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A CONCEPTUAL MODEL FOR IMPROVING CONSTRUCTION SUPPLY CHAIN PERFORMANCE

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Over the years, the UK construction industry through several reports and enquires has been admonished to change its business approaches. Research points to the industry's adversarial culture and disjointed relationships as the major hindrance in achieving collaboration and improved performance within construction supply chains. Common factors include the traditional construction procurement strategies driven by a win-lose mentality, competitive buyer-supplier relationships - pitting one supplier against another in order to achieve the optimum buy, and most significantly, loosely disseminated nature of information applications and exchange among project participants. Within this adversarial context, engagement with Building Information Modelling (BIM) and its philosophy is showing potential positive outcomes with regards to information exchange and collaborative working practices. This paper is based on a larger ongoing research project which aims to design a BIM-driven conceptual model for advancing collaboration and improved supply chain performance in UK construction projects. The research suggests that full deployment of the BIM concept possibly will greatly diminish the adversarial culture in the industry through promotion of collaborative working ideals. In turn, this will result in enhanced project supply chain performance thus, aligning with the objectives of the UK Government's construction strategy for 2016. Following this proposition, this paper based on a critical review of literature presents the essential elements required for the design of the proposed conceptual model, and its contributions to the construction management discipline.

Keywords: adversarial culture, building information modelling, collaboration, supply chain management.

INTRODUCTION

A number of supply chain management (SCM) definitions are provided in the literature (Flynn *et al*. 2010, Mentzer *et al*. 2001). These definitions commonly relate to the concept of integration which bridges the gaps between partner organisations, and facilitates efficient coordination of supply chain activities and collaborative working. Consequently, Xue *et al*. (2007) describes construction supply chain management as the integration of key construction business processes, which focuses on how firms make the most of their suppliers' processes, technologies, and capabilities with the ultimate goal of improving construction performance and adding client value at less cost. Adopted as suitable for construction supply chain management within the context of this research, this definition uncovers the failings in the present-day business practices and relationships between project stakeholders in the United Kingdom (UK) construction sector resulting in several inefficiencies.

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There is thus a significant gap between the conceptual SCM perspective and the dominant traditional supply chain management practices in the industry termed as an adversarial culture (Akintan and Morledge 2013). Culture in the context of the construction industry is described as the characteristics of the industry, its approaches to construction, competence of craftsmen and people who work in the industry, and goals and values of the organisation within which they work (Ankrah *et al*. 2009). In other words, it is about 'how things are done' in the industry.

Studies suggest that potentials exist in the use of integrated collaborative technologies (ICTs) to drive collaborative working in construction supply chains (Kapogiannis 2013, Ramanathan *et al*. 2011). Moreover, it is reported that BIM implementation is offering encouraging signs with regards to the advancement of collaborative working among construction supply chain members (Owen *et al*. 2013). Subsequent to this prospect, the UK Government launched its 2016 Building Information Modelling (BIM) adoption strategy (Cabinet-Office 2011). However, it is yet unclear how BIM and its characteristics relate with the dynamics of construction supply chain management towards enhanced collaboration and performance. Hence this ongoing research proposes a BIM-driven conceptual model which reflects the interplay between the comprehensive deployment of BIM and the development of a collaborative culture, culminating in enhanced performance in UK construction supply chains. The conceptual model is targeted at key projects' supply chain participants, within the domains of main contractor and subcontractor organisations. Contractually, main contractors are responsible for the successful delivery of projects. However, they rely on subcontractors to accomplish their work (Clarke and Herrmann 2004). To achieve high levels of success in their responsibilities, they must therefore develop enduring relationships with their key subcontractors and suppliers (Hook 2012). Subcontractors on the other hand need to appreciate the underlying benefits of collaborative working.

The unfolding sections of this paper provide a brief review of the practices in UK construction supply chains. This is followed by critical reviews of: the concept of supply chain collaboration and its basic principles; and BIM and its characteristics in relation to construction supply chain collaboration. Finally, the key elements required for the design of the conceptual model, and the contributions of the research project to the Construction Management discipline are presented.

CONSTRUCTION SUPPLY CHAIN MANAGEMENT IN THE UK

Over the decades, the UK construction industry has been criticised for its business approaches through several reports and enquiries. McGeorge and Zou (2013) outline some of these documents which include: the Simon Report, the Emmerson Report, the Banwell Report, the Latham Report, and the Egan Report. These reports, particularly the Latham (1994) and Egan (1998) highlight the low performance of the industry in forms such as: failure to meet client satisfaction, low profit margins, focus only on price not quality, unpredictability of project delivery within time, and budget overruns. The challenge in achieving closer integration and collaboration - key features of SCM - has been majorly attributed to the traditional adversarial culture among project stakeholders (Akintan and Morledge 2013, Latham 1994, MohammadHasanzadeh *et al*. 2014, Ross 2011). To a large extent, this adversarial culture underpins business practices and relationship management, which are problematic for the advancement of collaborative working.

