LEAN SUPPLY CHAIN DECISIONS: IMPLICATIONS FOR CONSTRUCTION IN A DEVELOPING ECONOMY

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ABSTRACT

Construction in developing economies is now a vital sector that contributes more than a marginal growth to the economic emancipations of countries in sub-Sahara Africa, South America and Asia. The upswing in construction activities tends to increase the number of actors that must make decisions, which determine project outcomes. Thus, astute decisions are critically important for project success. This paper addresses how lean supply chain decisions engender project value in the sector.

Qualitative approach in the form of "structured literature review" led to the primary data that were generated. Using lean 'general management' and 'construction management' as the subject area, supply chain decisions were examined in the literature.

The increased number of stakeholders, especially at the operational phase of project execution necessitates the negotiation of improved collaborative working within the supply chain. The interfaces between suppliers, subcontractors and contractors imply that supply chain decisions affect the finished product. These interfaces may either accelerate or decrease the rate of production on sites.

The enhancement of how supply chain decisions are made and the 'quality' of such decisions could drive out / reduce wasteful activities, and then ensure that the finished product achieve expected ends. This discourse contributes to management related initiatives that are already on-going in the industry, especially as it affects developing economics.

KEYWORDS

Developing economies, Lean construction, Performance, Supply chain management.

BACKGROUND

A book that was edited by Ofori (2012) documents shows the difference between developed and developing countries in the construction context. The book showcases the observations of authors that are conversant with construction research in emerging economies. With themes ranging from 'industry practices' to 'project management', the authors were able to bring to the fore the challenges and potential interventions specific to each dialogue. For instance, barriers to the adoption of lean construction

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techniques and principles were identified and a corresponding 'lean protocol' was proposed. Construction in developing economies is gradually evolving to address endemic poor project performance in terms of cost, time, quality, health and safety (H&S). This is because without creating an enabling environment through superior infrastructure (construction and related), businesses will find it difficult to thrive in the continent of Africa for example (Luiz, 2010).

Such comments reinforce the call for performance improvement in construction. Given that performance could be disrupted by the extent of variability in a process or activity, lean thinking provides a platform for improving upstream and downstream activities in construction. Variability in the form of wastes have been flagged as a major cause of poor performance that should be addressed in construction, especially in a developing country such as South Africa (Emuze and Smallwood, 2011a; 2011b). The intent of this discourse however centred on the premise that enhanced supply chain decisions could drive out / reduce wasteful activities, and then ensure that the finished construction products achieve expected ends. The objective is to use the reviewed literature to enact a research agenda that focus on performance improvement through lean supply chain decisions in construction.

PERFORMANCE IMPROVEMENT AND LEAN CONSTRUCTION

The need to enhance performance through proper coordination of multilayer subcontracting is not particular to a country, developed or developing. For example, the data collected from Hong Kong construction industry demonstrated that improper work practice among subcontractors contributes to poor quality; long communication chain contributes to poor time management; increased abortive and remedial work from them leads to increased cost overruns, and information sharing errors lead to poor coordination of processes (Tam *et al*., 2011). In developing countries where most materials and equipment are imported, problems due to mistakes, inefficiencies, delays and poor information sharing can be very costly in construction (Forbes & Ahmed, 2004). However, unlocking the creativity and innovative skills of workers, engineers, and managers in the infrastructure areas can certainly be driven through new perspectives in the construction management domain.

Management support, time given to improvement activities, employee engagement and motivation and the identification as well as the communication of the need for improvement, all mentioned by Mitropoulos and Howell (2001) in their conceptual model of performance improvement process, are crucial for change enactment in the lean construction framework (Morrey *et al*., 2013). The experience of the case study that was presented by Morrey *et al*. (2013) suggests that lean cannot be defined in isolation of context as it can be adapted to suit the needs of a business and its culture and objectives. Hence, lean construction techniques and principles can be engendered in a developing country context.

For example, majority of the construction professionals that were surveyed in Ghana (a developing country in West Africa) were receptive to the implementation of lean principles in the construction industry, and they were also of the opinion that the transfer of lean construction philosophy into the Ghanaian construction industry would bring benefits that include 'improvement of project delivery' and 'delivery of services / products that exceed clients expectations', among others (Ayarkwa *et al*., 2013a). The professionals (technical managers in contracting and consulting firms)

also contend that the transferability of lean construction philosophy into the Ghanaian construction industry can lead to a change in current practices that generate excessive wastes and sub-standard products (Ayarkwa *et al*., 2013a).

