation of designed (intended) heat flow
The predicted thermal performance of the fabric uses the summation of all the heat transfer mechanisms in the building (thermal transmittances together with thermal bridging and unwanted background ventilation losses).

Calculation of actual heat loss coefficient
The coheating test determines the actual heat loss through the structure. This is achieved by heating the internal environment to an elevated temperature and maintaining the temperature at 25° C. As the external temperature changes, the power required to maintain a stable temperature is adjusted. As the outside temperature drops more energy is required to heat the dwelling and as the outside temperature rises the energy is required. By monitoring the 'power in' against temperature change outside, the heat transfer through the building can be calculated. Losses due to ventilation, heat gains from solar and variations due to the wind are also considered within the calculations.

The results represent the culmination of many observations and tests. While these tests provide measures of heat flow as well as the difference between intended and actual performance, much more information can be gained from the studies. To understand the reason thermal performance is higher or lower requires investigation of designs, supporting documents and photographic evidence. For example:

- Records of changes, component assemblies and construction operations are important.
- Exploring the differences between the design and that built on site is essential to understanding the deviation in performance.
- By pressurising and depressurising the building under heated conditions, at the same time as undertaking thermographic surveys helps to trace and identify air movement, circulation paths and cold bridges.

When results are obtained for designed and actual performance, a forensic investigation can be undertaken to explore differences found. The information supporting each project is considerable and necessary to understand the building's behaviour. While the focus is on the measured level of building performance, clearly the observations provide much supporting data about the construction shortfalls.

Extent, representative and useful nature of performance data

It is noted that concerns have been raised over the sample size of the Leeds Metropolitan University (LMU) data (The Futures Group Think Tank, 2012). Although the reports from the Leeds group make no claim over the representative nature of the research, the Think Tank in their criticism provide an interesting observation, "this [LMU] sample relates to only 0.0064% of the housing stock constructed…", it would appear that the Think Tank is critical that such a small sample is influencing Building Regulation. Unfortunately, the work of Leeds Metropolitan University is the only sizable unit of information that the industry has with regard to the actual building fabric performance. However, the knowledge that so little research has been undertaken should be of concern for such a substantial industry, especially considering the contribution that the built environment makes to CO_2 emissions (the built environment accounts for 40% of the UK's CO_2). Failing to test or gather a representative sample, when 120,000 units roll out each year, is of considerable concern, especially when such high expectations are aimed at the industry with regard to reducing emissions.

Tolerance and control

Looking at the percentage difference from that intended to that achieved and the distribution (Figure 1), the results show that few of the tests on buildings are within +/- 15% of their intended (design, specified or expected) criteria. For commercial reasons, a low tolerance threshold is always preferred by industry, but is only gained by good quality control in both design and management. The figures in excess of 40% deviation from the standard designed are unacceptably high, yet this represents most (12/21) of the buildings studied (21 individual buildings were tested). If companies claim to provide buildings with specific performances, but know that their standards vary, the deviation needs to be considered and an element of over design or thermal tolerance should be introduced. The accepted tolerance would need to be added to the design to ensure the operational standard is achieved. Such tolerances will incur additional costs. However for the industry to operate efficiently and economically, it should attempt to meet the targets without over specification.

Although the government targets for low energy buildings are incremental they are very ambitious, especially since the evidence, however little, of buildings meeting less stringent targets is not good. The work of Bell *et al.* (2010) found that buildings constructed to 2002 and 2006 Building Regulations failed to achieve the requirements. The statutory regulations have significantly advanced yet little has been done to improve construction and control the process. Although many zero carbon prototype buildings exist, a serious concern is that most of the buildings remain untested (Bell *et al.* 2010), as the Think Tank suggest less than 0.0064% of buildings are tested. At best, buildings are limited to the laboratory information that is supplied with the building components, and although useful, the tests of materials in isolation do not reflect their performance when assembled (Hens *et al.* 2007). For buildings to operate effectively, the construction process should be managed and products must fit and function together to produce a building system that performs as specified.

RESEARCH METHOD

This paper reports findings of projects conducted by the Centre for the Built Environment research team at Leeds Metropolitan University. The information available on each project was reviewed and information from the researchers operating on the projects was obtained. The technical reports provide additional information to that reported in the academic journals and published research. A review of the reports with specific consideration to the points associated with the management process were considered. The technical reports and relevant links can be found on the Leeds Sustainability Institute web site (LSi, 2012), in addition to a review of the technical reports further information has been gathered through discussion with the research teams. The review provides an observation of the findings and re-occurring themes that would not otherwise be available. A further more detailed review of such information is also encouraged. This would become increasingly more important as more technical reports emerge from the Centre and the results from Technology Strategy Board's Building Performance and Evaluation Programmes.

FINDINGS AND RESULTS

The key observations from the reports relating to issues associated with the management of the design and construction processes are listed in Table 1 below.

Table 1: Thermal Performance: Management, Inspection and Supervision Issues

Problems with design and sequencing of operations

Issues identified which could have been rectified by correct installation or inspection

- Insulation was displaced or incorrectly fitted due to obstructions, such as debris, or protrusions through the fabric, such as vent and service penetrations. Where rigid partial fill insulation was used it was pushed off the surface of the wall creating voids around the insulation, allowing free flowing air. With changes in weather, internal environmental conditions and other phenomena that affect air pressure, the movement of air and heat energy bypasses and circumvents the insulation.
- Failure to inspect and correct errors
- There were a number of notable observations that could have been picked up by inspection. These included mortar build-up over fabric penetrations such as vents and between insulation causing continuous cold bridges.
- Debris was allowed to build-up resulting in discontinuity of insulation. The obstructions meant that there were gaps in the insulation. The irregularity of the surface to which the insulations was placed against prevented a close fit.
- Insulation was not fitted under and between some joists. Construction interfaces, that required cuts to the insulation to ensure a complete covering were often overlooked or poorly fitted.
- Gaps were found in party wall cavity socks thus failing to provide an effective continuous seal.
- Some of the insulation was simply not placed properly, not butted up together and not built up to the correct thickness.

Planning and sequencing

- Air, moisture and vapour barriers were installed and then punctured to put services through them, effectively removing the ability of the barrier to function properly. Failing to re-seal the barriers allows air movement within the fabric. Uncontrolled air movement leads to thermal transfer, bypass and moisture movement within the fabric.
- Insulation was sometimes removed to fit services. Once the services were installed the insulation and barriers were not properly reinstated.

Design control and interface management

- Some designs were complicated and difficult to build and due to these difficulties a poor end product was produced.
- Modification were sometimes made to the design. Changes to that which was specified sometimes had the effect of increasing or decreasing the size of components. Fitting components with different sizes to that specified meant they were either too small, resulting in gaps, or too large needing to be cut.
- Air barriers and vapour control layers were sometimes fixed in the wrong positions making them ineffective. The interface between the air and thermal barrier is important.
- In some cases instructions were not provided on how to seal barriers around fittings, penetrations and junctions. Folding and layering of building fabrics, such as vapour barriers, is problematic. Multiple layering to make up joints around corners and junctions needs some thought to make an effective seal without excessive build up.
- Incorrect use of tapes and sealants was common, specialist tapes are needed for different surfaces. Some jointing materials may need pressure between materials to make them effective.
- Pressurisation tests and smoke puffers revealed gaps around RSJs and service pipes.
- Loft hatches were sometimes specified and used that did not effectively seal.
- Services were positioned too close to the wall making it difficult to seal behind them.

- Services that were hidden or boxed-in were rarely sealed.
- Often the penetrations made to house some services become inaccessible once the main piece of plant is installed.

Workmanship

- Mortar beds were not filled and the gaps in the fabric were sometimes not sealed.
- Parging was often only applied to open easy to access faces. To provide an effective seal the parging should extend across the whole surface providing the air barrier, including behind fittings such as, stairs, partition walls and services.
- Sealants were applied at surface level rather than properly fed into the gap.
- Incorrect lifting and moving of structurally insulated panels caused damage.
- Incorrect expansion strips were sometimes used, making an ineffective seal.
- Junctions were not sealed. Points of air-leakage and infiltration were found around thresholds, windows and doors, between frame and breather membranes, around and through roof lights, roof panels, at the ridge, eaves and between roof panels.
- Air leakage was found around light roses, electrical sockets and other service fittings.
- Air leakage occurred through flooring panels that were damaged and poorly sealed.

EVALUATION

Many of the observations relate to a failure to deliver the work as specified or provide the necessary information, instruction and checks to workmanship. Construction works should be planned and sequenced to ensure thermal performance. To deliver building products that are thermally efficient requires a level of understanding of thermal performance that is currently overlooked in many aspects of construction practice. If developers and contractors are producing multiple units a quality control system which checks to ensure thermal performance complies with that specified should be used, such practice is common and regulated in other industries. Quality systems must be capable of checking that the performance specified is achieved. Once there is confidence that a building can be delivered to specification, sampling and control checks should be used to ensure the processes are working, where deviation occurs information should be fed back to enable correction. To improve the product new and existing knowledge should be fed to and through the team. Figure 2 provides a simple control and improvement loop for feeding information in and controlling the process. It is surprising that an industry of such scale does not employ such measures; however, the draft proposals for the next revision to the building regulations propose a ‘Publically Available Specification’ or an equivalent Quality Assurance scheme. It will be of public and economic interesting to see that the industry embrace this.

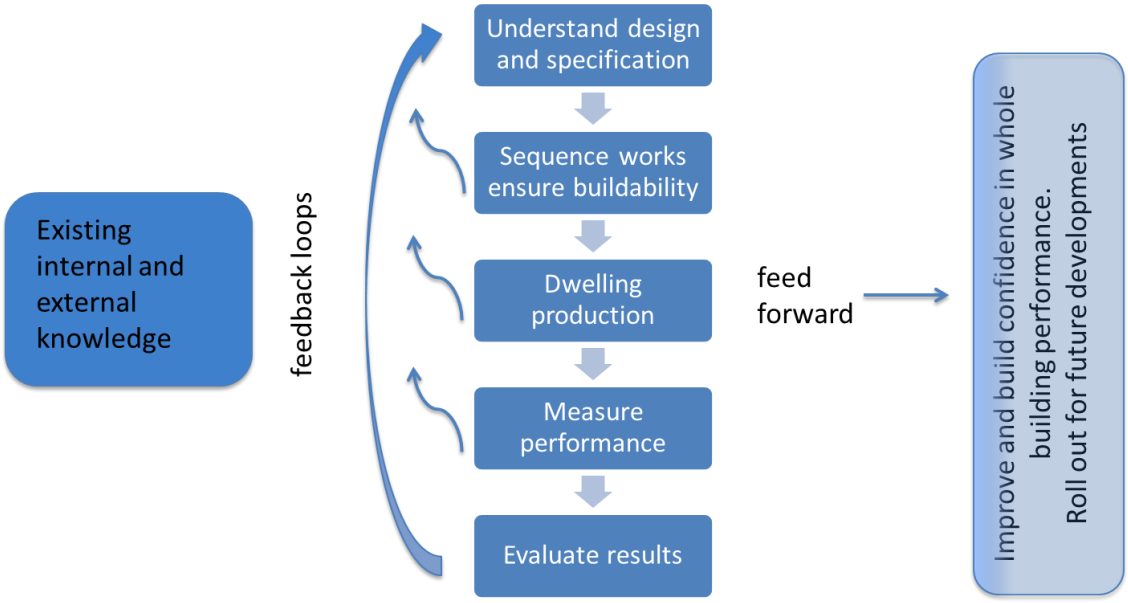

Figure 2, Improving building performance: A simple control loop

SUMMARY

The work has revealed problems with the design and construction processes and the sequencing of construction operations. Where the design information is incomplete or the design process overlaps with construction and change management is not used to control alterations, the building product is susceptible to performance deviation. As few buildings are tested for performance and compliance the profession has little information on the nature and extent of such problems.

Many of the problems observed are occurring in many house types studied and on different sites. The observations seem to suggest that where construction becomes complicated insufficient attention is given to design and construction processes. In some cases design issues are not resolved meaning that the site staff make the decisions regarding selection or assembly of products. Ad hoc decisions that are not properly informed by relevant expertise will have an effect on thermal performance. The results shown would tend to suggest that uninformed decisions are having an adverse effect on performance. The unstructured assembly of different components causes problems and there is evidence that function and fit of components is not being achieved. At each material interface the design needs to be examined and the process and sequencing of operations must be considered.

Training is required to ensure the industry is informed; however, further research is required to ensure that an informed knowledge base is developed. Emmitt and Gorse (2003) suggest that professionals generally select products from their favourite set of products, those which are tried, tested and previously used. We are entering a new arena where building performance needs to be considered differently. Currently, construction professionals may be selecting preferred products rather than those that they know perform, as the knowledge on actual performance is very limited. As professionals obtain feedback through effective monitoring, their ability to select and specify should improve. Currently, some details are not possible to build, it is important that such details are questioned so that effective and buildable solutions are found.

CONCLUSION

Low carbon buildings do exist and can be built. The challenge of mass produced buildings, is to provide the right processes to ensure buildings are reliable and consist with the specified standard. Getting the process right requires good management and supervision, as well as understanding issues that need to be considered.

In some cases the industry is attempting to develop low carbon buildings without a real understanding of the construction process and the performance of components used. Due to the lack of research, there is little information available on the thermal performance of the final building, thus little is known with regard to the issues that are affecting the overall performance. A better understanding of components, their assembly, design and the need for improved sequencing of operations is required. Managers and designers are overseeing and supervising tasks that they may not understand, therefore further research is required and the findings need to be quickly fed back to professionals and site staff to inform and improve practice.

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KEY CRITERIA OF SUSTAINABLE HOSPITAL REFURBISHMENT: A STAKEHOLDER REVIEW

Grant Wilson[1] and Mohammed Kishk

Scott Sutherland School of Architecture and the Built Environment. Robert Gordon University. Aberdeen. AB10 7QB. UK

Hospital refurbishment has taken a secondary role in the last decade, in favour of new build facilities. This has allowed the Client and the Design Team to build and specify with greater flexibility and from essentially a 'blank canvas'. Correspondingly, sustainability as an issue has been easier to plan and implement from the earliest briefing and design stage. The changing economic landscape has necessitated that the focus has now shifted to the refurbishment of the existing healthcare estate. Refurbishment is widely recognised as presenting unique challenges in its own right. Add to this the institutional and statutory requirements in the arena of sustainability and the unique functional characteristics of an operational hospital and these challenges are increased. Given the practical and economic challenges of refurbishment as an activity, weighed against a facility as multi-faceted and complicated as a hospital, a structured and prioritised process of decision making is required. A multi-criteria decision making (MCDM) approach is discussed as being most suitable for this process. A pilot study of a non-random sample of industry experts is analysed to establish a baseline knowledge platform of the key research variables and subsequent method of selecting criteria. The overall findings establish a good awareness of sustainable development and familiarity with key documentation and guidance, however knowledge of the capital investment appraisal process and the use of MCDM tools is shown to be very limited.

Keywords: hospitals, MCDM, refurbishment, stakeholders, sustainability.

INTRODUCTION

The time period spanning the latter half of the 1990s and into the first decade of the 21st century saw a huge amount of investment in the building of new infrastructure; notably with the construction of new hospitals under the Private Finance Initiative (PFI). In practical terms, and from the perspective of a new-build facility, the accessibility to funding, and the opportunity to plan, design, and build from what is essentially a 'blank canvas' presents the client and design team with the flexibility and opportunity to integrate all of the statutory, institutional, and desirable requirements, which includes the sustainability performance of the asset. Controversy of the PFI as a procurement vehicle aside, the fact remains that a raft of new-build PFI hospitals have been added to the NHS built estate. However, as positive as a programme of new-

[1]g.wilson2@rgu.ac.uk.

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build facilities may be, the fact remains that, as stated by Sheth *et al.* (2008), the majority of the healthcare facilities which will be used in the 21st century have already been built. The size of the existing estate, coupled with the well recognised economic challenges faced by the NHS presents a complex web of challenges for providing a 'fit for purpose' healthcare service that is legislatively and institutionally bound to meet a myriad of targets. The most challenging of these targets are arguably, those within the scope of sustainability and sustainable development. Wilson and Kishk (2011) highlighted that to meet its functional and statutory requirements, it is from the extensive existing estate, and the refurbishment process, where the solutions to the sustainability agenda must be found. The interface between continued functionality of the hospital and the requirements of sustainability is a priority issue when it is considered that a high proportion of the existing healthcare estate was planned, designed, and built for, a very different social and healthcare landscape of yesteryear. It is significant to appreciate that in the region of '30% of all existing buildings in the existing healthcare estate pre-dates the actual formation of the NHS as a service in 1948' (Kirkham and Boussabaine. 2005). In terms of the objectives of this paper, and within the perspective of the wider research, it is therefore imperative that a model is developed which identifies and considers the complex combination of decision possibilities faced by the client and design team in the refurbishment process.

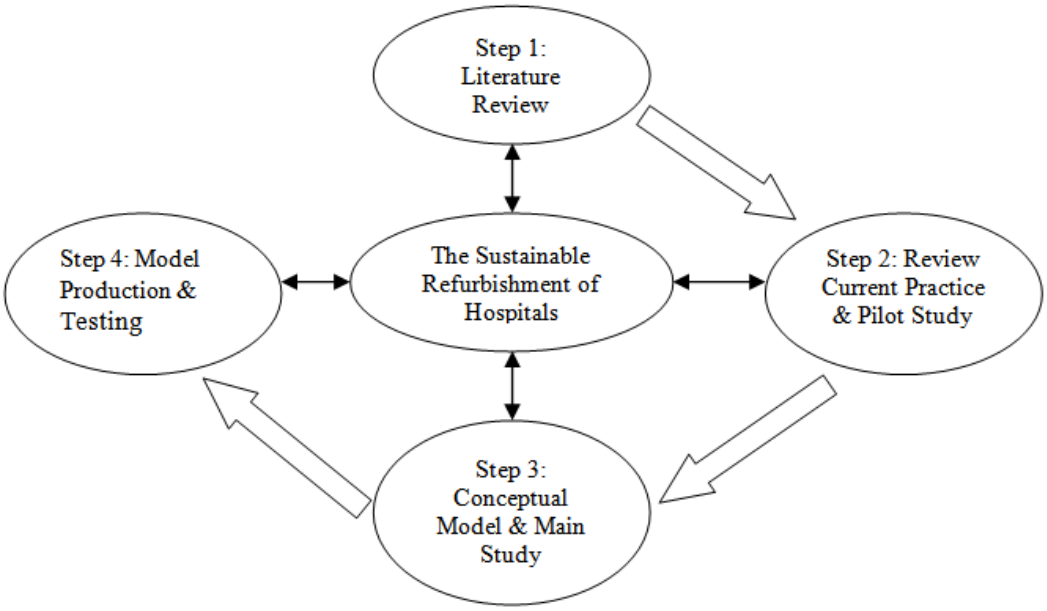

Figure 1: Methodological framework (adapted from Maxwell, 2005)

The main objective of this paper is to ascertain the need for a formalised and measured decision making process to be undertaken by the correct actors and within the optimum time frames of the refurbishment appraisal process. A review of the literature has shown that there is no standardised or measured process by which the client, the design team, and other industry professionals can compare a 'best fit', and best 'value for money' alternative, based on reasoned criteria. Primary data has been collected by means of a pilot study, which is a critical step in the methodological process shown in Figure 1. The final model (Step 4) is ultimately an exercise in 'measured trade-offs' to use the specification process in balancing the functionality/sustainability interface. Multi Criteria Decision Modelling (MCDM) techniques have been identified as best suited for this objective. The starting point in building such a model is to establish the main evaluation criteria and the relevant sub-

criteria, which will in turn allow for the subsequent mathematical construction of the weighted and ranked model. The research identifies the Department of Health's 13 sustainability issues (HTM 07-07. 2009) as the 'main criteria' level, and utilises Braunshweig *et al.*s (2000) reduction method to allow the subjective recognition of the relevant sub-criteria by the decision maker (Figure 2) although it is noted that this excludes potential staff and patient criteria outwith the DoH issues.