Adversarialism in construction supply chains

The prevalence of poor information sharing, disputes, and fragmentation in construction supply chains has been attributed to their adversarial culture (Akintan and Morledge 2013, Latham 1994, MohammadHasanzadeh *et al*. 2014, Ross 2011). For instance, Briscoe *et al*. (2001) argue that over the years, fragmentation – a consequence of the appointment of a large number of relatively small and disparate specialist contractors and suppliers for projects, with essentially arms-length relationships in place – has hindered the development of a unified approach to project delivery and team continuity between main contractors and key subcontractors. This is blamed for the low clients' satisfaction in traditionally procured projects (Xue *et al*. 2007). Other consequences of the adversarial culture include marginal use of collaborative technologies, poor joint-problem solving, difficulty in resolving claims, and a win-lose climate (Bishop *et al*. 2008, Chan *et al*. 2008). Hence, several studies and reports emphasise the need for a radical change in approaches towards construction supply chain relationships (Egan 1998, Latham 1994, Akintan and Morledge 2013, Pryke *et al*. 2014).

The adversarial culture inherent in UK construction supply chains is problematic principally to main contractor and subcontractor organisations. Main contractors' potential leading role and responsibilities in the delivery of projects have been widely acknowledged (Akintan and Morledge 2013, Clarke and Herrmann 2004). Hence, main contractors wield huge influence on the organisation of projects and the management of subcontractors' quality of work. Therefore, the inefficiencies and underperformance that are widespread in construction projects as a result of adversarial relationships and opportunism reflect the low SCM maturity of main contractors and their inability to play the essential role of supply chain managers. Furthermore, Kale and Arditi (2001) suggest that the quality of the relationship between main contractors and subcontractors influence the ability of main contractors to perform on projects, which inevitably has a direct impact on projects' outcomes. On the side of subcontractors, the scepticism and mistrust expressed towards collaborative working initiatives instigated by main contractors (Dainty *et al*. 2001) could simply reflect a lack of understanding of the implications of collaboration for all project participants and for the effectiveness of the overall project (Bygballe *et al*. 2010).

Nevertheless, it could be argued that adversarialism and opportunism in some situations appear as the appropriate relationship strategy to adopt. Prevailing economic conditions influence contractual partners to act – for very rational economic reasons – in more traditional, adversarial and exploitative ways (Bresnen and Marshall 2000, Pryke *et al*. 2014). Hence, collaboration is considered as the anomaly instead of adversarialism. However, these perspectives are driven by the narrower concern to simply reduce costs, or to pass costs and risks to those further down the project supply chain all in a bid to maximise profits (Bresnen and Marshall 2000, Dainty *et al*. 2001). In the face of such strong economic imperatives and well established traditions and interests, collaboration cannot offer an easy solution to the problems of adversarialism and opportunism inherent in the UK construction business environment. All the same, collaborative relationships could to a large extent inspire project stakeholders to work as a unified team, with more attention invested on optimal solutions that bring added value to the facility users, reliable steady profits for supply chain participants, and sustained whole-life performance to the clients.

A CRITICAL REVIEW OF SUPPLY CHAIN COLLABORATION

By definition, collaboration implies two or more independent organisations working jointly to plan and execute supply chain operations (Cao and Zhang 2010, Simatupang and Sridharan 2008), providing substantial benefits to the collaborating organisations. Potential benefits include high degrees of communication and integration between parties on a project, early involvement of key subcontractors (stakeholders) which improves articulation between the diverse phases of the project, effective platforms for inter-organisational and inter-project knowledge transfer and collective learning (Construction Excellence 2004), and increase in the propensity to develop trust (Kwon and Suh 2004). Overall cost of projects can be significantly reduced through good (collaborative) procurement practices in the UK (HM Government 2008).

There is a general view amongst project stakeholders that collaboration presents suitable ways towards overcoming problems and improving the overall performance of the construction industry. Regardless of the extensive interest and efforts to implement partnering initiatives culminating in collaborative working in the construction supply chains, there are suggestions that collaboration has no direct impact on project performance. For instance, a study by Nystrom (2007) shows no clear differences in project performance when comparing the performances of ten partnering projects with ten similar non-partnering ones. Nevertheless, Nystrom has not considered the implications of adopting robust ICTs such as BIM which is showing potentials for advancing collaborative working practices and improved performance in construction projects (Christian *et al*. 2011, Owen *et al*. 2013). There is therefore an understandable need to investigate how such technologies influence collaboration and project performance.

The basic principles of the collaboration concept found in the literature include: collaborative behaviour and attitude (Ha *et al*. 2011, Pusha and Mathew 2010, Soosay *et al*. 2008), collaborative culture (Barratt 2004, Kumar and Banejee 2014), and collaborative advantage (Cao and Zhang 2010, Cao and Zhang 2011, Vangen and Huxham 2006).

Collaborative behaviour and attitude

Collaborative behaviour and attitude refer to informal interactions described as embedded relationships, integration, strong ties, or strong coupling (Pusha and Mathew 2010). Such behaviours and attitudes are unstructured and are considered to have an affective nature of inter-departmental or inter-organisational relationships. Key examples of such behaviours and attitudes are informal communication (Pusha and Mathew 2010), and commitment to a win-win situation (Eriksson 2008). Channels for this type of communication are also informal in nature such as impromptu phone calls, chats, unstructured or informal emails, and contact without prior appointment (Pusha and Mathew 2010:442).

Informal communication facilitates the exchange of ideas, visions and innovative solutions (Cheng *et al*. 2000). This in turn would encourage partnering organisations on a project to jointly participate in planning and objectives setting. Consequently, individual organisations are able to deploy their cooperative efforts in order to generate common and compatible expectations in the project delivery. With such shared expectations in place, partners' commitment to the mutually generated objectives is easily achievable. Eriksson (2008) affirm that joint objectives facilitate the development of a win-win situation in which all project participants are striving

together to accomplish the same goals. Since attitudes and behaviours drive the development of a distinctive culture within organisations and industries at large, enhancement of collaborative behaviours and attitudes could positively influence the development of a collaborative culture.

Collaborative culture

A collaborative culture defines how individuals, teams, functions, and indeed organisations in a collaborative working arrangement act, share, and relate to each other (Kumar and Banerjee 2014). Therefore, a collaborative paradigm is important as it impacts on all aspects of collaborative working, without which higher levels of collaboration are unattainable.

Most frequently appearing elements of a collaborative culture found in the literature on supply chain collaboration can be summarised as: open communication, information sharing, joint decision making and trust (Ha *et al*. 2011:61). These basic elements assist collaborating supply chain members to create and sustain business environments necessary for working together and improving performance. However, it is pertinent to note that it is indeed a huge challenge to achieve cultural transformation within an organisation, l*et al*one across organisations. Unlike variables such as structures and reward systems that can be manipulated to accomplish desired changes, this is not the case for cultural transformation (Beer *et al*. 1990).

Collaborative advantage

The predominant objectives for developing collaborative relationships and culture in a supply chain are to have the ability to execute business activities effectively at the least possible cost, enhance profitability for all participants, and deliver better value to the customer. Collaborative advantage relates to the strategic positioning achieved over the competition primarily through collaboration between supply chain participants. It is the synergistic benefits of collaborative working that would not have been achieved by any individual firm working alone (Vangen and Huxham 2003). Cao and Zhang (2011) posit that value delivery through collaboration could take the form of cost savings through the transfer of best practices. They conceptualise the idea of collaborative advantage into five sub-components which include: process efficiency, offering flexibility, business synergy, quality, and innovation. The expectation is that these will guarantee a competitive edge for and performance improvements in supply chains.

BIM AND ITS BASIC CHARACTERISTICS

BIM is a digital representation of the physical and functional characteristics of a facility; a shared knowledge resource for information about a facility that forms a reliable basis for decisions during its lifecycle (NBIMS 2013). Project stakeholders from diverse professions feed critical data and information into a single shared data environment. The outcome is a 3D coordinated and reliable design information and model that provides an understanding of the facility's behaviour prior to construction (Froese 2010). In order to enhance coordination and planning, there is scope for integrating time and cost data into 3D BIM i.e. 4D and 5D (Greeman 2011).

BIM adoption in the ‘Sutter Health’ project – a healthcare provider in California, United States - aided the integration of people, systems, business structures and practices into a process that collaboratively harnessed the ability of all stakeholders to mitigate waste and optimize efficiency at all phases of the project (Christian *et al*. 2011). Expecting similar outcomes, the UK Government initiated its BIM strategy

which mandates that all awarded contracts over £5M will require the supply chain members to work collaboratively using fully collaborative 3D BIM (Cabinet-Office 2011). However, challenges in implementing BIM in UK construction projects have been highlighted. Key issues include dealing with the resistance to change, and achieving the required integration and interoperability between the Structural and the Mechanical, Electrical and Plumbing (MEP) designers and engineers (for details, see Arayici *et al*. 2011).