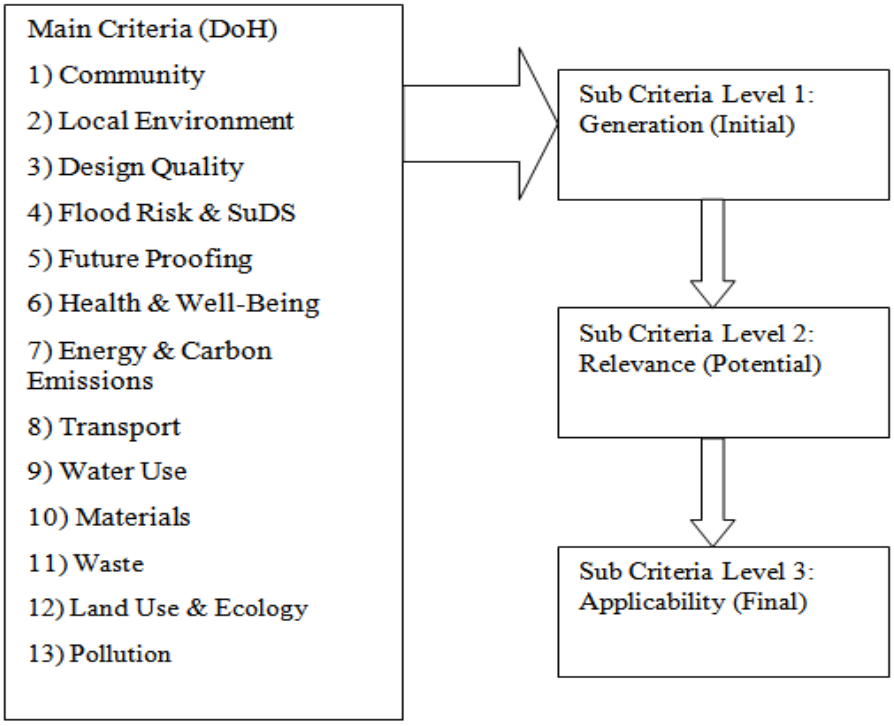

Figure 2: Sustainability 'Main Criteria' and relationship to the 'Sub-Criteria' process

THE CHALLENGE OF REFURBISHMENT IN THE FUNCTIONING HOSPITAL

The challenge of the generic refurbishment process is well understood and documented, and can be cited as the prevalence of 'uncertainty' in the actual works. (Egbu and Lee. 2006) (Quah. 1998) This uncertainty fuels one of the main design team and contractor challenges which is the potentially large number of variations as the work proceeds. Azlan-Shah (2010) clarifies this even further in focusing on the technical challenges of 'matching up' the evolving requirements within the constraints of the existing building, especially in regard to the more 'fixed' aspects such as building orientation, form, and thermal mass etc.

The unique characteristics of the hospital

The hospital is a unique facility amongst all other buildings. This can be demonstrated by understanding that in the standard acute facility, the hospital can in fact be an incorporation 'of all other buildings'. Offices, catering, living accommodation, factories, laboratories, transport depots etc. The modern hospital is a functioning combination of all of these building types. In addition to this uniquely multi-faceted facility, the key point which sets the hospital apart from all other building types, are the 'healthcare specific service requirements'. This is most easily demonstrated by referring to the healthcare specific publications such as the Health Building Notes (HBN) which set the required standards in regard to the planning and design of the

facility, and the Health Technical Memoranda (HTM) which have a similar role in setting healthcare specific standards, but focusing on the more detailed specification at the component level (Space for Health 2012). Although these very specific publications provide guidance on the requirements of the actual built asset, the other key point to understand, is that the hospital can be a constantly functioning facility. All of the building 'sub-types' and the requirement for a fit for purpose provision of service have the potential for operational requirement to be delivered 24 hours a day, 7 days a week, for 365 days in the year. This in itself is an enormous logistical challenge. When the necessity to undertake refurbishment works is introduced, the logistical challenges become far more pronounced, especially given the potentially fragmented nature of separate refurbishment activities or works packages being undertaken simultaneously.

THE REQUIREMENT FOR AN MCDM APPROACH

The hospital has been identified as a unique and highly complex facility. When the uncertainties of the refurbishment process are added to this, the proposed project is already starting from a position which has many inter-related, and often conflicting, criteria. This 'multi-criteria' starting point presents a logical progression to the use of multi-criteria decision modelling (MCDM) techniques. Loken (2005) makes the point that the Decision Maker (DM) is primarily concerned with finding the 'optimal solution', which may only really be possible if measured against a single criterion. The volume of financial and technical considerations within the refurbishment process makes this completely impractical. Triantaphllou (2000) recognises this and highlights the key advantage of MCDM which seeks to ascertain the 'best alternative' when presented with multiple sets of decision criteria. Bouyssou (2000) captures the over-arching essence of decision making techniques in describing them as…"A set of explicit and well-defined rules to collect, assess and process information in order to be able to make recommendations in decision and/or evaluation processes". Although Bouyssou (ibid) clearly recognises the limitations and imperfections of any 'single' MCDM method, a process of 'weighted evaluation' is the most practical and inclusive given the nature of the refurbishment issues, and the composition of the DM team. The critical mechanic of this system, is the comparison of 'every' criteria, to 'every' criteria, which are subjectively ranked, as proposed by Kirk and Dell'Isola (1995) which then allows alternatives to be developed in weighted terms.

MCDM versus existing methods

There are a vast number of sustainability assessment methodologies, many of which have the flexibility or version to accommodate healthcare. Similarly there are many which are focused on, or amenable to the refurbishment process. However, there are few which capture the refurbishment of healthcare facilities. The NHS is restricted to a narrow choice of assessment methods as part of the funding approval processes, guided by the capital investment procedure within the HM Treasury Green Book 'Appraisal and Evaluation in Central Government' (2011). This in turn is the main reference document for the Capital Investment Manual (1994) and the more recent Scottish Capital Investment Manual (2010). The majority of the NHS building works are subject to Building Research Establishment Environmental Assessment Method (BREEAM) assessment, the Achieving Excellence Design Evaluation Toolkit (AEDET), and reference to the Activity Data Base (ADB). Other methodologies have been adopted, albeit on a far smaller scale, such as the Leadership in Energy and Environmental Design (LEED) system, and many of the smaller value refurbishment

projects are ignored completely. Although these systems 'do exist', it is widely felt within industry that they ‘are not suitable’ for application to hospital refurbishment. This is proved by the Building Research Establishments (BRE) withdrawal and current redevelopment (in 2012) of the BREEAM Healthcare (Refurbishment) assessment. As effective (or otherwise) as these methodologies may be, there is one fundamental difference when compared against the MCDM technique. To achieve a set 'rating' score, almost every method provides guidance on specification and element or component selection. However, critically, there is no process of deriving the best specification or design alternative based on a weighted, calculated, and measured selection process. Given the complex nature of the hospital refurbishment process, and as stated earlier, the challenging economic parameters, it is proposed that a model which has the capacity to prioritise specification choices and design decisions would be of great benefit to the client and design team at the early planning and outline proposal stages. The capability of extracting the subjective expert judgement of the design team and the clinical and operational requirements of the client, and then enabling an objective prioritised system of 'trade offs' to be established 'specific to the facility in question' will be of great value to the project delivery. This value is in turn measured against value for money and the requirement to attain the functional and sustainability standards required by the facility and the wider NHS.

Drawbacks and limitations of MCDM

The potential for using MCDM techniques, and the value of doing so has been discussed. However, notwithstanding the benefits of quantifying and prioritising the vast amount of possible criteria, Trianttaphllou (2000) identifies what he terms the 'decision making paradox'. This paradox recognises that given the sheer number of existing and continually developing models, the only true way to establish which method to use is by means of a multi-criteria decision making process. The looped impossibility of this scenario highlights the fact that ultimately, the decision making process is founded on a subjective platform. This seems contrary to the objectives of many of the methods used. The 'criteria' itself, which is naturally the backbone of the MCDM process presents its own limitations. The MCDM process cannot be considered as a 'black box' which will provide ready made solutions. The end result is only as good as the quality and relevance of the data or criteria which is fed into the model. Zavrl *et al.* (2009) expand on this point in recognising that the criteria itself is governed by its ease of availability, or as modelled by Braunschweig *et al.* (2001) and shown earlier in Figure 2, the criteria selection process follows 'generation', to 'relevancy', and finally 'applicability'. This may seem straightforward enough, but caution must be observed in understanding whom the parties are that select the criteria. The clearest example related to this research, is the identification of four distinct expert groups, namely; design team professionals, healthcare professionals, sustainability professionals, and academic professionals. This limits the criteria to that which is prioritised by these respective disciplines and could, it may be argued with some validity, create restrictive parameters to the models results.

A PILOT STUDY

The criteria selection process has been discussed, although it has also been shown that there are variables out with the criteria itself which have an effect on the efficacy and validity of the decision making process. This includes the current tools and systems in use, and the appraisal and procurement process itself. In addition to the main objective to ascertain 'the need' for an MCDM approach, 2 further key objectives of the pilot are

to ‘establish the knowledge base of targeted professionals in the area’, and to ‘inform the content, direction, and format of the main surveys construction’.

METHODOLOGY

A brief questionnaire was offered to 33 professionals from within the disciplines of healthcare, design and construction, sustainability, and academia. The questions were primarily quantitative in nature and were designed to evaluate levels of experience in various healthcare facility building types, and their relationship to the fields of refurbishment and sustainability, respectively. Respondents were also queried on their knowledge and experience with the appraisal and procurement processes for works relating to healthcare, and the most commonly used tools/systems and technical guidance documents as identified from the literature review and secondary data collection. An assessment of the respondent’s experience of using MCDM methodologies was also sought. Elements of qualitative response were also made possible, primarily for feedback on the format and applicability of the pilot study itself. The 'purposeful sampling' strategy described has the deliberate goal of engaging the industry experts in the given fields. Table 1 demonstrates the groupings and related professional characteristics for the pilot. Cresswell (1998) identifies two methods of sampling, of which the pilot questionnaire claims a hybrid mixture of both. The 'stratified purposeful' approach is key in the context of the research, as it is understood that the optimum scenario in regards to both timing and stakeholder engagement lays in the initial financial and technical appraisal processes. Given the over-riding factor of the public purses requirement to achieve best 'value for money', this places the early decision making opportunities within the realm of the expert professionals. This supports the second methodology of 'criterion sampling' which demands that the study population achieve a minimum standard of professional knowledge and/or experience which, in effect, is the qualification gateway for the respondent’s participation.

Table 1: Sampling methodology for the Pilot Study

Professional Strata	Sample Characteristics
Healthcare Professional	Client / Clinician
Design Team Professional	Designer / Constructor
Sustainability Professional	Consultant
Academic Professional	Researcher

LIMITATIONS OF THE STUDY

The study was subject to practical limitations deemed necessary to provide parameters to the research aims. As described above, the sample population was limited to four distinct professional disciplines. The general public (both patients and visitors) has been considered to possess limited technical expertise in the planning, design, and construction process (generally) and as such were omitted from the more specialised format of the questionnaire. It is accepted that the focus on professionals does not encompass the full model, and especially in regards to the criteria such as (but not limited to) *community*, and *health and well-being*, there seems an obvious conflict. It is reiterated however, that the targeted decision makers, and the envisaged intervention point of the model in the appraisal process supports this approach. The inclusion of legal and technical guidance and documentation has been limited to the most commonly used, as supported by the literature review and secondary data

collection. The 'main criteria' (Figure 2) are taken from the Department of Health's own guidance. These criteria are focused on the planning, design, construction, and operation of a healthcare facility, and do not take account of the far wider sustainability agenda, and as such are representative of sustainability 'in this context only'. The over-arching appraisal and procurement processes have been restricted to the study populations experience with the *HM Treasury Green Book*, the *Office of Government Commerce* (OGC) Gateway process (although recognised as archived), and the *Scottish Capital Investment Manual* (SCIM). This approach has limited the surveys appreciation of the relationship and connectivity's to the various Public Private Partnering arrangements.

SURVEY RESULTS AND DISCUSSION

From an evenly distributed invitation to 33 professionals from selected 'strata' (table 1), 17 complete responses were returned. This represents a 55% response rate. Of this percentage, the majority (8 responses) were from the Design Team Professional category. Healthcare Professionals followed with a response rate of 5, and en equal 2 responses for both Sustainability and Academic respondents. There were 2 incomplete responses which were disregarded due to insufficient data. The results demonstrated that the majority of the population sample was experienced in their field with more than 10 years' experience and that this experience was based mainly on the standard acute, and specialist acute hospital. This is a significant observation, as the smaller scale facilities such as the GP Surgery, the health centre, or specialised community hospitals make up a large proportion of the existing NHS estate. The sample was also queried on their experience of the refurbishment process in regard to the range of facilities, of which the only *Good* response was for the standard acute hospital. The GP Surgery, health centre, and community hospital shows either '*no experience'* or '*slight experience'* which gives weight to the observation that a large part of the health portfolio is considered in different terms of scale and/or importance. The question arises at this point, that the distinction and interpretation of what refurbishment as an activity consists of, is essential to classify within the wider decision making process. The prevalence of the Public private Partnership (such as PFI etc.) has separated the refurbishment process in the sense that the consortium are obligated to undertake the Facilities Management of the asset, and as such, may have differing drivers from the standard health authority decision making process. The overall knowledge and experience with the main legislation in regards to building/technical standards, the health technical memorandums and building notes, and the clinical output specification was shown to be '*Moderate'* to '*Good'*, however this does not reflect the samples awareness in optimising the decision making process and subsequent specifications. Before considering this issue in greater detail, it was considered logical to assess the knowledge base and experience in regard to the main existing tools and processes which are (for the most part) encouraged or mandatory for refurbishment works to be undertaken on a health facility. The most positive response for the *Activity Data Base* (ADB), the *Building Research Establishment Environmental Assessment Method* (BREEAM), and the *Achieving Excellence Design Evaluation Toolkit* (AEDET) was that they were 'good reference documents'. The criticism was more wide ranging, and respondents felt that (especially in relation to refurbishment), these tools were 'unsuitable for application to an existing building', and were seen to be an exercise in 'box-ticking'. This experience and viewpoint is representative of the industry experts frustration at 'undertaking assessments for the sake of the assessment itself', while possessing the knowledge that the process in regard to hospital

refurbishment is arguably, not fit for purpose and ignores the 'case by case' approach required when considering an existing and unique built asset.

The case for Multi Criteria Decision Modelling

The study population were asked to rank the main criteria (Figure 2) in order of importance; 1 being the most important, and 13 the least important. The caveat was made that there may be conflicts in this process, and it was to be undertaken to the best of the respondent's ability. This is a critical aspect of the pilot study; as immediately, the sample are required to participate in a very basic form of multi criteria analysis and ranking. Space was left for additional comments to be made on the process, and practically all comments described the 'overlap' amongst criteria, and the difficulty in prioritising because of the integrated nature of the criteria themselves. These observations are validated by the generally *Good* to *Excellent* level of awareness felt by the respondents on the interpretation of sustainability within their respective disciplines. A multi criteria approach is, by necessity, a process of 'trade-offs' and 'best fit' scenarios when faced with a sizeable and often conflicting set of criteria. The comments that the existing tools and methodologies related to the issues of refurbishment and sustainability (respectively) are viewed as good 'guidance' documents, supports the idea that there is no well understood or standardised decision support system in common use. Figure 3 demonstrates one of the pilots key findings, as the lack of experience or knowledge with MCDM techniques points to a gap in understanding and utilisation of a measured and calculated methodology.

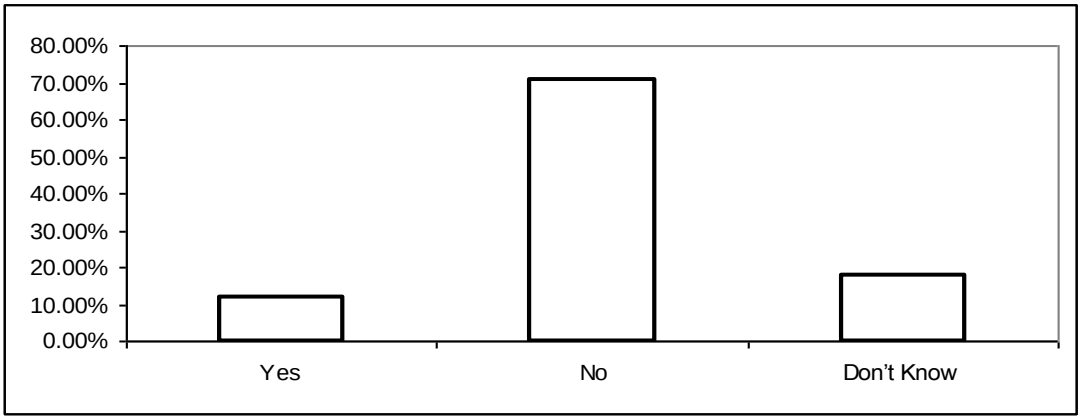

Figure 3: Respondents experience in participation of an MCDM process

This is a salient point in providing the contextual validation for the research project and directs further research into the reasons 'why' such a high proportion of experts have such limited experience with these logically fundamental appraisal tools. Figure 2 identifies the 13 issues stated as the 'main criteria', but it must be understood that each of these criteria encompasses a range of 'sub-criteria' as derived by the decision makers and stakeholders using the reductionist approach offered by Braunschweig *et al.* (2000). In the prioritising exercise described above, the 2 clear leaders were the issues of '*Health & Well-Being'* (7 rated as highest priority) and '*Energy & Carbon Emissions'* (6 rated as highest priority) These results will inform the selection of a sub-criteria branch selected for the models creation and testing for the purposes of the research.

Figure 4 is presented as the second key finding of the pilot, in assessing the knowledge of level and experience with the UK standard capital investment processes.

The inference from both figures 3 and 4 supports the research objective of integrating a calculated decision making process within the time frames and requirements of the capital investment guidance documents. It is proposed that a fundamental disconnection exists between the functional and service needs, the sustainability requirements, and the best ‘value for money’ option when considering the activity of hospital and healthcare facility refurbishment.

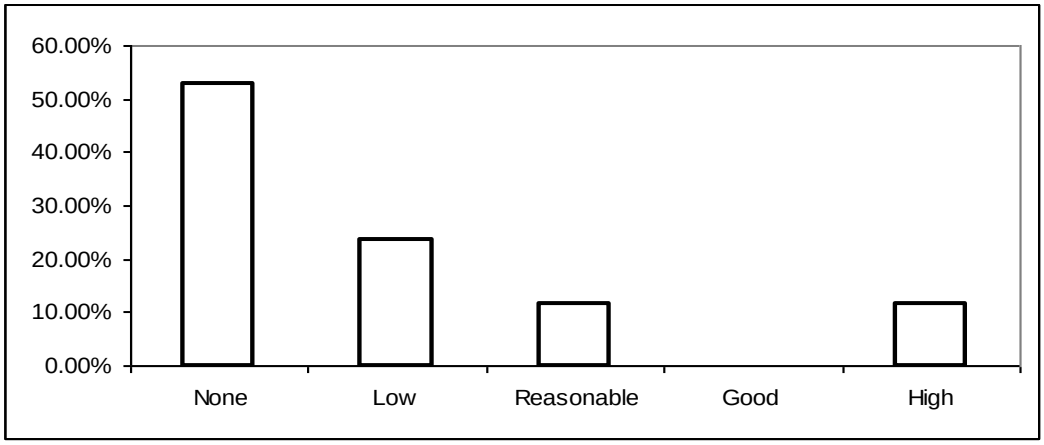

Figure 4: Respondents level of knowledge of the capital investment appraisal process

The guidance within capital investment documents is very clear in demanding that the over-riding factor in the process is ensuring the best *value for money* from the preferred option. This however, must also meet current (and potentially future) legislative and institutional requirements in regards to sustainable development, and it is unclear from reviewing the documents themselves, where the decision making process is formalised in this regard.