Basic characteristics of BIM with potentials for construction supply chain collaboration include:

Communication and information sharing
BIM promotes rich information exchange and processing activities facilitated by cross-functional and cross-organisational communication. It offers platforms for improving communication and collaborative working with computer applications able to directly use and exchange building information (Arayici *et al*. 2011, Bryde *et al*. 2013, and Singh *et al*. 2011). In a sense, the increasing interest in BIM can be attributed to the development of new project management frameworks such as Integrated Project delivery (IPD), which depend on closer collaboration and effective communication (Eastman *et al*. 2011). Such levels of communication and information exchange are vital in the building of trust and emergence of collaborative behaviours (Ha *et al*. 2011, Kwon and Suh 2004).

Coordination and cooperation
Inter-organisational information systems offer possible approaches to manage integration, cooperation, and coordination challenges encountered in construction (Maunula 2008). So, with the multi-disciplinary collaborative working supported by the extensive use of BIM, effective resources allocation, and flow of materials and related information are achieved with much ease. Bryde *et al*. (2013) asserts that the coordination of complex project systems is perhaps the most popular application of BIM at present.

Joint decision making and problem solving
Considering the diversity of professions working together on a BIM-based project, the 3D BIM facilities the management of all aspects of the composed model in a manner that any possible conflicts can be exposed and resolved while still in the planning phase of the project (Grilo and Jardim-Goncalves 2010). Consequently, it is possible to get the actual construction ‘right at first time’ thereby eliminating redesign and rework situations. This approach relies on the alignment of project activities through joint decision making and joint problem solving (Cao and Zhang 2010, Ramanathan *et al*. 2011, Simatupang and Sridharan 2005, Soosay *et al*. 2008).

Project data and information management
Often times, construction organisations rely on information provided by other project partners to progress their activities in the project delivery effort. Hence, it is required that such data and information be accurate, accessible, and available in formats that are compatible and inter-connected for interoperability. BIM holds integrated building information in a single repository ensuring consistency, accuracy and accessibility of data and information (Arayici 2008). Consequently, the potential benefits of BIM are delivered via the shared utilisation and value added creation of integrated data. This is considered as having interoperability, and is described as the seamless exchange and use of building data and information between multiple applications over any or all disciplines, and over any or all lifecycle phases of a building development (Arayici

2008). Therefore, regardless of the type of computer application used, data and information are mutually accessible by the discrete organisations working together on the project. This is achieved by the use of standard data exchange languages. Currently, the International Foundations Classes (IFC) published by the International Alliance for Interoperability (IAI) and city Geographic Markup Language (cityGML) is the only open global standard (Arayici 2008).

PROVISIONAL FINDINGS

The review so far suggests that the collapse of the traditional adversarial culture inherent in the UK construction industry could enhance the industry's overall performance and competitiveness. Research affirm that openness and trust which engender integration and a collaborative culture can be successfully achieved over a shorter time through formal processes, tools and techniques specifically engineered to achieve them (Brensnen and Marshall 2000, and Owen *et al*. 2013). Thus, in spite of the culture of distrust within the industry, early adoption of BIM is showing a collapse of traditional adversarial relationships, even in projects where there are no collaborative legal frameworks (Owen *et al*. 2013). This ongoing research therefore suggests a conceptual model which reflects the interaction between BIM characteristics and basic supply chain collaboration principles resulting in improved construction supply chain performance. Key elements and related variables essential for the design of the proposed model have been identified from literature, and are presented in Table 1.

Table 1: Elements and associated variables of the proposed conceptual model

Elements	Variables	Elements	Variables
Collaborative behaviour and attitude	Informal communication, commitment to a win-win situation	BIM	Coordination, cooperation
Collaborative culture	Information sharing, joint decision making, trust	Project data and information management	Integration, interoperability
Collaborative advantage	Innovation capabilities, process efficiency, flexibility offering, quality offering, business synergy		
Project supply chain performance	Cost reduction, lead/delivery time reduction, quality enhancement, revenue enhancement		

CONCLUSION

This paper has presented a brief review of the UK construction supply chains' adversarial culture and its adverse impact on the development of collaboration and performance. It is the view of this ongoing research project that successful BIM adoption will provide the much required drive towards collaborative working among construction supply chain members. It advocates that BIM use will have a significant positive association with the development of a collaborative culture culminating in improved construction supply chain performance. Therefore, it proposes a BIM-driven conceptual model; and through a review of relevant literature, has identified the key elements and variables required for the design of the proposed model. As contributions to the Construction Management discipline, this research will provide strategic approaches towards developing a collaborative culture in UK construction

supply chains, and a clear understanding of the relationship between BIM adoption, collaborative culture, and project supply chain performance.

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