SUMMARY AND WAY AHEAD

It has been shown that the activity of refurbishment is generally a unique process with specific challenges, most notably in the area of 'risk'. Undertaking this activity in the arena of healthcare adds more layers of complexity and risk by the nature of the facility and its service and functional requirements. Sustainability has been discussed as a key evolving issue in regards to legislation and institutional requirements. The current assessment methodologies have been questioned in their suitability in achieving a 'best fit' scenario unique to an existing facility, and in achieving best value for money throughout the capital investment appraisal process. Given the number of variables and often conflicting criteria, an MCDM approach has been suggested, although a pilot study of industry experts has demonstrated a lack of knowledge and experience in both MCDM techniques, and the appraisal process itself.

This paper informs and validates the undertaking of a 3 year PhD research programme to develop an integrated decision support model to optimise the sustainable refurbishment of hospitals and healthcare facilities. Secondary and primary data will be used in creating a prototype model to demonstrate the decision making process from start to finish. To this end, a further paper is planned to conceptually model the process. The final output for the research will be a user friendly software based interface which will interactively prove the process from start to finish.

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A MULTIDISCIPLINARY LITERATURE REVIEW OF LOW AND ZERO CARBON TECHNOLOGIES INTO NEW HOUSING

Whitney Bevan[1] and Shu-Ling Lu

School of Construction Management and Engineering, University of Reading, Reading, RG6 6AW, UK

The UK Government is committed to all new homes being zero-carbon from 2016. The use of low and zero carbon (LZC) technologies is recognised by housing developers as being a key part of the solution to deliver against this zero-carbon target. The paper takes as its starting point that the selection of new technologies by firms is not a phenomenon which takes place within a rigid sphere of technical rationality (for example, Rip and Kemp, 1998). Rather, technology forms and diffusion trajectories are driven and shaped by myriad socio-technical structures, interests and logics. A literature review is offered to contribute to a more critical and systemic foundation for understanding the socio-technical features of the selection of LZC technologies in new housing. The problem is investigated through a multidisciplinary lens consisting of two perspectives: technological and institutional. The synthesis of the perspectives crystallises the need to understand that the selection of LZC technologies by housing developers is not solely dependent on technical or economic efficiency, but on the emergent 'fit' between the intrinsic properties of the technologies, institutional logics and the interests and beliefs of various actors in the housing development process.

Keywords: low and zero carbon (LZC) technology, multidisciplinary literature review, new-build housing, zero-carbon new housing.

INTRODUCTION

In response to robust evidence of anthropogenic causes of global warming, many governments are increasingly putting in place national targets for carbon reduction. The United Kingdom (UK), for example, is committed to a 34% reduction in carbon dioxide emissions by 2020 and 80% by 2050 compared to 1990 levels (DECC, 2011; HM Treasury, 2008). The housing sector plays a vital role in achieving this demanding target. The existing housing stock within the UK emits over 25% of total carbon emissions (EST, 2008). The UK government has encouraged the reduction of carbon emissions from new housing by implementing a number of policies and incentives. The Code for Sustainable Homes (the Code), in particular, is driving innovation in the housing development sector by stating that all new homes built in England should be zero carbon from 2016 (CLG, 2009). This challenge of achieving

[1] w.bevan@reading.ac.uk

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zero carbon homes is being met, in part, by the use of low and zero carbon (LZC) technologies (CLG, 2010; Boardman, 2007).

There is a growing literature on LZC technologies that traverses diverse disciplinary boundaries, but the recurring starting (and finishing) point for much of this is a technical perspective which concentrates on their performance and cost characteristics (Lees and Sexton, 2011). There are many LZC technologies on the market that can potentially be used in housing to comply with the new regulatory requirements; some of which have appeared to have been readily accepted by housing developers, while other technologies have been rejected. The selection criteria, though, are not bounded by technical performance, but encompass a range of commercial and path dependency considerations (Sexton and Lees, 2012). The reality is that the narrow technical rationality conceptualisation does not represent that actual irrationality (based purely on measures of technical efficiency) of LZC technology adoption and diffusion. The field is thus prone, we argue, to technical rationality or an assumption that the technical performance of LZC technologies will, alone, guide selection and use.

The aim of the paper, through a literature review, is to identify the sources, tensions and potential pathways out of the technical rationality distorting our understanding of the adoption and successful integration of LZC technologies into new housing. This review draws upon technological and institutional literatures to shed different, but complementary, perspectives. The review confirms the dominant technical rationality of the literature. The instrumentality of technical efficiency and cost-benefit as drivers for the selection of 'optimal' LZC technologies are privileged. There is a smaller, but now discernible counter body of literature emerging which is beginning to both contest and shape this technical rationality by bringing attention to way that companies are responding to and translating myriad regulation and market pressures into logics which inform the selection criteria and processes.

This paper is organised as follows. First, a definition of LZC technologies is given. Second, technical and institutional perspectives on the selection of certain LZC technologies into housing are discussed. In the final section, discussion and conclusions are drawn.

DEFINITION OF LOW AND ZERO CARBON TECHNOLOGIES

The definition of low and zero carbon (LZC) technologies is slippery and is dependent on different actor perspectives. The National House-Building Council (NHBC) (2010: 2), for example, defines LZC technologies as “generally applied to renewable sources of energy, and also to technologies which are significantly more efficient than traditional solutions or which emit less carbon in providing heating, cooling or power”. This term can be applied to a wide range of technologies and indicates that it is not solely renewable technologies that will be discussed, but those which may use a combination of renewables and fossil fuels.

The Energy Saving Trust (EST) (2010: 4), when put up against the NHBC Foundation definition, blurs the boundary of the term by stating LZC technologies are those “that are zero carbon in operation (powered by 100% renewable energy) and those that are considered to be low carbon in operation (powered at least in part by fossil fuels)”. The EST (2010) further suggests that LZC technologies have an output of heat (e.g. heat pumps) and electricity (e.g. solar photovoltaic), in addition stating two further energy efficient technologies within the definition: mechanical ventilation heat

recovery (MVHR) and passive flue gas heat recovery. This definition is more specific than the previous, however a slight tension is created as it excludes cooling as an outcome of LZC technologies.

A broad definition is offered by Boardman *et al.* (2005) who define LZC technologies as "renewable energy generators or technologies with better fuel efficiency than conventional technologies, and which are retrofitted to or integral to the building or community" (p. 109). This more expansive definition does not specifically state that the technology must be attached to a building, nor is there a mention of any restriction on carbon emissions.

For the purpose of this review, the definition of a LZC technology is a synthesis of the definitions already detailed. The aim is to create a broad definition that accommodates the diversity of technologies discussed in the literature. The downside of producing such an inclusive definition, of course, that from any given perspective it will lack precision (or reproduce desired bias?). A LZC technology therefore is defined as 'a technology that can provide heating, cooling or power (or a combination of outputs) and will be powered solely by renewable energy (zero carbon) or powered in part by fossil fuels (low carbon).' Examples of LZC technologies include, but are not strictly limited to: solar photovoltaic (PV), solar thermal, wind power, hydro power, heat pumps (ground/air/water), combined heat and power, biomass boiler, MVHR and fuel cells (adapted from EST, 2010; NHBC, 2010; SBSA, 2007).

Further, it is interesting to note that there are three recurring terms for this group of technologies: LZC technologies, renewable energy technologies [1] and microgeneration technologies [2]. All three terms have different boundaries that include and exclude various systems. Due to the changing nature of this field, as new technologies are constantly being invented and improved, it is not surprising that the boundaries of each term are permeable. It is useful to recognise the flexibility and comparisons between each term. However, we argue, that microgeneration technologies and renewable energy technologies should be classified as subgroups under the overarching broader definition of LZC technologies.

Notwithstanding the hazy and shifting boundaries of the LCZ technologies, the substantial insight is that the literature overwhelmingly frames the definitional debate in terms of the energy services produced by the technology (i.e. heating, cooling, and so on). The debate is, though, weakly coupled to the technological and institutional contexts within which they are located. The following section comment on these two perspectives.

DIFFERENT PERSPECTIVES ON THE SELECTION OF LOW AND ZERO CARBON TECHNOLOGIES IN HOUSING

Technological perspective

The 'technological perspective' focuses on the attributes of the technology artefact itself (e.g. its scientific performance, technological potential, lifecycle) and privileges these attributes as being the crucial determinant to the uptake of LZC technologies.

The selection of LZC technologies by housing developers to date is predominantly driven by their fundamental technical and economic attributes (Lees and Sexton, 2011). Monahan and Powell (2011), for example, compare four different energy typologies within fourteen new low energy affordable homes, including ground source heat pumps (GSHPs); solar photovoltaic (PV) and solar thermal; passive solar and

mechanical ventilation and heat retrieval (MVHR); and, conventional high efficiency gas boilers (the 'control' scenario). The criterion of what constituted a certain LZC technology being a 'success' was on the basis of 'low energy use', 'low carbon emissions' and 'affordability.' The results show that all the case study homes used less energy, emitted less carbon and had lower annual running costs compared to the average UK household, emphasising the benefits of LZC technology integration over the 'basic house' design (Monahan and Powell, 2011). (Though what constitutes a 'basic house' design is not clarified in detail.) They further highlight the more noticeable tension between the different technologies in terms of affordability. The investigation demonstrates that technological performance (lowest possible energy use and carbon emissions) is important, but if the technology is not affordable by society, its selection may be affected.

Similarly, at the home occupant level, Caird *et al.* (2007) conducted a study of why certain LZC technologies (solar thermal, solar PV, micro-wind turbines and wood-burning stoves) are adopted or rejected by householders in existing homes. It was found that drivers of LZC technology uptake can be identified as the ability to gain a reduction in energy use, saving money and home owners wanting to be environmentally conscious. Caird *et al.* (2007) and Element Energy (2008) concur that the financial aspect of the technology (e.g. high capital cost of the system and long payback periods) is the main factor preventing the householders from adopting the technology.

Moreover, Pan and Cooper (2011) suggest that the financial aspect of the system can create both drivers and barriers towards LZC technology adoption. They stress that direct capital cost was a high priority for the housebuilders when selecting a suitable system for the housing project, and further led to choose a certain supplier due to the initial capital cost of air source heat pump (ASHP) systems. They further emphasise the importance of both short and long term expenses of the technology and its effect on selection. In addition to the financial aspect of the technology, the research identifies non-cost influences such as LZC technological performance, along with features of the technology that may affect its integration within a residential property, for example, ease of implementation.

Element Energy (2008:10) drills further down on the financial issues when it discusses how "consumers place a very low value on on-going costs compared with up-front capital costs." Consumers find the installation of microgeneration technologies unaffordable, while there is no or scant deliberation on the potential long-term savings of the system. The perceptions and values of society are linked to behaviour within this finding, similar to the work by Caird *et al.* (2007). In disagreement with Element Energy (2008), Faiers and Neame (2006) suggest that the economics of the technical system (economics in this context refers to the long-term investment, for example, the payback period or life-cycle costs of the system), is important, if not more important, to consumers than the initial capital costs.

Boardman *et al.* (2005) reiterate the previous key message stated by Element Energy (2008), that LZC technologies are not a cost-effective method of energy generation at this present moment. This message is presented for many technologies, for example, LZC technologies (Boardman *et al.* 2005), microgeneration technologies (Element Energy, 2008), along with technologies that have been on the market in the longer-term (ten years plus) such as fuel cells (Brown *et al.* 2007). This is also appears to be the case in community-owned technologies. The potential capital gain generated by

certain technologies is a driver for its uptake, whereas those systems that are not cost-effective, or unable to achieve funding, are being rejected by communities (Walker, 2008).

In summary, the technological perspective has a focus on the actual technology (material artefact) itself; how it performs, the demands of the system when integrated and the micro-economics of the system. There appears to be a great emphasis on LZC technologies in comparison to conventional forms of technologies, in many cases the latter being more desirable due to certain characteristics (cost, reliability). The influences discussed within this section, specifically the financial aspects of the technology, are interpreted as a barrier or driver to the uptake of LZC technologies.

The technological literature is characterised by a unit of analysis which does move beyond the discrete LCZ technology or the home within which it is located. There is often an acknowledgement of the broader pressures for low and zero carbon homes (for example, UK national target commitments or the Code for Sustainable Homes). However, how these broader pressures enable or constrain the selection logics of those actors actually making those decisions is rarely detailed - there is an implicit assumption that the decision is a 'given.' It is this assumption which is of interest to the literature flavoured by an institutional perspective.

Institutional perspective

The 'institutional perspective' recognises that organisational behaviour is enabled or constrained by an institutional context. In other words, this perspective states that how an organisation acts or pursues its activities is not caused solely by economic and technological factors, but also by institutions. The ‘institutional perspective’ is interpreted in this paper as the role of institutions (such as government, local authorities, trade associations) through their policy, regulations, standards or guidelines in influencing the adoption of LZC technologies.

The importance of institutional factors that contribute to the selection of LZC technologies in new homes is less emphasised in the literature, but strands are to be found and are growing in volume and influence. A number of commentators have highlighted the vital role of governments in the uptake of LZC technologies. Without government support, the uptake of a LZC technology tends to be slower in the market place. Brown *et al.* (2007), for example, suggest the Japanese success of integrating fuel cell technology within the residential combined heat and power system is the result of a partnership of government and industry intervention. Negro *et al.* (2012), for instance, indicate the need of additional attention from policy makers in seeding up the diffusion of renewable energy technologies.

More specifically, a number of government instruments (e.g. policies, regulation) have been identified that have an influence on the uptake of LZC technologies (e.g. West *et al.* 2010; Element Energy, 2008). West *et al.* (2010), for example, state that the implementation of regulations and policies has a positive effect on the uptake of renewable technology (through the understanding of public opinions and the application of this understanding to policies).

Numerous studies further indicate that financial incentives can aid the adoption and diffusion of LZC technologies within housing. Li *et al.* (2011), for example, indicate that incentives, regulations and encouragement from the government are the main reasons why the uptake of solar water heaters in Dezhou, China has been successful. Similarly, Element Energy (2008) makes a normative stance that if in the form of

subsidies, policies could be a key driver and resolve the issue of finance involved with microgeneration technologies. In contrast, Faiers and Neame (2006) state that previous policies offering grants or subsidies for solar thermal and solar PV installation have not acted as an incentive for adoption.

To further complicate the role of institutions, Boardman *et al.* (2005) amplify their responsibility; not only referring to the financial incentives that governments and local authorities can execute, but also changes to the market, changes to building regulations (new and existing build) and the provision of technological information within R&D, the supply chain and those installing the technology. The importance of markets and market policies are highlighted and suggested they are of great influence to the uptake of LZC technologies (Boardman *et al.* 2005; Tsoutsos, 2002). Although the provision of finance is not deemed as the most important element of increasing LZC technologies within housing, other drivers of LZC technologies (e.g. changes to markets) are related to and revolve around the cost (Boardman *et al.* 2005).

Foxon and Pearson (2007) further point out that it is not the lack of policies that are hindering low carbon technologies, but the process in which they are implemented. They conclude that policies designed with long-term strategies and those that combine government and stakeholder interaction will prove to be successful. (There is little indication of how broadly or narrowly the concept of a 'stakeholder' is defined.) Element Energy (2008) agree with Foxon and Pearson (2007) with the focus on the importance of policy definition, design and structure regarding their success. They are not underestimating the role of policy implementation, but suggest that attention should be paid to the details of the policies, such as carefully selected combined policies (as oppose to single policies).

In summary, the institutional perspective reveals that the uptake of LZC technologies is influenced by the logics of numerous institutions (such as local authorities or governments inflicting policies, standards or regulations). Evidence demonstrates that these influences predominantly act as drivers, as oppose to barriers, of LZC technologies. There are, however, cases where barriers are created against the technology or more commonly, a specific technology becomes favoured over others.

The literature is searching for linkages with the technological literature and is posing interesting questions for future research. The literature, however, tends to feature normative assertions that policies could do this or that (drawing, often, from experiences from other sectors such as manufacturing). The supporting empirical work to test these normative assumptions is an urgent research need.

DISCUSSION AND CONCLUSION

The technological and institutional literatures focused on LZC technologies in new housing have very different loci of investigation. Table 1 provides a summary of the perspectives and issues of each set of literatures. In broad terms, the technological literature considers and weighs the efficiency of different LZC technologies and generally makes an optimising assumption that the most efficient technology will be selected and used. There is an implicit positivism where the concern is with generalisation and prediction and the need to control the selection of LCZ technologies on the single goal of technological efficiency. The institutional literature, though rarely explicitly drawing upon the institutional theory literature, tentatively argues that regulatory and commercial logics create selection routines by housing developers which are not driven by technology optimisation criteria. Indeed, research

has revealed instances where regulation compliance and commercial considerations have all been displaced by technical rationality.

Table 1 A summary of contributions to the two perspectives of the selection of low and zero carbon technologies

Multidiscipline perspective		Variables	Contributions
Technological perspective	Enablers	Low energy use	Lees and Sexton (2011), Monahan and Powell (2011), Pan and Cooper (2011), Peters *et al.* (2011), Element Energy (2008), Caird *et al.* (2007), Faiers and Neame (2006), Boardman *et al.* (2005)
		Low carbon emissions	
		Affordability	
		A reduction in fuel bills	
		Financial aspect of the system (high initial cost, long payback periods)	
		Economics of the system (e.g. payback period)	
		Technological development/improvement can aid a reduction in the cost of a system	
	Barriers	Financial aspect of the system (high initial cost, long payback periods)	West *et al.* (2010), Osmani and Reilly (2009), Caird *et al.* (2007), Brown *et al.* (2007)
		Technologies not cost-effective	
		Technologies not reliable	
Institutional perspective	Enablers	Government policy / regulations (economic / financial incentives, e.g. government grant, subsidies, renewable heat incentive; information to the public: renewable energy and environment; policies providing information; and, raising public awareness through customer motivation)	Li *et al.* (2011), Peters *et al.* (2011), Pan and Cooper (2011), West *et al.* (2010), Element Energy (2008), Brown *et al.* (2007), Foxon and Pearson (2007), Boardman *et al.* (2005), Tsoutsos (2002),
		Clear regulations (user knowledge, large scale, definition)	
		Encouragement from the government	
	Barriers	Lack of government intervention and promotion	Brown *et al.* (2007)

What is apparent is that both sets of literatures is that each, at best, acknowledges each other but generally do not authentically engage each other in a theoretical or empirical sense. Rather, the prevailing literature, by adopting a single perspective, tends to reveal a sometimes detailed, but nonetheless partial, incomplete picture. Discrete pieces of the jigsaw can be assembled to present a fragile 'leap of faith' picture that suggests that the selection of LZC technologies by housing developers is not solely dependent on technical or economic efficiency, but on the emergent ‘fit’ between the intrinsic properties of the technologies, institutional logics and the interests and beliefs of various actors in the new housing development process. There is an urgent need, though, for theoretical and empirical research which explicitly bring together these considerations into a systemic whole.

NOTES

[1] Renewable energy technologies are defined as “on-site solutions providing heating or power which are more efficient or emit less carbon than more traditional solutions” (NHBC, 2012: iv).

[2] Microgeneration technologies are defined as “On-site or building integrated equipment that generates electricity, but could include fossil fuels” (SBSA, 2007:44).

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DELIVERING ZERO CARBON HOMES IN THE UK

Emma Heffernan[1], Wei Pan [2] and Xi Liang [3]

[1, 2] *School of Architecture, Design and Environment, University of Plymouth, UK, PL4 8AA*

[3] *College of Life and Environmental Sciences, University of Exeter, UK, TR10 9EZ*

In the UK and internationally, a plethora of voluntary and mandatory energy efficiency standards for new buildings exist, with the common aim of mitigating the impact of new buildings on climate change. However, the take-up of voluntary schemes has been limited and, as a result, many governments have seen the need to introduce mandatory schemes through legislation; from 2016 all new build homes in England and Wales will be required to achieve zero carbon in regulated energy consumption. The international context of voluntary and mandatory building energy efficiency standards is examined through a review of the literature. The review is expanded by a series of semi-structured interviews with construction professionals involved in the delivery of low and zero carbon homes in the UK. In order to establish why zero carbon homes are not being developed, themes of drivers and barriers and challenges in relation to the delivery of zero carbon homes are explored. The drivers which emerged are categorised into four groups: legislative; economic; social responsibility and individual; and the barriers and challenges into a further four groups: skills and knowledge; legislative and governmental; economic and industry. Skills shortages and knowledge gaps for all involved in the delivery of zero carbon homes were seen as the primary barriers and a gap in the literature also exists in this area. Gaining a greater understanding of the skills and knowledge required for the delivery of zero carbon homes is therefore confirmed as the focus for further research.

Keywords: housing, skills and knowledge, sustainability, zero carbon.

INTRODUCTION

Approximately 29% of all carbon dioxide (CO2) emissions in the UK are directly from the domestic sector; the largest proportion of this (83%) is produced by space heating and domestic hot water (DECC 2011). Through the Climate Change Act (HM Government 2008), the UK Government has committed to a legally binding target of reducing CO2 emissions by 80% of the 1990 level by 2050. Working towards these targeted reductions, there will be a requirement for all new homes to be 'zero carbon' from 2016 (CLG 2007). New build housing has the potential to be a leader in both energy efficiency measures and meeting the CO2 emission reduction target. A broad range of voluntary and mandatory standards, regulations and rating tools for new build homes around the world currently exist, some with a focus on energy efficiency, some with a broader 'sustainable' agenda (CLG 2008). These standards provide a historic background to and current international context for the forthcoming zero carbon

[1] emma.heffernan@plymouth.ac.uk

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homes standards in the UK and therefore warrant critical review. The aim of this paper is to contribute a better understanding as to why low and zero carbon new build homes are not being built in any numbers in the UK through an exploration of construction industry perceptions around zero carbon homebuilding. The objectives of the paper are to:

- Compare the building standards for low and zero carbon homes in the UK and internationally;
- Investigate the drivers for low and zero carbon homebuilding;
- Identify the barriers and challenges in delivering low and zero carbon homes.

LOW AND ZERO CARBON BUILDING STANDARDS

International design and construction standards

Internationally there exist numerous labels for energy efficient homes, which include low-energy (Sweden), energy-plus (Germany), zero-net energy (USA), passive house (Germany) and sustainable homes (UK) (Williams 2012, Mlecnik *et al.* 2010). A 2008 European survey identified 17 different terms for low and zero energy homes (European Commission 2009). There are many different motivations for regulating or rating the energy efficiency of new buildings. Typically, countries with harsher winter climates have been the quickest to act in the implementation and uptake of mandatory and voluntary building energy efficiency standards. Sweden for example, has had national minimum building energy efficiency requirements since the early 1950's (Hjörth *et al.* 2011) and the Building Regulations in the UK have included standards for limiting heat loss since 1965 (McManus *et al.* 2010), whereas in Australia, energy efficiency requirements for new buildings were not implemented until 2003 (NatHERS 2011). Australia has been able to avoid regulating energy use in buildings for so long due to its climate and its richness of resources; fossil fuels are both plentiful, with no risk to supply, and cheap (Saman 2012). Many European nations first started to seriously consider the need for reducing their dependence on fossil fuels, and therefore improving energy efficiency, as a result of the energy crisis of the 1970's (Williams 2012). More recently, mandatory energy efficiency regulations have been tightened as a result of concern over climate change and its potential impacts (Goodchild and Walshaw 2011, McManus *et al.* 2010, Peterman *et al.* 2012).

In Sweden, the standards for energy efficiency have been equivalent to or better than level 4 of the UK Code for Sustainable Homes (The Code) since 2006. The energy efficiency requirements were tightened in 2009 and again in 2011. Future changes to the regulations are planned for 2015 and 2018-2020 for a move to 'Nearly Zero Energy Buildings' (Hjörth *et al.* 2011). Sweden is currently the only country in which energy efficiency certification is based on measured performance (carried out after 2 years of occupation). As a country that has led the way in terms of energy efficiency, this may be a sign of the future in the UK.

In France, the requirements for energy efficiency of housing are set out in the Thermal Regulations (RT2012). RT2012 requires a maximum primary energy use of only 50kWh/m2yr for all new housing (Grenelle Environnement 2012). A future target has been legislated for with a mandatory requirement for Energy Plus Houses by 2020, this has been established nationally, despite the varied climatic conditions that exist across France. In addition to this mandatory standard, the Haute Qualité Environnementale (HQE) is a holistic environmental standard under which there is a requirement for energy consumption to be 10% lower than prescribed within RT2012.

Within the residential sector in the USA, Energy Star for Homes is the most popular of the three primary voluntary green ratings systems (17% of new homes in 2008 (Reeder 2010)). Energy Star is focused on energy efficiency; however, indoor air quality requirements have been introduced as part of the 2011 update. Achieving Energy Star for Homes is a requirement within the other primary green rating systems; LEED for Homes and National Green Building Standard. An improvement of 15% over the national regulations is required to gain certification under Energy Star.

The vast nature of Australia and its devolved governing status together present issues for the setting of national building standards. The National Home Energy Rating Scheme (NatHERS) is a 10 star energy rating scheme which uses computer simulation to model primary energy loads and assess the thermal comfort of housing. Since 2010, it has been mandatory to achieve a 6* rating for all new housing. Prior to its introduction in 2003, less than 1% of new housing would achieve a 5* NatHERS rating (NatHERS 2011). Under the scheme, 69 climate zones have been defined, each with an individual energy consumption target. Unlike the majority of regulations within Europe, this rating excludes energy used for domestic hot water and lights it also excludes unregulated energy used by appliances.

There has been a proliferation of voluntary standards and sustainable building rating tools in recent years which assess buildings against a broad range of criteria; there has been criticism of some within the literature as, under certain schemes, buildings with only standard energy efficiency are able to gain 'green' certification (Byrd and Leardini 2011, Mlecnik *et al.* 2010).

UK STANDARDS FOR LOW CARBON HOMES

The most prominent sustainability label for housing in England is the Code for Sustainable Homes (CLG 2008). The Code is a voluntary sustainability rating tool in which homes can be certified from level 1-6; 6 being the most sustainable. Maximum CO2 emissions levels are mandatory for each of the six levels of the Code. The importance of energy efficiency within the Code is highlighted by the fact that the energy category is weighted to account for 36.4% of the overall points available. Since its inception in 2007, over 40,000 homes have been certified at post-construction stage; of these over 37,000 have achieved level 3 (CLG 2011a). All social housing attracting funding from the Homes and Communities Agency has been required to achieve Code level 3 as a minimum and some Local Authorities have introduced a requirement within policy to achieve a certain Code level. These borderline mandatory requirements account for its high degree of uptake; the private housebuilding sector has not bought-in to the Code to any significant extent on a voluntary basis; private developments account for less than 15% of post-construction certified homes under the Code (CLG 2011a) whereas they account for around 80% of all new build homes (Wilcox 2009).

‘Zero carbon homes’ will be a mandatory standard in the UK from 2016, announced in 2007, originally the standard was ambitious, requiring not only regulated energy (for heating, cooling, hot water, ventilation, auxiliary services and lighting) to be zero carbon, but also unregulated energy covering all home appliances (CLG 2007). Lowe and Oreszczyn (2008) commented on the ambitious speed and scale of the zero carbon policy and made recommendations to limit the targeted reduction of CO2 emissions. In the face of concern from the construction industry and with the deepening of the global financial crisis, the definition has been amended to include only regulated energy. Therefore, the definition for the purposes of this study will be that currently

proposed to be included within the 2016 amendments to Part L of the Building Regulations; broadly: "A new-build home from which there are zero net CO2 emissions from regulated energy use". The means by which zero carbon can be achieved are flexible: compliance with a Fabric Energy Efficiency Standard (FEES); generation of on-site low or zero carbon energy (Carbon Compliance); and 'Allowable Solutions'. Allowable solutions allow for an element of local, near or off-site carbon offsetting (Zero Carbon Hub 2011). Figure 1 illustrates the changing definition for zero carbon and its relation to the Code.

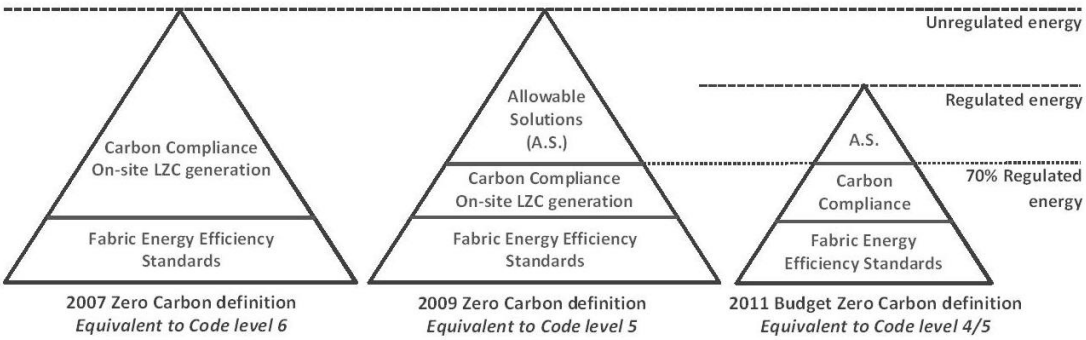

Figure 1: The changing definition of Zero Carbon (after Zero Carbon Hub 2011)

The international standards upon which a comparison is drawn focus on the energy efficiency of buildings in terms of their fabric; limits are set for maximum regulated energy usage in kWh/m2yr. The UK standards differ in their use of KgCO2/m2yr as a metric; however, the introduction of FEES as part of the zero carbon homes standard will provide a requirement for minimum levels of energy efficiency in kWh/m2yr.

DIFFUSION OF ENERGY INNOVATION WITHIN HOUSEBUILDING

The literature has shown that the take-up and diffusion of voluntary green building ratings systems has been slow and limited (Mlecnik *et al.* 2010), this is due to the status of the economy, financial motives and the structure of the construction industry (Peterman *et al.* 2012); the construction industry is formed of a complex supply-chain, through which the diffusion of new knowledge is not easy. Goodchild and Walshaw (2011) state that in the case of zero carbon homes, as a socio-technical system innovation has been discouraged by the lack of financial incentives. The literature has shown that there are conflicting views with regards to market demand; Lovell (2005) found that the housing market has failed to respond to increasing consumer demand for low energy homes. The Callcutt (2007) Review however suggests that there is a lack of demand for highly energy efficient homes due to homebuyers being poorly informed, and even for those that are cognisant of the benefits of energy efficiency, their preferences for price, size and location of a home typically outweigh any preference for energy efficiency. Lovell (2005) concurs with this and suggests that the industry has a tendency to stifle innovation because decisions in housing are not just based on cost and concludes that economic supply and demand theory is too simplistic to apply to the complex housing market with its myriad of socio-technical issues.

Osmani and O'Reilly (2009) undertook a study using a questionnaire survey within which responses were received from 41 of the top 100 housebuilders in England. The study sought to identify drivers for and barriers to zero carbon home building from the housebuilder's perspective. From the findings they categorise drivers for zero carbon homes into 4 groups: legislative, cultural, business, and financial; and barriers into a

further four groups: legislative, cultural, financial, and design and technical. Legislation was found to be both the strongest driver and the most significant barrier. The Callcutt (2007) Review supports these findings; stating that with the lack of a strong market driver, the Government need to legislate, however, unless this legislation is credible, clear, sustained and enforced, it may act as a barrier.

SKILLS SHORTAGES AND KNOWLEDGE GAPS

A recent research study looking at the energy usage of new homes against their design energy usage (Miles-Shenton *et al.* 2010) found that the homes studied used an average of 100% more energy. Equally concerning is a recent study of Building Control departments within two District Councils (Pan and Garmston 2012) which found that only 35% of the new homes applications analysed provided necessary proof of compliance with Part L of the Building Regulations. They conclude that this is due to both inadequate systems within the Building Control departments and poor provision of information by the builders. Both of these studies are potentially indicative of skills shortages and knowledge gaps within the housebuilding industry.

Glass *et al.* (2008) used the PEST model of analysis (political, economic, social and technological) to identify enablers and barriers in developing improved standards in new build construction. Amongst the categories of social and technological barriers, a number of issues around skills and knowledge are identified, including: skills shortages; migrant workers; need for CPD and education; lack of know-how; lack of research and development; poor client knowledge; and poor specification writing and estimating. Amongst their recommendations to tackle these and the other barriers identified are: the instigation of regional demonstration projects; tighter legislation and quality control; and the establishment of a 'pan-institutional think tank' to identify new educational routes and career paths.

The Academy for Sustainable Communities' report, Mind the Skills Gap (ASC 2007) presents findings from a study to assess projected gaps in supply and demand of the necessary skills for the delivery of sustainable communities. The results for different sectors are presented for both England as a whole and its nine regions, of which the South West is one. The study forecasts that the South West will be likely to encounter the second greatest skills gap of the regions identified, with the most significant deficiencies amongst planners, landscape architects, architects, urban designers, surveyors and developers.

The Callcutt (2007) Review confirms this forecast; it makes reference to a shortage in the professions which are not directly employed within the housebuilding industry, but who are essential to the successful delivery of housing; such as planners. Their recommendations to tackle this issue are that planning departments should be formed of multi-disciplinary strategic teams and that, as part of a co-ordinated training programme, planning team members should be seconded to and from private practice. The review also suggests that skills shortages in the housebuilding sector are, in part, due to the structure of the industry; a significant majority of firms in the sector have made use of contingent labour whereby they have no obligation to consider the long-term training of those staff.

The review of the literature has identified that the diffusion of voluntary energy efficiency measures for buildings has been slow (Callcutt 2007, Lovell 2005, Mlecnik 2010, Peterman 2012); the views of housebuilders in England on the drivers and barriers have been explored (Osmani and O'Reilly 2009), but not those of the wider

industry. The extant research has also failed to cover challenges that have been experienced in the delivery of low and zero carbon homes. The review of the literature has shown that there are existing skills shortages and knowledge gaps which might potentially be exacerbated through the introduction of the zero carbon homes standard.

RESEARCH METHODS

Mixed methods were employed within this research. A critical literature review was carried out to identify and compare international building energy efficiency standards and subsequently, a series of in-depth interviews were carried out in order to explore perceptions of the drivers, barriers and challenges relating to the delivery of low and zero carbon homes. Twelve semi-structured interviews were conducted, with the aim of scoping for broad themes. The interviews were conducted with professionals within the housebuilding sector in South West England and also with a small number of national-level experts in the field of low carbon homebuilding in the UK (Table 1). Whilst most of the interviews were carried out with construction professionals from South West England, the majority of these professionals have worked outwith the area and a number of interviews were carried out with national experts. The findings therefore have relevance beyond the regional context. The interviewees were selected using a combination of purposive and snowball sampling (Bryman 2012); participants with suitable experience in the field of low and zero carbon homebuilding were initially selected and they then suggested other appropriate interviewees. Bryman (2012) suggests that snowball sampling is well suited for use in qualitative research. The interviews comprised a series of open-ended questions developed for this research; 7 interviews were conducted face-to-face and 5 over the telephone. The first 2 interviews were transcribed and analysed in order to check internal validity and the interview questions were expanded at this stage. The qualitative data was analysed and coded through NVivo using thematic analysis (Bryman 2012).

Table 1: Interviewee categorisation

Organisation type	No. of interviewees	Position/ Role
Client	2	Housing Association Development Manager
Contractor	1	Chief Executive
Design consultant	2	Architect, Energy Consultant
Local Authority	5	Planning Policy/ Building Control Officer
Government Agency/Quango	2	National policy expert
Total	12	

FINDINGS AND DISCUSSION

Drivers for low and zero carbon building

The interviewees were asked to identify drivers for zero carbon homebuilding. Whilst not intending to quantify the findings due to the exploratory nature of the study, the emerging themes have been categorised into groups and the groups placed in order of significance (most significant first); drivers: legislative, economic, social responsibility and individual (Table 2).

Legislation was seen as the most effective driver for the delivery of low and zero carbon homes; this view concurs with the findings of the Osmani and O'Reilly study of housebuilders (2009). The clarity of direction is seen as a necessity for pushing

through the implementation of this challenging standard, this is further supported by the literature (Goodchild and Walshaw 2011, Peterman *et al.* 2012).

Table 2: Emerging themes - Drivers

Legislative	Economic	Social Responsibility	Individual
Climate Change Act	Cost of fuel	Fuel poverty	Positive action
Building Regulations	Prototyping	Moral drivers	Common sense
	Easier asset management	Limited resource use	Comfort
	Employment		Moral drivers
	Market demand		

Rising fuel prices have meant that homeowners are increasingly conscious of the cost of heating homes and this translates into an economic driver for low and zero carbon homes. In terms of financial drivers for a developer however, there were divergent views amongst respondents regarding the existence, or not, of market demand for low and zero carbon homes. Within the Osmani and O'Reilly study (2009), financial drivers were seen as the least significant theme whereas within this study they were seen as the second most significant theme. These divergent, and at times polar, views are symptomatic of the complexity of the housing market as a socio-technical system.

Social responsibility was one group of drivers identified for the volume delivery of low and zero carbon homes. With fuel poverty and energy security being issues of importance throughout the UK, a number of the professionals interviewed saw the need to address these concerns as a driver for zero carbon homebuilding.

The theme of individual drivers was identified as the least significant group of drivers within this exploratory study. Respondents suggested that comfort, common sense, morals and the desire to do something positive for the environment were all drivers for individuals.

Barriers and challenges for low carbon building

The interviewees were also asked to identify barriers and challenges for low carbon homebuilding. These comprise four groups (most significant first): skills and knowledge; legislative and governmental; economic and industry (Table 3).

By far the most significant barriers and challenges identified by the respondents were those relating to skills shortages and knowledge gaps. Interviewees' perceptions were that knowledge gaps existed for all parties involved in the delivery of housing, including planners and the build and maintenance teams. Skills and knowledge gaps were not identified as an issue within Osmani and O'Reilly's study of housebuilders (2009). However, both Callcutt (2007) and Glass *et al.* (2008) found skills and knowledge to be an issue of concern for the implementation of enhanced standards in new build construction and for housebuilding in general, though not specifically for zero carbon homes. A gap in the literature in respect to both understanding and addressing the skills shortages and knowledge gaps for the successful implementation of the zero carbon homes standard was therefore highlighted by this exploratory study. The level of awareness and knowledge of users and the general public were also identified as significant barriers and challenges. One respondent interviewed in the context of a new low carbon home development saw end user education, in terms of operating a low carbon home, as a much greater challenge than the education of the delivery team. The need to educate the occupants of low and zero carbon homes,

albeit an area with a lack of exploration in existing literature, is outside the scope of this paper.

Table 3: Emerging themes - barriers and challenges

Skills & knowledge	Legislative & Governmental	Economic	Industry
Knowledge - Build, O&M	Uncertainty re ZCH	Lack of market drivers and payback	Nature of housing market - volume housebuilding
Knowledge - Users	Moving the goalposts	Capital cost	Being context specific
Knowledge - Designers	Planning agenda	Promoting growth	Collaborative working
Skills availability			Cultural change
Hard to persuade people			New business models
Moving from demonstration to mainstream			Product availability

Amongst the respondents, there was a feeling that, although the government have affirmed their commitment to the zero carbon homes policy, with a track record for changing the goalposts, until there is legislation in place, the industry is reticent to make firm steps to prepare. These findings are supported by the literature (Callcutt 2007, NHBC 2010, Osmani and O'Reilly 2009).

Economic barriers were also identified; there is a perception amongst the wider industry that there are a lack of market drivers and financial payback for low and zero carbon homes; however respondents held conflicting views in both of these sub-themes. Osmani and O'Reilly (2009) found that the lack of financial incentive was seen as a major barrier by housebuilders. The issue here lies in the separation between those paying for and those receiving the benefit; the popular view holds that zero carbon homes do not attract a sales premium.

Barriers and challenges themed around the nature and culture of the housebuilding industry were identified by the interviewees. Amongst the themes identified were the need to work more collaboratively, flexibly and in a context specific way. These barriers differ from those identified within the study into housebuilders' perceptions (Osmani and O'Reilly 2009) where lack of confidence in green technologies and practice being based around current regulations were identified under their corresponding theme of cultural barriers. Another view of respondents within this exploratory study was that the current business model of the industry acts as a barrier.

CONCLUSION

This paper has compared a range of voluntary and mandatory energy efficiency standards for new build housing in the UK and internationally, reviewed the literature on the theory of diffusion of innovation within the housing sector, and, through interview-based research, explored stakeholder perceptions of why low and zero carbon homes are not being delivered. The comparison has shown that the zero carbon homes standard for the UK is progressive and challenging but one which the industry feels is achievable given the right support; clear legislation and sufficient skilled workers with appropriate levels of knowledge of zero carbon homebuilding.

The research into perceptions around the delivery of zero carbon homes has elucidated and identified a number of themes of drivers including: legislation, economic, social

responsibility and individual; and barriers and challenges including: skills and knowledge, legislative and governmental, economic and individual. The legislative drivers were seen to be critical to the delivery of zero carbon homes; to the extent that the UK Government's delay in providing a clear definition of zero carbon is seen as a barrier. The primary barriers and challenges to moving forward with the delivery of zero carbon homes, however, were those relating to skills shortages and knowledge gaps for those involved in planning, designing, building and maintaining the homes; this is where this research contributes to knowledge. There is a need for greater understanding of the necessary skills and knowledge for the effective implementation of the zero carbon homes standard and, further, strategies for addressing the skills shortages and knowledge gaps identified. The wealth of feedback from the interviews on skills and knowledge as a barrier and the lack of extant research on the subject of skills and knowledge for zero carbon homebuilding in the literature, confirm this as the focus for further research.

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DELIVERING SUSTAINABLE BUILDINGS IN RETAIL CONSTRUCTION

Zainab Dangana[1], Wei Pan and Steve Goodhew

[1] *School of Architecture, Design and Environment, Plymouth University. PL4 8AA, UK.*

The demand for high performance 'green' or 'sustainable' buildings is becoming increasingly important in the retail industry. Large construction companies in this sector have started to show leadership by working with their customers and supply chains towards sustainability in both products and operations. However, it remains unclear how clients' benefits from achieving sustainability can be maximised and the associated risks be minimised, in order to add value and differentiate the output of retail construction. This paper reviews the practice of sustainable buildings within the context of retail construction, and also explores how the UK mainstream retail sector is currently addressing the challenges of sustainable retail buildings. The arguments are informed by a combination of literature review, a desk study of sustainability strategies of large client organisations and construction companies, and a case study with a leading construction company in the UK. The results demonstrate that businesses can benefit from embracing a sustainable approach while they need to adapt their business models to the rapidly changing environment. A demand-driven sustainability agenda is called for in the UK retail sector. The results also provide the basis for an in-depth, longitudinal case study to develop a framework to optimize process, energy and carbon efficiency in retail construction using sustainable technology. Such a framework should provide a sustainable technology model for retail customers to realize the full benefits of sustainable buildings and also assist construction companies and their professional advisors deliver green buildings more efficiently in the future.

Keywords: green buildings, low carbon, sustainable retail construction.

INTRODUCTION

The business of retailing contributes to global warming, waste, carbon emissions, landfill and pollution (Sinha 2011). 'Sustainable' or 'green' buildings are designed and constructed with emphasis given to environmental, social, and economic priorities (Lapinski *et al.* 2006). Sustainable development provides the potential for meeting current needs whilst safeguarding the ability of future generations to meet their own needs (WCED 1987). Buildings use about 40% of global energy; they offer the greatest potential for reducing cost and energy consumption by 30-80% using proven and commercially available technologies (UNEP 2012). Carbon emissions from energy use in non-domestic buildings account for around 18% of total emissions in the UK of which 18% is from retail (Carbon Trust 2009). The British Retail Consortium

[1] rutsdangana@plymouth.ac.uk

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estimates that retail accounts for around 3.5% of UK greenhouse gas emissions with shopping centres contributing close to three million tonnes of carbon dioxide (CO2) to the UK's total emissions each year; equivalent to the emissions of nearly half a million homes (BCSC 2012). It is therefore necessary to reduce the overall footprint of the retail sector's operations to create sustainable retail buildings (BRC 2012). In 'Securing the Future' (HM Government 2005) the Government emphasised that 'Retailers both shape the sustainability of their supply chains and determine the range of products and services available to consumers and also have a role to play in cutting down on energy, water use and waste in their own operations', the retail industry plays a crucial role in achieving sustainable retail buildings.

The 2011 annual report by Retail Forum (2011) highlights sustainability as having an increasing impact on retailers due to burgeoning levels of legislation and a growing awareness among consumers. Retailers are responding to regulatory and voluntary commitments made by Government; however, sustainable buildings are not something that can be achieved by the retail operator alone but involve the collaboration of an integrated, multidisciplinary design team (Retail Forum 2011).

The project addresses an on-going research project which aims to optimise process, energy and carbon efficiency in retail construction by capitalising on sustainable technology, with an overarching research question: "How can energy and carbon be reduced for retail construction in a commercially-viable way?" It remains unclear how clients' benefits from achieving sustainability can be maximised.

The research objectives underlying this paper are:

- Review the practice of sustainable buildings within the context of retail construction
- Identify the drivers, barriers and opportunities for sustainable retail buildings
- Explore how the UK mainstream retail sector addresses the challenges of sustainable retail buildings.

Sustainable buildings and the retail sector

Green retailing presents a very real opportunity for retailers in virtually all aspects of their business but due to its newness still lacks the benefit (RILA 2012). Kilsource *et al.* (2009) conducted a survey of retailers' attitudes about green initiatives to gauge their understanding of the challenges, risks and rewards of employing more environmentally sustainable practices. The report reveals that retailers have integrated environmentally sustainable practices into their businesses and in so doing have achieved significant cost savings in operations as well as benefits to brand image. An overwhelming number of respondents view a reduction in energy consumption at the store level (92%) and throughout the supply chain (88%) as a key opportunity to realise additional cost savings. A study by Carbon Trust (2010) highlights that with a full energy retrofit, retail stores can reduce their energy use by 30%; savings of 40% can be achieved by adding doors to refrigeration cabinets and 25%-50% of lighting energy can be reduced by using new fittings and having a well-designed lighting scheme with effective controls.

Practice of retailers in delivering sustainable buildings

Even in a challenging economy, retailers are committed to sustainability and expanding their sustainability platforms as a result of cost savings and optimised performance (Aberdeen Group 2008). They are reducing their environmental impact and building resilient supply chains by innovating, investing in sustainable initiatives

and working together. Leading retailers recognise that they must embrace sustainable business practices if they are to continue to be competitive and are transforming their operations in a drive towards sustainable retail (BRC 2012).

'A Better Retailing Climate' was launched in April 2008 setting out the sector's collective environmental ambitions with leading retailers signing up to the voluntary initiative. Since 2008, all major retailers have had an environmental or ethical strategy to deal with operational costs and systems, informing customers and trying to influence their suppliers. Declarations and targets from two retailers' website and online corporate social responsibility (CSR) report have been used to provide the background to the study.

As part of its 2020 sustainability plan (Sainsbury's 2012), Sainsbury's is committed to reducing absolute operational carbon emissions by 30% by 2020. The company has trialled a range of renewable technologies in stores and is the first retailer globally to use on-site geothermal energy, having installed geothermal technology in nine stores. Sainsbury's is also the first retailer to install LED lighting in their store with LED lighting solutions for freezer cabinets, saving around 75% of energy compared to conventional lighting. The Sainsbury's flagship environmental store in Dartmouth features environmentally friendly measures such as solar powered fans, wind turbines to power the checkouts and rainwater used to flush toilets. By using renewable energy, the store consumes 50% less energy from the national grid and is targeting 40% less carbon emissions than a conventional outlet. The frame of the store was built using 200 trees; 400 were planted to replace them. Sainsbury's completed a carbon-negative extension to its Durham store in 2010, with 50% more space although the store now requires 10% less energy than before. This was achieved using on-site renewable power generation and new refrigeration technology. Sainsbury's is currently trialling other features, such as bee hotels and electric car charge points.

Tesco aims for all of its new buildings to emit, on average, 50% less CO2 by 2020 than an equivalent site in 2006 (Tesco 2012). For all stores, Tesco aims to include features such as timber frames instead of metal, the use of natural light, better ventilation, reduced energy and water consumption (through a metering system), energy self-sufficiency (combined cooling, heat and power (CHP) plants to generate their own electricity), eco-friendly fridges and more recyclable fixtures. Tesco’s store in Ramsey, Cambridgeshire, opened in December 2009 and is the retailer's first zero carbon outlet. It uses timber construction, sun-pipe lighting and collects rainwater to flush the toilets and run the car wash. It also sells surplus energy, generated by an on-site CHP plant, back to the National Grid. Tesco was the fourth best company in the world on carbon disclosure, and was also named the top retailer in the world for their work on climate change. The ranking demonstrates the leading role of UK retailers in reducing carbon emissions (BRC 2012).

Drivers, barriers and challenges for sustainable retail

Consumers and retailers are becoming increasingly conscious of sustainability. They are conscious of where and how products are produced, the amount of energy used, the resources and materials consumed during production and distribution, and the energy efficiency of retail outlets in which the goods are sold (BRC 2012). Sustainability is increasingly being utilised as a marketing tool by retailers (Fieldson and Rai 2009) concerned with understanding and disseminating the whole life impact of buildings. They focus on declaration of greenhouse gas (GHG), carbon footprint or business CO2 emissions, waste reduction and recycling to achieve the ambitious

targets set by Government. The need to lower total costs of operations and compete for customer loyalty is driving an increasing number of retailers to adopt green initiatives that include the retail supply chain, store, and overall brand image. Compliance with legislation is increasingly a driver for companies in the retail sector to establish clear corporate goals followed through with practical actions to reduce carbon emissions (Hogg *et al.* 2011).

According to research which surveyed 100 retailers (Aberdeen Group 2008), the top five pressures driving green retail enterprise were competitive advantage (57%), rising cost of energy (38%), need to increase brand value/equity (34%), need for innovation (31%) and present/expected compliance mandate (30%). The research classified retailers into three groups; best-in-class (top industry performance), industry average and laggards (below average performance). The best-in-class businesses included active energy management as a core activity with the greatest decrease in energy costs of 20%. Industry average businesses had a 4% decrease in energy costs while the laggards had a 39% increase in energy costs. A study by BBP (2010) identified five key barriers to retrofit in UK commercial property:

- Commercial – lack of business case for investment in retrofit and the split incentive between owners and occupiers;
- Roles and processes – no designated role within an organisation with the responsibility of delivering energy saving and carbon reduction interventions;
- Financial – lack of availability of capital funds;
- Technology – skills shortage, immature technologies, supply chain failure, building and operational constraints, lengthy pay back periods;
- Policy – lack of regulation or incentives for action and insufficient focus by policy makers on existing building stock compared to new build.

Previous studies highlight many barriers to sustainable design, construction and facilities management in retail environments. However, Fieldson and Rai (2009) mentions retailers could reap great benefits from using sustainability as a marketing tool; as it offers an opportunity to achieve efficiency savings while adding value to the clients.

METHODOLOGY

The research included a critical literature review and an exploratory study. Qualitative data was gathered using focus group discussions with professionals in the retail industry and a preliminary case study with a leading retail construction company in the UK. Semi-structured interviews were carried out with ten senior managers in the company predominantly involved in sustainability and retail construction. The interviews were all conducted face-to-face, lasted 20 minutes each and added significantly rich data. Field research was used to study the case study company (which is referred to as Company A). This is a form of qualitative research that lends itself well to studies of dynamic or rapidly changing situations (Singleton & Straits 2005) and consisted of formal meetings, informal discussions and observation and document analysis reviewing company documents, reports and electronic databases.

A focus group of 12 participants was used, consisting of six retailers and six construction professionals with experience in retail construction. The researcher was interested in the ways in which individuals discuss a certain issue as members of a group rather than individuals (Bryman 2012; Fern 1982).

The aim of the study was to understand the key issues that retailers are concerned with related to sustainable retail and identifying the drivers, barriers and opportunities for green retail buildings. Triangulation of sources helps ensure credibility of arguments; hence the triangulation approach was used to ascertain whether the themes identified within the literature review were perceived to be the same by professionals working in the retail industry today. These themes included the drivers, barriers and opportunities for sustainable buildings. Using triangulation from different methods therefore allows this study to build a more robust evidence basis for the argument (Bryman 2012).

Organisational Case Study

Company A is a family owned business working, principally, in housing, retail and other construction (and re-fit), interiors and land development. Key clients include Hammerson, Seagrove, Land Securities, M&S & housing associations. The company currently has more than 2,000 employees and 12 offices across the UK with an annual turnover of approximately £1.5bn. The company is committed to protecting the environment and undertaking all operations in an environmentally responsible manner. It anticipates that understanding and planning to manage climate change liabilities will help to strategically direct the business, whilst also providing short term performance improvements, cost savings and providing opportunities for new service offerings. The company has implemented numerous sustainable initiatives including low carbon housing, research around low energy site cabins and developing and testing sustainable construction materials and technologies. The company delivered the first stand-alone M&S ‘store of the future’ (an eco-learning store) in Sheffield. This store is a flagship for M&S and includes the use of third generation refrigeration technology. Designed to BREEAM excellent standards, this £5.5m project is a 12,000sq. ft. carbon-neutral building incorporating a range of sustainable technologies including timber frame, reclaimed bricks, 100% LED lighting, and rainwater harvesting and 99.4% of site waste was recycled. With a major focus on developing and learning about sustainable solutions, in line with M&S’s 'Plan A' ambitions, the trial store features a ‘living roof’ and a green wall to support wildlife.

RESULTS AND DISCUSSION

The data collected was coded and analysed using content analysis, in which a set of categories were established and the number of instances falling into each category were counted (Bryman 2012). A preliminary coding exercise utilising Nvivo software was used and the following themes emerged as drivers, barriers and opportunities as illustrated in figure 1 and discussed.

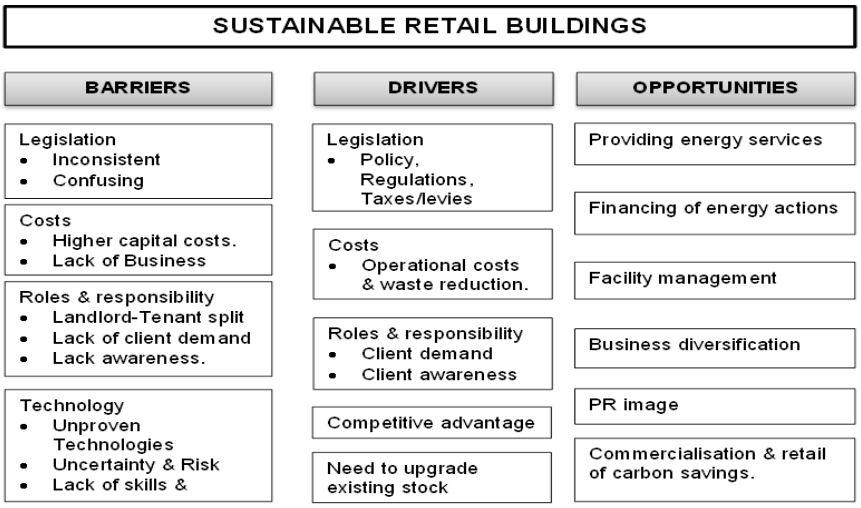

Figure 1: Drivers, barriers and opportunities for sustainable retail buildings

Legislation

The participants considered legislation as both a driver and a barrier. It was perceived as the main driver for both retailers and construction professionals to provide green retail buildings. However, the UK energy policy is considered as uncoordinated, inconsistent and confusing for both construction professionals and retailers. There exist a lot of applicable incentives and policies such as CRC, carbon heat incentive, green deal and feed-in-tariff. Retailers lack an understanding of what is applicable, or how to maximise the opportunity or minimise cost impact. They require a simple and consistent policy framework that provides the confidence to invest in reducing emissions. However legislation was also considered a barrier due to the uncertainty about government policies. Changes to the CRC energy efficiency scheme (removal of the financial recycling payments from the scheme has reduced the incentive for business to reduce carbon emissions) and FITs in late 2011 have damaged business confidence in the reliability of government policy and reduced investment. A more co-ordinated and consistent policy framework that will enable legislation to be a driver rather than a barrier is demanded by retailers and construction professionals.

Cost

The participants considered cost as both a driver and a barrier. This was perceived as a driver for retailers keen to reduce operational running cost; the participants favoured technologies with short pay back periods. However, the newness of the technologies; lack of substantial evidence of cost benefits; the potentially higher (capital) costs of energy efficient products and the impact on sales result in cost being considered more a barrier. There was a similar view from the construction professionals that the cost for a sustainable building is considered a barrier for retailers anxious to pursue sustainability in capital projects. Previous research also shows clients are concerned with higher risk. However, Kats *et al.* (2003) report that the costs and financial benefits of green sustainable buildings have a cost premium of only 2%. This investment can be reasonably anticipated to return ten-fold over the life of the building through the anticipated savings from reduced energy consumption, water use and waste. Thus, there was a general perception that sustainability costs more. This is often not the case unless a decision is taken to follow an exemplar route or where the issues are addressed late in the design process leading to expensive sustainability add-ons (Yates 2003). To overcome this barrier, Hakkinen *et al.* (2011) suggest that financial incentives and innovative fiscal arrangements should be available so that the

extra costs could be accommodated with the help of financing arrangements. Construction professionals would have to use their knowledge and expertise to educate retailers, and provide advice to assist them in making decisions which suit their demands.

Reducing waste was considered as a driver which has an effect on the cost by both retailers and construction professionals. All participants in the focus group highlighted the issue of only leasing a store for ten years, and fixtures only being designed to last for that long; there was a desire for greater longevity for store fixtures by retailers. The issue of the circular economy was discussed, whereby retailers would lease FF&E as opposed to ownership. This would encourage manufacturers to build to last, as well as offering refurbished items rather than a business model built on selling new products. Retailers promoted the idea of a circular economy in which waste is treated as a resource, reducing costs to buy new. Managing reusable equipment to avoid landfill would be sustainable if organised centrally.

Roles and responsibility

This was perceived as both a driver and a barrier. The landlord-tenant split was considered a barrier by both retailers and construction professionals. For the construction professionals, it was seen as a barrier as the landlord is reluctant to invest in technologies to improve building efficiency and reduce operating costs that will be beneficial to the tenant while the tenant has no control in making such decisions as he is not the owner. Retailers suggested investment in the energy efficiency of buildings could be more effective when implemented by an integrated and concerted team involving owners and end users. Strong, dynamic and informed relationships between these parties could lead to a greater awareness of the opportunities in the building, improved efficiency efforts, increased tenant satisfaction and shared cost savings.

For the construction professionals, client demand was considered a driver as it is increasingly being demanded by leading sustainable retailers. However it is also a barrier as laggard retailers are not aware of the new technologies and benefits and hence are reluctant to adopt them.

Improvements to existing commercial stock

The general perception of retailers was that the real challenge is with increasing the efficiency of the existing stock. The majority of sustainable innovation to date has been implemented on new build with very little work currently being undertaken for the primary purpose of improving energy efficiency and reducing carbon emissions in the UK's existing commercial building stock. This was also identified in the literature review which found that the existing building stock remains largely untouched while very little is known about how green building initiatives might be incorporated into existing buildings (HM Government 2011). There is a big opportunity to cut carbon emissions and generate financial benefits, reducing emissions from existing building using existing technologies can lead to a net economic benefit of £4-5bn by 2020 (Carbon Trust 2010).

Competitive advantage

Driven by discriminating customers and increasing competition, retailers and construction professionals are trying to enhance their product offerings, service levels and pricing models and are searching for new ways to gain and sustain competitive advantage. It was observed from the studies, retailers seeking competitive advantage in their sustainability strategies tend to be more actively involved in sustainability

within their supply chains and derive the most benefit from their efforts. Retailers who do not see the business case for sustainability tend to only do what they see as necessary to manage risk, such as resource availability. Also, those who see sustainability as a competitive advantage tend to look further into the future when developing related strategies. They generally apply metrics in order to set measurable goals for their efforts and are moving toward the development and use of industry-wide and universal metrics, rather than just those that are defined internally.

With sustainable construction evolving so quickly, particularly in terms of new technology, retailers must ensure they keep up with the latest developments. To achieve this, many of the most forward-thinking retailers are now putting competition to one side to discuss lessons learnt and best practice. Though some retailers, grocers in particular, remain concerned about giving away information that could help rivals make operational efficiency savings, an increasing number are realising that co-operation can help everyone improve margins while also benefitting the environment.

Technology

There is uncertainty about future energy prices and the risk associated with new or unfamiliar products, technologies or services to achieve green retail buildings. Construction professionals were of the opinion that there is a lack of the skilled labour required to deliver green retail buildings as well as lack of awareness around technology. Also, the longevity of current solutions based on the pace sustainable technologies are advancing has created a general reluctance amongst both retailers and construction professionals to adopt new technologies.

Pearce and Vanegas (2002) identified that risks associated with the reliability and effectiveness of a new product prevent many professionals from specifying green or sustainable building materials. This lack of enthusiasm may be attributable to clients' risk aversity (Barbour Index, 2012). However, some leading retailers, like M&S, are keen to explore and exploit new technologies and are building stores known as eco-learning stores, in which new technologies are experimented with and if beneficial will be rolled out in future stores. Reducing anxiety about the risk associated with green specifications through a fair allocation of responsibilities and awareness should increase the uptake of new and innovative sustainable technologies.

Collaborative working

A major barrier identified by constructional professionals was their lack of early involvement in projects to enable better specification, design and certainty of budget to promote green retail buildings. Step change in carbon reduction in infrastructure requires the key decisions to be made very early in the design process in order to minimise the capital and operational carbon (RICS 2011, HMG 2010). Industry-wide challenges such as team formation, fragmentation of design disciplines, undefined roles and responsibilities and misalignment of incentives are major problems to the project delivery process (BBP 2010, Yates 2003). The integrated design process seeks to ease these challenges through increased communication and collaboration between team members. The integrated design process can be encapsulated by early participation in the project by everybody involved and comprehensive discussion of each system design (Yates 2003). Increased collaboration aids the development of efficient and effective designs which reduce energy costs and increase occupant satisfaction.

CONCLUSIONS

The retail sector involves several activities that have a direct impact on climate change. Retailers can improve their environmental performance and make cost savings that will improve profitability and competitiveness. Step change in carbon reduction in retail construction can be achieved by aligning existing work practices, such as early engagement, client dialogue and the whole life approach to the low-carbon agenda. The paper has reviewed sustainable building practice in retail construction, identifying the drivers, barriers and opportunities for sustainable retail building. The study found key challenges that need to be addressed at the levels of government policy, organisational structure and practical implementation for the retail industry. Current policy does not create the sufficient incentives; within individual organisations, corporate management needs to be more aligned with desired sustainability outcomes; and more 'real world' information is needed on the performance and carbon impact of new technologies. Retailers are leading the way in improving resource efficiency and reducing environmental impact. At the most pro-active end of the spectrum, leading retailers such as M&S have demonstrated how sustainable stores can produce both cost and retail brand benefits, and are motivating others to follow suit. Among more reluctant retailers, a much greater number are finding themselves penalised by Carbon Reduction Commitment (CRC) payments and other regulations. With further legislation on the way they, too, are paying increasing attention to store sustainability. Laggards and leaders are both moving forward.

The focus group workshop and interviews with the case study company may appear to be limited to underpin new theoretical knowledge. However, Flyvbjerg (2001) argues that even a few cases can be important for enhanced knowledge. For generalisation, such limited case numbers will serve as a starting point for further studies, (Flyvbjerg 2001; Yin 2007). The results provide the basis for an in-depth, longitudinal case study by which to establish a matrix for the decision making process in selecting sustainable technological solutions applicable to the retail industry to optimise energy usage and carbon efficiency and effectiveness for retailers.

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A CONCEPTUAL MODEL FOR USER-CENTRED PASSIVE BUILDING DESIGN

Alzaed A[1] and A.H.Boussabaine [2]

School of Architecture, University of Liverpool, Liverpool, L69 7ZN, UK

The integration of end user factors (EUFs) into passive building design processes is suggested to be of major importance for improving mental health and wellbeing of the building's end-user (E-U). Currently, there is a lack of a robust approach that helps the designer to integrate these factors into the design processes. There is also a need to understand what the most relevant E-U factors are and how to integrate them into passive design processes. Hence, the thesis of this work is to address this challenge by proposing a systemic conceptual E-U centred passive building design model "UCPBDM" that integrates the E-U factors into the PD strategies. The UCPBDM approach is based on ISO 13407 and ISO 9126 standards. Accordingly, we extend the theory of passive design by systemising and incorporating E-U factors. Overall, our investigation builds knowledge by extending E-U centred design theory to passive building design context and by proving a list of effective E-U factors.

Keywords: conceptual modeling, passive building design, quantity surveying, user-centred design, user factors.

INTRODUCTION

The integration of EUFs into passive design (PD) is one of the important issues currently in the build environment. The reasons behind this interest stem from the fact that the existing building design processes do not fully incorporate the EUs' needs over the life cycle of the designed building assets. This has led to dissatisfaction with the usability, reliability, performance and operation of many building assets. The need to incorporate human factors into building design is highlighted by several authors and organisations. For example, the Ministry for the Environment: Manatū Mō Te Taiao (N/A,p.3) stated *"The design team should involve future users and facilities management staff in the design process, and develop a building user's guide to inform occupants of the building's design intent"*. Noticeably this statement advocates the integration of E-Us' needs by the designer into the design requirements and specifications. The idea at this juncture is that the designer ought to meet E-U needs before the completion of the design. This is necessary because retrofitting the design at the post-construction stage to meet E-U needs will be an expensive proposition. This view is supported by other authors: *"The area that is still not covered is the research on human factors, especially the post occupancy evaluation and the reuse or recycling of building products" (*Ismail & Hokoe, 2009, p.3). The authors indicate that

[1] A.Alzaed@liv.ac.uk

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research is limited in the area of UFs, especially in relation to post-occupancy evaluation (POE). The POE theory deals only with UFs at the post-construction stage. What is needed is a process by which UFs are considered at the early stages of the building design process. It is argued that *"the greatest challenge for HF/E today is to develop a new mission of sustainable human-centred"* (Karwowski, 2007b, p.25). The author stressed the need for EUFs and ergonomics. In this statement E-U comfort forms the main pillar on which building design is conceived. Technology Strategy Board (TSB) (2009, p.4) declared that *"more expertise in human factors research and user-centred design is needed in engineering consultancies, product manufacturers, building designers, facilities management companies and others"*. The statement recognises user-centred design (UCD) as a necessary requirement throughout the process of building, construction and operation. This work totally agrees with TSB on the need to integrate UFs into PDs. This will enhance the design sustainability in terms of E-U needs and environmental considerations. Therefore this research is aimed at contributing to the endeavour of understanding how the E-U needs are fully integrated into the PD processes. Our approach is based on ISO 9126 and ISO13407 which deal with the process of user-centred design in the software industry. This research is developing a similar process for architects and designers to capture the E-U needs during the design process in a systematic way. This paper will present the conceptual User-centred Passive Building Design Model and explain its main components. The paper also reports on the preliminary results from the EUFs effectiveness assessment survey.

METHODOLOGY:

The methodology that is followed by this research is based on literature critical analysis and prototype modelling. The analysis followed by this research is based on system development methods. We have carried out our intensive literature review into UCD methods and factors in the building, engineering and IT industries. The investigation spans from 1955 to date. The literature showed that there are no coherent models in the building industry that capture the total E-U factors as portrayed in ISO standards. However, in the IT industry the theory of UCD is well advanced and developed. Thus, the extracted knowledge from literature was classified according to ISO 13407 and ISO 9126 standards. Also, these standards are developed based on system development methods. Hence, we used ISO 9126 to generate EUFs and ISO 13407 is used for developing a systematic process for integrating UFs into PD. We have extracted 132 E-U factors. The selected UFs are currently being assessed for their effectiveness in satisfying E-U needs. The next stage of this research will test the validity of one of the selected prototype models in real-world design projects.

USER-CENTRED PASSIVE BUILDING DESIGN MODEL

The proposed UCPBD is shown in Figure 1. The model is defined as “a passive design approach that places both E-U and passive design strategies at the centre of the design process for focusing architects’ mind on E-Us through the planning, design, development and operation of building assets”. As shown in the figure the model consists of four interactive processes. The model is created based on the knowledge gained from ISO standards. Each of the processes of the model is described in the following sections.

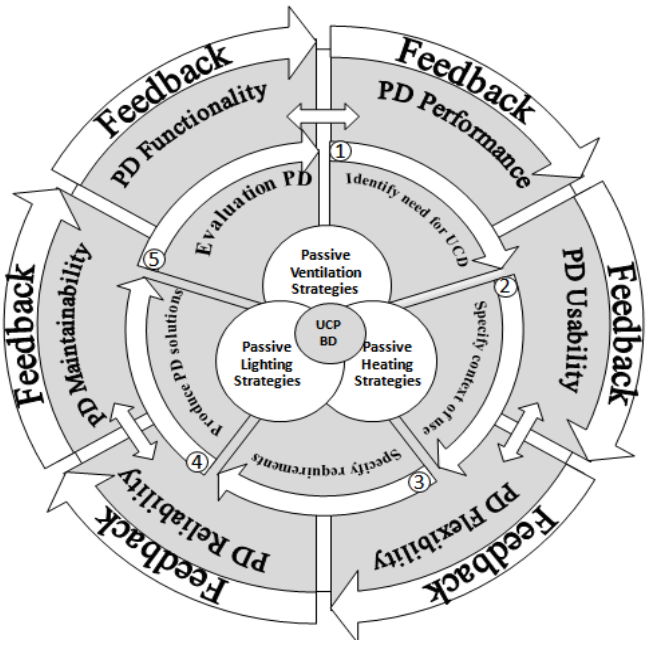

Figure 1: User-centred Passive Building Design model

6. Core PD Strategies:

PD is an approach that emerged to reduce the environmental impact by using any non-mechanical means for heating and cooling buildings. This is normally achieved through design strategies that make use of natural environment sources in a way that enhances the three dimensions of PD; that is to say, lighting, ventilation and heating (L.V.H). It is theorised that by following these design strategies it will lead to the reduction of consumption of energy and environmental pollution. The PD is based on these three main design constructs as shown in Figure 1. The PD is defined as *"an approach to building design that uses the building architecture to minimize energy consumption and improve thermal comfort. The ultimate vision of passive design is to fully eliminate requirements for active mechanical systems"* (Vancouver, 2008. p.3). Feist (2007) defined PD as *"a passive house is a building in which thermal comfort can be guaranteed by post-heating or post-cooling the fresh-air mass flow required for a good indoor air quality".* Even though the previous definition refers to the indoor air quality and thermal comfort, these measures are considered to be part of the E-U need requirements. However, the definitions do not consider all of the E-U needs as envisaged in ISO standards. The definition of the three dimensions of PD that we adopted in this work is as follows:

Passive Ventilation (PV): This is defined as *"the introduction and/or removal of air that used both convective air flows resulting from the tendency of warm air to rise and cool air to sink, and takes advantage of prevailing winds. Many passive ventilation systems rely on building users to control their operation"* (Hotel & Association, 2010, p.30). In this definition E-Us are considered as an integral part of the passive ventilation, along with prevailing winds. This signifies that both orientation and the E-U preferences are essential construct factors in passive ventilation.

Passive Lighting (PL): This is defined thus: *"daylighting has often been recognized as a useful source of energy savings and visual comforts in buildings"* (Li & Tsang, 2008, p.1446). The statement declares that there is a need to consider the equilibrium between energy demands and E-U comfort. Daylighting is considered here as a balance between E-Us' wellbeing and energy needs.

Passive Heating (PH): The third dimension of PD is coupled with the previous two dimensions: *'thermal comfort is that condition of mind which expresses satisfaction with the thermal environment"* (Ashrae, 2004, p.4). Thus thermal comfort is dependent on how the E-U senses the surrounding environment. Satisfaction plays a pivotal role in thermal comfort of E-Us. Thermal stratification is a complex phenomenon that is based on multiple factors.

It is evident from these definitions that there is a large element of coupling between PD strategies and the E-Us' comfort. Hence, it is unimaginable that we can deliver sustainable buildings without considering the E-U needs as the main drivers for the design of efficient building assets. Thus, embedding these PD strategies with E-U needs into the design process will assist the designer to optimize E-Us' aspirations. This in turn would result in prolonging the design service life of buildings.

1- User-centred Passive Building Design Process:

The second component in our proposed conceptual model (see Figure 1) is the process by which PD strategies are interrelated with E-U needs. The process proposed for implementing this component is shown in Figure 3. The UCD theory has evolved from the software and computer science disciplines. Its main purpose is to promote the designing of software based on E-U needs. UCD is defined thus: *"User-centred design is a broad term, used to describe a design philosophy and a variety of methods in which the needs, wants, and limitations of end users are placed at the centre of attention at each stage of the design process*" (Uckelmann *et al.* 2011, p.68). Prähofer *et al.* (2002, p.1) clarified the reason for considering E-U needs thus: "users are able to customize and adapt the software systems in use to their particular needs at hand, so that they can perform their work more efficiently and effectively". As stated in the introduction, the research in this field has accumulated into ISO 13407 and ISO 9126 standards. The aim of these two standards is to help the software designers to integrate E-U needs during the software design process. ISO 13407 deals with the process that the designer needs to follow for integrating E-U needs into product design. We have adapted this process to develop our UCPBD approach. The process of this standard as cited in ISO 13407 (1999) is shown in Figure 3. Jokela *et al.* (2003) summarised the process stages 2-5 as:

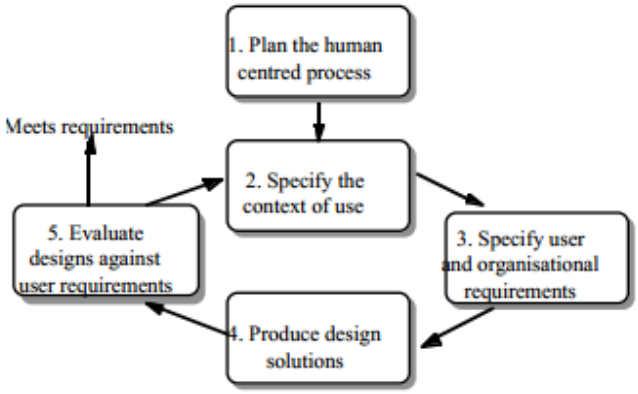

Figure 2 : ISO 13407 process (ISO 13407, 1999, p.6)

- *Specify the Context of Use*: the purpose of this stage is to identify the E-U, usage environment and the need for using the product.
- *Specify User and Organizational Requirements:* identifying the factors that can enhance E-U role to use the product without any obstacles.
- *Produce Design Solutions:* the solutions that have been suggested to fulfill E-U needs such as interaction, interoperability and portability of the product.

- *Evaluate Designs against Requirements*: answers the question to what extent the end product meets E-U needs.

We consider these stages as vital for linking between PD strategies and E-U needs aspiration. These stages are used as a foundation for our UCD process theory. The first stage is the planning stage. This stage determines the harmonisation between E-U needs and the system design components. The final stage is to evaluate generated solutions against a predetermined list of E-U aspirations. If these aspirations are not met then the designer needs to go back again to specify the context of use.

We have modified this process to reflect the special characteristics of the building design processes. The modified UCPBD process is shown in Figure 3. The process is conceived based on the assumption that the architect at all stages of the PD process will keep E-U needs in their minds. The process shown in Figure 3 is a sub-process in our conceptual model illustrated in Figure 1 (the sub-process is denoted by numerical steps, i.e., 1-5, in Figure 1). This process is divided into five main stages as shown in the following figure.

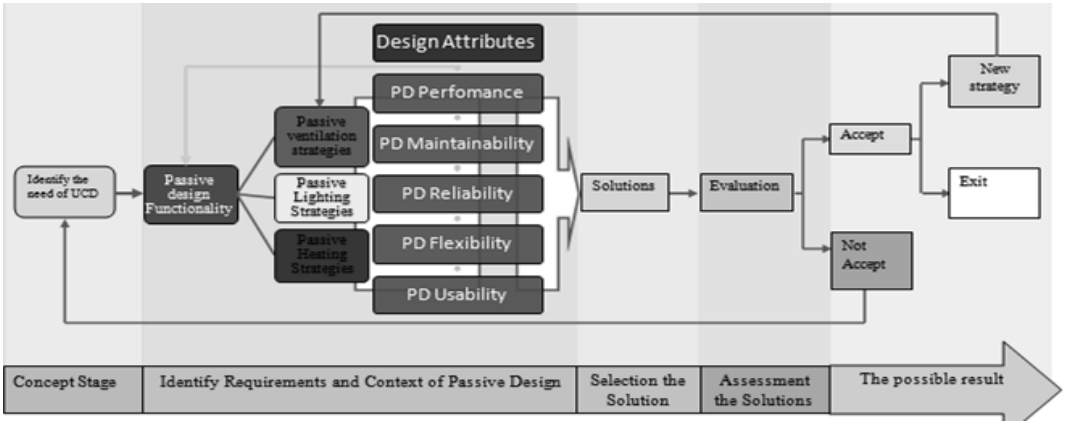

Figure 3 : User-centred Passive Building Design Process

Identify the need for user-centred design:
The main purpose of the stage is to assess whether the user-centred design approach is the appropriate route for delivering the proposed design. Normally this procedure starts at a very early stage of the design process. It is anticipated that most of this work is carried out at the concept stage as shown in Figure 3. The designer is required to identify the aspiration of the client and investigate if these aspirations can be delivered using the user-centred design method. The outcome of the stage is to set the design outline assumptions and boundaries.

Identify requirements and context of concept:
Understanding and interpreting E-U needs and design context are the main purpose of this stage. The results from the first stage are fed into this stage with a view to converting E-U needs into design solutions. PD solutions are investigated for their suitability and their functional requirements. The investigation is based on the context of use. The quest here is for the designer to elicit all E-U requirements in relation to PD strategies.

The Solution Selection:
The main purpose of this stage is to synchronize E-U needs with PD strategies. Based on the analysis from the previous stages the designers should have a list of E-U requirements and matching design solutions. To find an optimum design solution the designer needs to have access and knowledge about E-U needs determinant measures.

The challenge at this juncture is how the designer can reconcile between the conflicting demands of PD functions and the ever evolving E-U needs. It is expected at this point of time that the designer will select two or three alternative solutions that best capture E-U aspirations and integrate optimistically with PD functions.

The Solution Evaluation:
The purpose of the stage is to evaluate the selected design solutions from the previous stage. The selection should be based on pre-determined criteria and simulation results. The simulation results are from testing the design solutions in relation to E-U aspirations and PD functionality. It is expected that E-Us should be involved in the process of assessment. The results of the assessment are fed back into design strategies. It is expected that all errors etc are rectified at this stage. Beyond this point any change in the design will be costly and time-consuming.

The Possible Result:
This stage will show to what extent the designer is successful in capturing E-U aspirations and integrating them with PDs? The stage will determine if the architect meets E-U needs or not. If the selected design solution passes all of the selection criteria the solution is adopted. However, if the solution lacks in completeness the designer needs to go back to the second process to re-start the process of modifying and generating new features and requirements so that the solution will comply with the selection criteria. In the unlikely scenario that the selected solutions fail to satisfy the integration of the E-U needs with PDs, then the designer needs to go back to the concept stage to fix this anomaly and rectify the dysfunctional design solutions.

2- Passive design human attributes:

The third component of our proposed model considers the interaction between E-U requirements and PD strategies. As stated previously this was developed based on ISO 9126. This standard was developed to enhance the quality of software. It is described as "*a software product quality model, quality characteristics, and related metrics*" (Zeiss *et al.* 2007, p.2). The standard classifies E-U needs into coherent categories. There is certain similarity between the design attributes advocated by the standard and the building design performance measures. This standard includes six main attributes and their sub-attributes as shown in Figure 4.

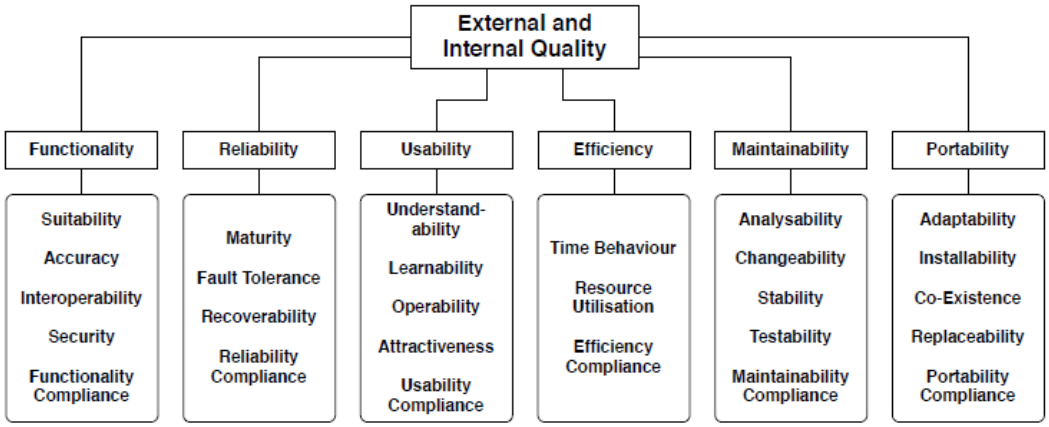

Figure 4 : ISO 9126 attributes and sub-attributes.

The main purpose of these attributes is to improve the quality of software in use. Zeiss *et al.* (2007, p.2) mentioned "*the quality perceived by an end user who executes a software product in a specific context*". The integration of E-U needs in the design of a product is the main pivotal point in this definition. Before explaining the relevance

of these attributes to passive building design processes, we provide a brief definition of the attributes as envisaged in the IT industry. These are shown in Table 1.

*Table **1**: ISO 9126 design attributes definitions*

ISO 9126 Attributes	**Definitions**
Functionality	A set of attributes that relate to the existence of a set of functions and their specified properties. The functions are those that satisfy stated or implied needs.
Reliability	A set of attributes that relate to the capability of software to maintain its level of performance under stated conditions for a stated period of time.
Usability	A set of attributes that relate to the effort needed for use, and on the individual assessment of such use, by a stated or implied set of users.
Efficiency	A set of attributes that relate to the relationship between the level of performance of the software and the amount of resources used, under stated conditions.
Maintainability	A set of attributes that relate to the effort needed to make specified modifications.
Portability	A set of attributes that relate to the ability of software to be transferred from one environment to another.

The attributes in Table 1 are used as a base for developing our new conceptual model. We refer to them as PDHA. The researchers define PDHA as [Factors that capture the needs, wants and limitations of E-Us in relation to functionality, performance, maintainability, reliability, usability and flexibility]. We modified the attributes of efficiency and portability to be performance and flexibility respectively. This modification is necessary to reflect the characteristics of the building design process. As illustrated in Figure 5, our PDHA consists of five main attributes. These attributes are subdivided into several sub-attributes. The list of E-U sub-attributes is extracted from a literature review and case studies. In the following sub-section we provide the definition of each of the PDHA's main attributes.

Passive Design Functionality (PDF):

This attribute is defined as [A set of design determinants that relate to the existence of a set of PD functions (i.e. Ventilation, Lighting and Heating) that fulfil E-Us needs]. This driver is characterised or measured by five sub-attributes, which are (1) Site, Orientation and Vegetation (2) Building form (3) Space planning (4) Roof (5) Facade and envelope. Each of these sub-attributes is assessed by several E-U satisfaction metrics.

Passive Design Performance (PDP):

We propose to define this attribute as [A set of determinants that measure passive design functions performance under stated E-Us' conditions]. In our model, we determined seven sub-attributes for the performance driver. These are (1) Site performance, (2) Space performance (3) Thermal comfort (4) Ventilation (5) Lighting (6) Acoustic (7) Adequacy consumption and strategies. Each of these sub-attributes is composed of several E-U factors. These factors are used to assess the design performance.

Passive Design Usability (PDU):

This attribute is defined in our research as [A set of attributes that relate to operability and compliance of PD strategies to regulation standards and E-Us' operational

efficiency]. Its sub-attributes are (1) Operability (2) Human behaviour. These sub-attributes are assessed by several factors that enhance the usability of building assets.

Passive Design Flexibility (PDFL):

The passive design flexibility is defined in our research as [A set of attributes that relate the ability of PD strategies to be remodelled to satisfy new use conditions]. The flexibility driver is composed of two sub-attributes, which are (1) Future adaptability (2) Flexible space. These sub-attributes are measured based on E-U satisfaction metrics.

Passive Design Reliability (PDR):

We define PDR as [A set of determinants that relate to the capability of PD functions to maintain their level of performance under E-Us' stated conditions within the design service life period]. This driver is made up by three sub-attributes, which are (1) Durability (2) Material reliability (3) Resilient. Each one of them is measured by several factors' reliability metrics.

Passive Design Maintainability:

Our definition of PDM is based on the definition of ISO 9126. PDM is defined as [A set of determinants that relate to the ease of inspecting, maintaining and modifying design to satisfy evolving E-Us' needs]. This driver has three sub-attributes: (1) Standardization (2) Material (3) Accessibility. Each one is measured by several factors which are extracted from the literature review in a way that enhances E-U needs.

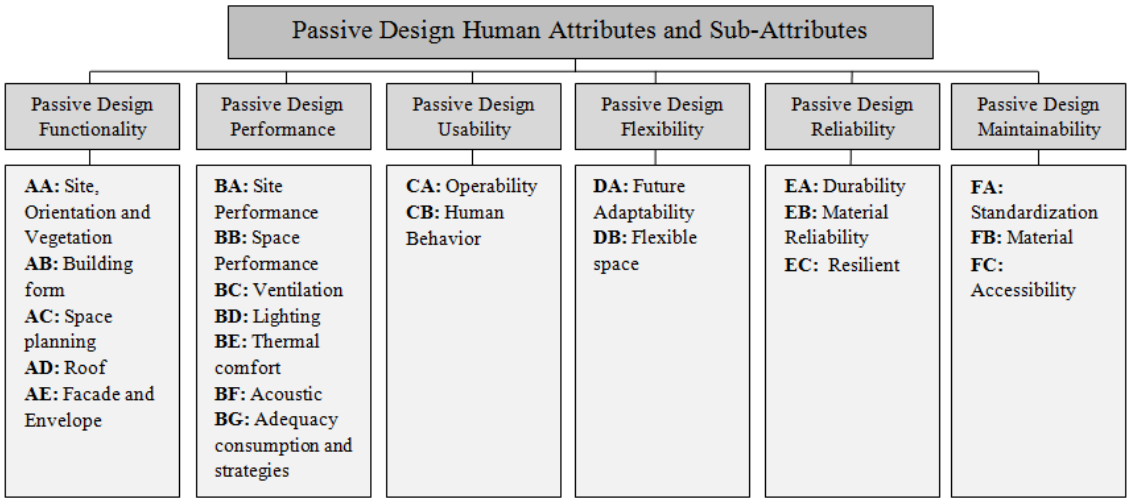

Figure 5: UCPBD attributes and sub-attributes

3- Feedback:

The last component in our proposed model is the feedback loop. The evaluation results of each generated design solution are fed back through the stages of the UCD processes. The feedback loop is considered as a dynamic process by which enabling and effectuating E-U conditions are brought together through simulation and sensitivity analysis to test the robustness of the generated design solutions. From this perspective, the designer should learn from previous E-U experiences and feed these back into future design solutions.

Before we proceed in the development of the proposed model we have to validate the effectiveness of the selected E-U factors. We are currently in the process of carrying out this assessment via a questionnaire. The following are the preliminary results from

this exercise. The results are only from nine respondents. We don't consider these results at this stage of the research as statistically significant; they are reported only for illustration purposes.

PRELIMINARY RESULT

The result was extracted from the views of nine practising architects in the UK. The end product of this research is mainly aimed for designers in the building industry. Thus, architects are used as a survey instrument. Their views were sought regarding the effectiveness of the UCPBD factors. Their views are grouped under the six headings of E-U main attributes show in Figure 5.

Passive Deign Functionality:

The orientation of buildings for optimum L.V.T. measure was selected by 89% of respondents as a very effective factor. 78% of the respondents reported using the nearby landforms and structures for wind protection and summer shading as effective factors. The building form measure was chosen by 78% of the respondents as necessary for optimum V. However, in the space planning design measures, only 66.7% of architects selected the PD strategies of using central atriums, lobbies and courtyards as optimum for providing vertical air, locating central exhaust paths, organising rooms, providing a solar-oriented interior zone and linking the exterior and interior airflows for optimum V as effective factors. The roof sub-attribute is composed of several factors. 66.7% of respondents selected "Use solar roof collectors on the south-oriented surfaces" as an effective measure. Some of the facade factors, such as "Provide shading strategies doe optimum V and Use Trombe wall or double façade to collect solar gain", are also selected by 66.7% of the architects as effective.

Passive Design Performance:

In terms of the site performance, 66.7% of the designers chose "utilising views and orientation" as very effective for performance from the point of view of E-Us. The space performance factors, i.e., the adequacy of PD space available for functions/activities, were selected by 77.8 % of the respondents as effective. The thermal performance factor - "the temperature controls provide for the needs of different occupants" - is indicated as effective by 66.7% of designers. The proportion of respondents who choose "air quality in space enhances or interferes with wellbeing of occupants" was 77.8%. in terms of passive lighting factor, while "the visual comfort of the lighting" was chosen as an effective factor by 77.8% of respondents. The measure of "the horizontal utility systems are configured to serve multi-user needs" is the highest proportion of effective factors among adequacy consumption and strategies.

Passive Design Usability:

The operability factors that are deemed effective by architects include "optimum position of service and passive element or equipment for operability, design passive space (PS) that is well-suited for multi-user activities and capabilities as well as space to provide multi-user comfort (light, fresh air, optimal temperature)". 66.7% of the architects supported the selection of these factors for measuring PD usability.

Passive Design Flexibility:

The future adaptability factors of "design the PS to cope with changes in flow of E-Us, design PS based on future use scenarios" were selected by 66.7% of the respondents as an effective measure for design flexibility.

Passive Design Reliability:

The two durability design factors [Design PD service life to match E-U needs and Consider PD details that are reliable for rainfall, humidity, heavy snowfall, flooding and intense sun degradation] were selected as effective factors by 77.8% of architects. Two measures of material quality factors - "use high quality material with long service life to handle PD functions and (2) use standardisation of PD elements and materials respectively" were selected by 77.8% of respondents as very effective and effective factors. The factor of the adaptability sub-attribute of "Specify PS strategies for E-U behaviour usage (such as accidental impact)" was deemed as effective by 88.9% of respondents.

Passive Design Maintainability:

A high percentage of architects thought that "Provide L,V in expected maintenance areas, Design for ease to remove or replace L.V.T elements, Design for ease to adjust L,V,T physical element features" were the most effective factors within the standardization sub-attributes. 66.7% of respondents selected "Minimise use of unique materials of PDs" as an effective factor from the material measures sub-attributes. Finally, 66.7% of the designers highlighted the majority of accessibility design factors as effective factors.

DISCUSSION

The ISO standards that are used in software design have been proven valuable in integrating E-U needs into all software products that exist in the market nowadays. Similarly, if such a system as proposed in this work is adopted in the design of passive buildings, it will revolutionize the building design sustainability agenda. PD is one of the approaches that are used to mitigate environmental impacts. It is through the optimum linkage between functionality, performance and E-Us' needs in building assets design that environmental impacts can be reduced. The UCD process proposed in this work can maximise the level of E-U satisfaction and comfort, leading to an increase in building service life. Dealing with the perceptions and psychological needs of the building E-Us and how they interact with the facility in a systematic way as proposed in this study will certainly enhance the chance of delivering highly performing buildings. We have demonstrated in this work how the socio-techno-economic drivers ought to be considered in PD of buildings in order to meet E-U requirements. For this reason, we extracted tens of drivers. These drivers will be subjected in the future work to further reduction to concentrate only on the most effective measures that will make a huge difference to the E-U experience. The preliminary results so far indicate that architects selected around 40 factors out of 132 as being the most effective. The next stage of the research will try to interpret and explain the importance of the selected measures.

CONCLUSION

UCPBD process and PD human attributes make up the core of the proposed conceptual model. This work has considered E-U aspirations from physical, economic and psychological aspects. The proposed model will add knowledge to the existing methods for helping designers to meet E-U needs in the design of passive buildings. Hopefully this will contribute to the satisfaction of the E-Us and lead to designing

highly performing building assets. This study may go a long way to build up capacity and knowledge in this vital area of practice and research. Further work will consolidate the validation of the selected E-U factors, and develop a tool to assess the building design for the inclusion of the E-Us' design measures

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DIAGRAMMATIC REPRESENTATIONS OF SUSTAINABILITY – A REVIEW AND SYNTHESIS

Stuart Moir[1] and Kate Carter[2]

[1] *School of the Built Environment, Heriot-Watt University, Edinburgh, UK, EH14 4AS*

[2] *The Edinburgh School of Architecture and Landscape Architecture, Edinburgh College of Art, University of Edinburgh, Edinburgh, UK, EH3 9DF*

Models, and in particular diagrams, are frequently used to facilitate the understanding of complex concepts, such as sustainability. Determining the appropriateness of such representations is important if the associated notions are to be understood and related activities to be practically implemented in applicable fields, including the construction industry. An extensive review of existing pictorial models of sustainability was conducted in order to determine their propriety in relation to the sustainability concept. In addition to encompassing the conventional Venn diagram and nested circles depictions, this effort included an inspection of advanced sustainability models. It was determined that none of these diagrammatic representations adequately consider all of the key constituent elements of sustainability, namely: its notional dimensions of environment, society and economy; space and time; and the need for active participation in its implementation. Therefore a synthetic, multi-part visual model was developed to address this perceived deficiency which, when compared with contemporary construction practice, revealed the need for a holistic framework to enable a wider appreciation of sustainability's core principles as applied to the built environment.

Keywords: diagrams, modelling, sustainability.

INTRODUCTION

The idea of sustainability has been disparaged for being "an empty concept, lacking substance" (Fortune and Hughes 1997). Similarly, the related (and frequently synonymous) notion of sustainable development (WCED 1987), has been branded nebulous, riven with contention (Taylor 2002) and intrinsically ambiguous (Wackernagel and Rees 1996: 33). Despite these criticisms, 'sustainability' has been institutionalised by many different interests and organisations (Giddings, Hopwood and O'Brien 2002), ostensibly as a result of political expediency (Middleton, O'Keefe and Mayo 1993) rather than exhaustive formulation. Therefore, there is a distinct risk that a sustainable future will not be realised unless the concept is expressed in a manner which allows its notional essence to be clearly exposed. As sustainable construction is the construction industry's response to sustainable development (Ding 2005), the outcome of such a consideration has the potential to have a direct bearing

[1] S.Moir@hw.ac.uk

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on construction practice. It is averred here that an appropriate model of sustainability will prove to be an important step towards achieving this goal.

Waas *et al.* (2011) state that models are "simplifications of the complex reality" acquired through various modes of learning with the aim of enabling decision making. Moreover, they are "analogous to maps ... they have many possible purposes and uses, and no one map or model is right for the entire range of uses" (Constanza *et al.* 1993: 547). Multiple models of sustainability have been proposed and categorised (Todorov and Marinova, 2009), which include quantitative, standardising and pictorial models. In particular, well-constructed diagrams, especially when accompanied by sufficiently detailed explanatory text, can allow for comparatively complex ideas to be readily grasped and understood (Lozano 2006). Images are often recalled more easily than non-image data and can reveal a conceptual tangibility that may be difficult to express concisely in words. However, Giddings, Hopwood and O'Brien (2002) caution against excessive abstraction in figurative form as this may lead to a distortion of the associated theory. It is diagrammatic representations of sustainability that will be explored in this paper. A synthetic model of sustainability is proposed and the implications of this model for the construction industry are briefly discussed.

THE VENN DIAGRAM MODEL OF SUSTAINABILITY

Overview

Sustainability is frequently conceptualised as consisting of three distinct dimensions – environment, society and economy. The relationship between these aspects can be shown graphically by a Venn diagram (Figure 1a) composed of three overlapping circles, with each circle representing a separate dimension (O'Riordan 1998). The size of each circle and the extent by which it impinges upon the other two can be varied to express the perceived importance of each aspect relative to the others and the extent by which the dimensions are interrelated through sharing constituent elements. Most commonly, the circles are arranged symmetrically around a central area of confluence (i.e. where all three circles incompletely coincide) denoting the integration of part of each dimension such that sustainability is nominally achieved. Partial integration of the aspects is shown where only two of the three circles overlap.

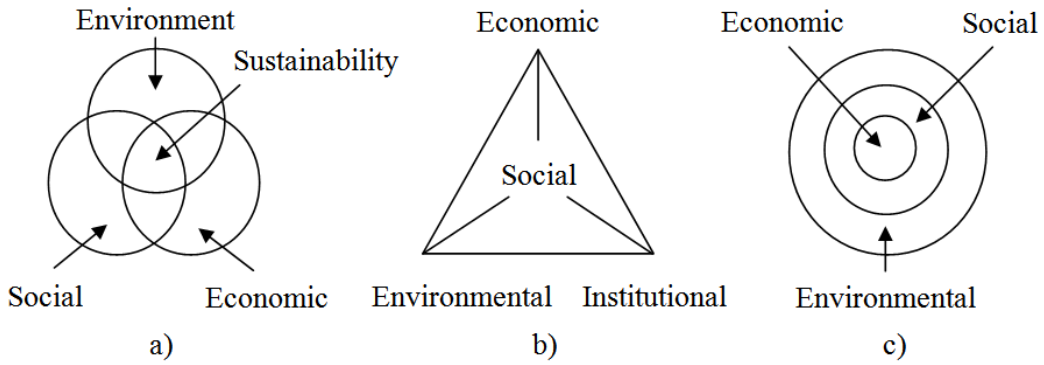

Figure 1 – Various diagrammatic representations of sustainability

Limitations of the Venn diagram model

This model has proved to be a very popular and palatable way of relating the conceptual complexity of sustainability to a wide audience and evidence exists of the Venn diagram representation being adapted to suit the requirements of specific interests, e.g. industry recasts the dimensions as people, planet and profit (Elkington

1998). However, its simplicity is beguiling and Giddings, Hopwood and O'Brien (2002) point to three specific issues associated with this visualisation.

Firstly, they state that, fundamentally, the diagram can be interpreted as ignoring the intrinsic, immutable relationships existing between each of the dimensions. Also, it can facilitate the assumption, per the precepts of 'weak sustainability', that the unfettered substitution of physical and human capital for natural capital can occur indefinitely (Neumayer 1999). This is at odds with the 'material reality'. Similarly, Mebratu (1998) refers to the Venn diagram as a "cosmic (mis)perception". He states that by characterising the dimensions as independent systems the model falls into a reductionist epistemological trap which fails to account for the inherent interactions between "the parts, the whole and, most importantly, the interaction[s] between the parts and the whole". Moreover, areas of bivalence, where only two of the dimensions overlap, are deemed to be essentially contradictory, while, according to Lozano (2006), regions featuring no overlap can be incorrectly perceived as being unrelated to sustainability. Most pertinently, the complete visualisation does not demonstrate or sufficiently imply the logical conclusion of the concept – the full integration of the environmental, social and economic dimensions.

Secondly, despite the socio-economic focus of international efforts led by the United Nations (and the frequent portrayal of all three circles as being of the same size), there is a tendency among some proponents of sustainability to prioritise the environmental dimension above the other aspects. This can perhaps be ascribed to the comparative ease by which some measures of environmental performance can be quantified. Such an approach is counterintuitive within the context of government and business – the 'political reality' – where neo-liberal economic perspectives predominate.

Finally, it is asserted that the compartmentalisation of sustainability (i.e. addressing issues associated with each aspect in isolation), although an understandable approach based on historical precedent and the need for specialisation to enable the study of complex phenomena, encourages the employment of technical fixes to both the environment (e.g. pollution control) and the economy (e.g. landfill taxes, cost benefit analysis). Such a sectoral approach, which perceives balancing or trade-offs as appropriate actions within the solution space, frequently fails to consider wider social issues and is often implemented at the expense of a deeper understanding of the interrelatedness of the dimensions (Lozano 2006).

Notwithstanding the preceding analysis, perhaps the sharpest criticism that can be levelled at this model is that it inadequately represents issues relating to scale and the dynamic processes of change over time (Lozano, 2006).

SOME OTHER MODELS OF SUSTAINABILITY

Additional models and diagrammatic depictions of sustainability have been proffered. Some are explicitly grounded in the existing Venn diagram representation (Lozano, 2008: 1842-1843). Elsewhere, other dimensions have been added to or replace the established sustainability aspects of environment, society and economy. For example, the inclusion of a 'cultural' dimension has been mooted (UCLG 2009: 17), although society and culture could be merged into a single socio-cultural aspect as these dimensions are inherently linked (BFPPS 2009). In contrast, Kohler (1999) opts to nominally replace the 'society' aspect with a 'cultural' dimension.

Reflecting the importance of institutional change in meeting the goals of sustainable development, as identified previously in *Our Common Future* (WCED 1987) and by

the UN (UN, 1992), some authors (Meadowcroft 2000, Spangenberg, 2003) have added a fourth 'institutional' aspect to the existing established dimensions (Figure 1b). This aspect is also referred to as 'democracy' or 'governance' (Waas *et al.* 2011). In this context, the institutional dimension seeks to reconcile the environment and economics in decision making so as to better express the common interest through public participation in democratic and political processes across a range of spatial scales (Spangenberg, 2004, Centre for Sustainable Development 2006: 30).

THE NESTED CIRCLES MODEL OF SUSTAINABILITY

Overview

Often, a different representational tact to those outlined previously is taken. Giddings, Hopwood and O'Brien (2002) maintain that the evolutionary development of mankind is intrinsically linked to society and that almost all human activities are dependent on and impact upon the natural environment. Furthermore, the economy can be identified as a subset of society; the production and exchange of goods and developments in industry, business and technology are all in part based on social interactions. Therefore, in contrast to the Venn diagram with its suggestion of equivalency between the dimensions, they commend a hierarchical model consisting of three nested circles with rotational symmetry (Figure 1c). This representation is considered to be a more appropriate depiction of sustainability as it facilitates "a conceptual outlook more sympathetic to integration" (Giddings, Hopwood & O'Brien, 2002). In this model, economy is a subset of society rather than the paramount aspect (despite its central position within the diagram) and both of these dimensions are bounded by and implicitly depend upon the natural environment. Note, however, that the environment can still exist if society is no longer present (Lovelock 1988) and, at least in some locations and on some scales, society can persist without an extant economy.

Limitations of the nested circles model

However, even this improved nested circles model still has its constraints. Giddings, Hopwood and O'Brien (2002) consider the graphical representation of three unified dimensions as a further abstraction which ignores the multitude of environments, societies and economies that exist spatially (from the macro to the micro scale) and temporally. This is a valid point as such diversity is uninimical to the continued existence of humanity (Jacobs 1961). Moreover, conceiving the economy as a single entity continues to insufficiently recognise non-monetary provisioning (Langley and Mellor 2002), further embeds the misconception of the primacy of the market in meeting human needs (Lozano 2006) and fails to differentiate between beneficial and detrimental impacts of economic activity. Also, there remains an outstanding need to better represent that human enterprise and well-being (both material and cultural) are intrinsically (and unidirectionally, i.e. the dependence ultimately resides with society only) linked to the environment and can only exist within its bounds. Lozano (2006) maintains that the emphatic delimitation of the three dimensions still panders to compartmentalisation and continues to inadequately represent the relationships that endure between the dimensions. Moreover, crucial spatial and temporal considerations remain insufficiently characterised while the similarly important governance aspect is noticeable only by its absence.

ADVANCED MODELS OF SUSTAINABILITY

Geometric three-dimensional model of sustainability

In response to these omissions, two further, more advanced representations of sustainability are worthy of description. Lozano (2006) proposes a novel visualisation of sustainability which develops models expressed in two geometric dimensions (as differentiated from the three notional sustainability dimensions or aspects of environment, society and economy) into a single, spatially and temporally cognisant diagram composed of three geometric dimensions. This enhanced representation is essentially realised through a two-stage evolutionary process.

The first stage, which can use either the Venn diagram or the nested circles model as a developmental departure point, involves the progressive equalisation and integration of the three sustainability aspects, such that any perceptions of economic primacy (or indeed the predominance of either of the other aspects) are diminished in favour of a more integrational perspective. This action yields the First Tier Sustainability Equilibrium (FTSE), a representation of full spatial integration shown diagrammatically as a continuously rotating circle where all parts of each aspect are in concurrent dynamic contact (Figure 2a).

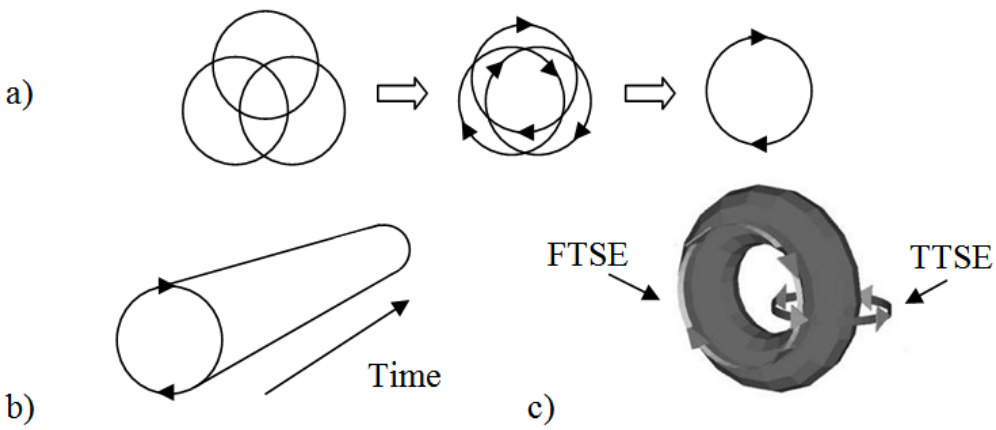

Figure 2: Diagrammatic representations of FTSE and TTSE (adapted from Lozano, 2008)

The second stage initially requires that the FTSE model is further evolved to address inter-generational concerns. Ideally, this is shown in three geometric dimensions as a perfect cylinder (Figure 2b), where there are no deviations in the interactions between and emphasis on the aspects over time such that a temporal equilibrium is established. Thereafter, the two equilibria (i.e. spatial and temporal) can be combined by "inter-relating the FTSE in dynamic change processes through time, passing from the inter-generational to the holistic perspective" (Lozano 2006) to realise the Two Tiered Sustainability Equilibrium (TTSE). This state is shown as a geometric torus (Figure 2c), where "sustainability issues lie inside the [torus] and are in perennial movement inter-relating with other issues, continuously rotating in ... two axes" (Lozano 2006).

Five-dimensional model of sustainability

A further visualisation, provided by Seghezzo (2009), stems from an assertion that the WCED (1987) definition of sustainable development is severely limited. Specifically, it is essentially anthropocentric, overstates the significance of the economy, largely neglects spatial and temporal considerations and fails to account for non-physiological needs such as love, safety and esteem. In response to this he proposes that sustainability is conceptually reframed so as to better account for the territorial,

temporal and personal aspects of development, as illustrated by a novel five-dimensional sustainability triangle (Figure 3). This representation displays the three conventional geometric dimensions of space (entitled 'Place'), the temporal dimension (labelled 'Permanence') and a human introspective dimension (termed 'Persons'). These aspects are shown within the triangle – the vertices of which are labelled intra-generational equity, inter-generational equity and identity / happiness – over which are laid the circles of a traditional symmetrically arranged Venn diagram. Seghezzo (2009) notes that Place and Persons are tangible aspects that exist in the present time whereas Permanence is the idealised and subjective projection over time of events associated with Place and Persons.

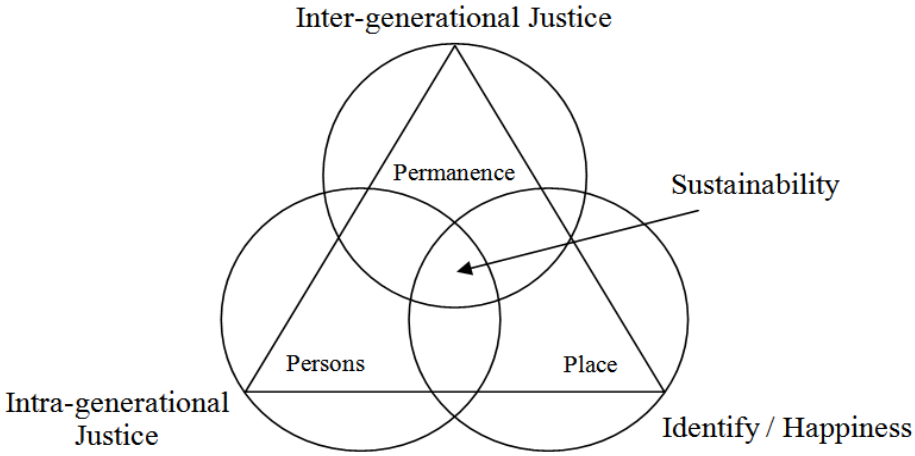

Figure 3 – Five dimensional model of sustainability (adapted from Seghezzo, 2009)

Limitations of the advanced models

The issues associated with the Venn diagram and nested circles models are only partially addressed by these advanced representations of sustainability. The final stage of Lozano's geometric three-dimensional model derivation presents interactions between the three notional sustainability dimensions over space and time but fails to acknowledge a need for appropriate governance. In addition, without an understanding of the detailed derivation of its form this model is somewhat transcendental. Seghezzo's five-dimensional model similarly captures spatial and temporary considerations, relates them to human equity requirements and furthermore acknowledges the importance of the individual (and, by extension, communities and groups). However, it incorporates the substantially criticised Venn diagram into its form and, again, does not explicitly emphasise the need for procedural fairness. Despite these criticisms, these models are not without merit. They develop our understanding of the issues requiring attention, albeit not in a consummately representative manner, if a sustainable future is so be realised.

A CONFLATED MODEL OF SUSTAINABILITY

The previous analysis of the diagrammatic models suggests that sustainability can be conceptualised as consisting of multifarious, spatial and temporal interactions between the notional dimensions of environment, society and economy, shaped and influenced by full public participation in associated decision-making. As none of the reviewed models sufficiently address these attributes in concert, a conflated diagrammatic representation of sustainability is proposed, that acts as a synthesis of existing ideas rather than yet another exclusive visualisation. This model, which is substantially

based on the thinking of Lozano (2006), differs from previous efforts in that it seeks to make the transition to the geometric three-dimensional torus model (deemed here to be the most appropriate end point for a representation of sustainability) explicit in a single rendering (Figure 4). Thus, as a progressive triptych, the diagram reduces the requirement for extensive, accompanying descriptive text. Furthermore, it illustrates that stakeholder influence is inextricable from any consideration of sustainability.

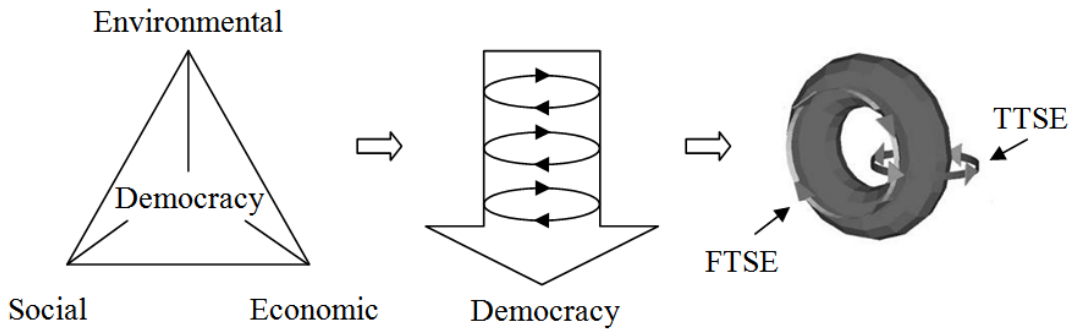

Figure 4 – Conflated model of sustainability

Following on from Meadowcroft (2000) and Spangenberg (2003), the conflated model commences with a simple 'four pillar' representation of sustainability, depicting the notional dimensions of environment, society and economy and the idea of full stakeholder engagement. Thought was given to the most appropriate manner by which to denote the participatory aspect. The terms 'institutional' and 'governance' imply a barrier to participation such that only Establishment interests can effectively contribute to sustainability discourse. Moreover, these expressions fail to indicate that the perspectives of individuals have the potential to bear on related activities. Therefore, it is put forward that 'democracy' is a more appropriate term to use in this context. Democratic participation, in its broadest application, not only represents the ability to actively contribute towards the realisation of a sustainable society but also, on a personal level, serves to empower individuals to rely on their own intimate faculties and "localised and embedded identities" when assessing the substance and weight of environmental problems (Macnaghten and Urry 1998).

Therefore, the first part of the model takes the form of an equilateral triangle with a sustainability aspect at each of its vertices and 'democracy' at its centre, with each line shown denoting a relationship existing between the pillars. The position of the democracy pillar is not arbitrary – its location seeks to emphasise that participation is paramount to all considerations of sustainability. The second stage of the model borrows from Lozano's interim, spatial representation of sustainability and is shown three-dimensionally as three equalised and integrated circles in continuous rotation. However, environment, society and economy are depicted here as a three-dimensional 'pancake stack', physically separated but implicitly connected, and fully permeated by the notion of participation as democracy. The final part of the diagram shows the TTSE torus shape, visually identical to Lozano's rendition but, by progressing through the previous two stages of the model, the spatial and temporal application of democracy is implied. The intervening FTSE stage is excluded from this representation as, in the opinion of the authors, it is sufficient to describe in text the spatial-to-spatial and temporal transition between the second and third parts of the model (an intuitive leap?), thus avoiding unnecessary diagrammatic complexity.

IMPLICATIONS FOR THE CONSTRUCTION SECTOR

Having determined the notional elements of sustainability from the analysis and following an adaption of existing diagrammatic representations of the concept, it falls to understand what insights this knowledge provides that are relevant to the contemporary construction industry. Much of the effort to implement sustainable construction focuses on the pre-hoc use of methods to assess the sustainability of buildings and other constructed assets. This is in part due to the ability of such schemes to translate the conceptual complexity of sustainability into a manageable, finite set of performance criteria (Cole 2005). However, these methods fail to sufficiently address the social and financial aspects of sustainable construction (Todd *et al.* 2001), are typically limited spatially in their application to the boundaries of assessed sites (Ding, 2008), and are found wanting in terms of life-cycle material, energy and cost considerations (Rees 1999, Cole 2005). This position risks the institutionalisation of a limited definition of sustainable construction that is not cognisant of the aspects expressed in the conflated model and therefore not fully aligned to the notion of sustainability.

Outwith the context of assessment, many sustainability challenges exist in an industry typically characterised by *inter alia* organisational complexity, contractual wrangling, and an overriding focus on short-term profit maximisation (Green 2011). This situation is further complicated by a range of distinct perspectives on sustainability (Mebratu 1998, Hopwood, Mellor and O'Brien 2005) that seek to influence the political and cultural context within which construction takes place. It is thus evident that progress towards a sustainable future through construction theory and practice will require new structures of knowledge and thinking based on an inclusive vocabulary which enables participation over the complete project lifecycle.

Such an exigency can perhaps be fulfilled by the Cosmonomic Idea of Reality. Originally proposed by the Christian philosopher Herman Dooyeweerd (1894-1975) and later secularised and adapted to suit the built environment by Brandon and Lombardi (2011), this theory presents a holistic, integrated perspective on the universe through the expression of fifteen interrelated dimensions of reality, or modalities. These modalities, which include the sustainability aspects exposed in this paper as well as both lower order (e.g. numerical, kinematic) and higher order (e.g. aesthetic, ethical) dimensions, are structured in a non-arbitrary order whereby earlier modalities in the 'cosmonomic order of time' serve as foundations for the later. This framework has been commended for embracing complexity while avoiding reductionism and/or subjectivity (Brandon and Lombardi 2011).

CONCLUSIONS

Through a review of current diagrammatic models of sustainability, this paper set out to arrive at an appropriate visualisation which exposes the essence of the sustainability idea. Therefore, a synthetic model has been proposed that seeks to fully represent the identified aspects of sustainability (i.e. environment, society, economy, space, time and democracy) in a progression of figurative forms. Expressed thus, contemporary sustainability practices in construction are comparatively insufficient, in particular with regard to enduring, active stakeholder participation. This has in turn revealed the need to seek out and evaluate new structures to practically yet comprehensively address the holistic requirements of sustainability within a construction context. In response, the Cosmonomic Idea of Reality, adapted to suit the characteristics of built environment, has been tentatively put forward as a suitable candidate framework.

However, it remains to be seen whether advanced diagrammatic representations, and indeed consequential frameworks, relating to sustainability can effectively capture the collective imagination of construction researchers and practitioners. Progressive pictorial models of sustainability are only recent appreciations and thus their general and built environment specific impact cannot yet be determined. Furthermore, many extant theoretical structures that attempt to capture the practical requirements of sustainability have ostensibly failed to gain widespread appeal in the manner that the adaption of Dooyeweerd's theory now seeks to achieve. This is despite an acknowledgement by some of these frameworks of the importance of time and space, e.g. BEQUEST (Bentivegna *et al.* 2002), and participation, e.g. LUDA (LUDA n.d.).

But perhaps such a denouement lacks empathy. The rigorous comprehension of sustainability, subject as it is to temporally sensitive cultural perceptions, is a relatively nascent phenomenon and there is still much to learn. Therefore, it is hoped that the conflated model presented here will prove to be an important step towards a clearer notional understanding of sustainability and thus facilitate the achievement of a sustainable future.

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