Hence, the performance improvements occasioned through the implementation of principles inherent in lean construction in developed countries such as Australia, Denmark, Finland, the United Kingdom (UK) and the United States of America (USA) (Ballard & Howell, 2004; Johansen & Walter, 2007), can be replicated in a developing economy. The gains of reduced NVAAs and improved productivity that accompany lean construction implementation (Mossman, 2009) should propel the adoption. Lean thinking is thus synonymous with getting the right items to the right place when they are needed, in the right quantity and quality while minimising NVAAs (Kempton, 2006).

The proliferation of lean construction has been brought about through its close link with continuous improvement in the industry. Through the use of themes that are related to theory; production planning and control; people, culture and change; and supply chain management (SCM), lean construction has gained recognition as a performance improvement philosophy in the industry (Forbes & Ahmed, 2011).

SUPPLY CHAIN MANAGEMENT IN CONSTRUCTION: A SYNOPSIS

Despite the attention that SCM has attracted among researchers, the translation of its concepts and techniques into the construction industry is still a challenge (Isatto & Formoso, 2011). Construction SCM is an emerging area of practice that is more concerned with the coordination of discrete quantities of materials and related specialist services delivered to specific construction projects (Vrijhoef & London, 2009). Reasons for the use of SCM in construction are not limited to:

- The organisation and sourcing of materials is becoming increasingly complex across the global construction industry;
- Construction clients are demanding faster, more responsive construction processes, and higher quality facilities, and
- There is mounting evidence of improvement in project performance through taking a supply chain perspective.

Given the reported advantages that horizontal SCM offers SMEs in construction in terms of business survival and competitiveness, industry stakeholders cannot afford not to exploit its potentials. Bjornfot *et al*. (2011) observed that an analysis of the economic data from the development of the national Swedish timber industry during the 2008-2010 economic meltdowns indicates that the amount of bankrupt SMEs in the northern Swedish timber industry has been fewer than the national average. They contend that even though there may be other reasons for this, horizontal supply chain collaboration among the SMEs was a key reason for the improved business survival rate. According to them, horizontal supply chain alliance provides a flexible business climate that leads to improved competitiveness and survivability in a volatile market (Bjornfot *et al*., 2011). It is however notable that because construction supply chains are subject to sequential, pooled and reciprocal interdependencies, and to interdependence owing to the need for synchronising a range of supply chains to each and every construction site, there appears to be a major hindrance to the development

of appropriate SCM models and efficient supply chain practices in construction (Bankvall *et al*., 2010).

A supply chain is often complex, dynamic and involves the constant flow of information (forecast, orders, schedules), material (components, end products), and funds between different and independent stages in a project life cycle (Azambuja & O'Brien, 2009). According to Azambuja & O'Brien (2009), understanding customers' expectations and supply chain uncertainty in terms of demand and supply that a firm faces is essential for developing the right capabilities or abilities to serve its market. A supply chain may need to emphasise its efficiency capabilities that depend on a set of final product characteristics and expected performance. For example, a responsive supply chain is able to address a wide range of quantities demanded, meet short lead times, handle a large variety of products, meet a very high service level, and handle supply uncertainty with in-built structural flexibility (Bjornfot & Torjussen, 2012). The linkage of the lean and agile paradigms to the engineered-to-order (ETO) sector (such as construction) focus on the proposition that lean and agile strategies can be mapped onto supply chain structures in order to assist the determination of their applicability in the sector (Gosling & Naim, 2009a). Thus, while SCM may be practised on a single project, its greatest benefits materialise when it is practised across all projects in a firm; involves multiple organisations, and is applied consistently over time (Tommelein *et al*., 2009).

Managing the supply chain in construction is vital because contracts themselves tend to be broad commitments. For instance, as uncertainty and complexity arise, project managers find it increasingly difficult to coordinate the project supply chain by managing contracts, which will, in turn, result in delegating a larger share of the coordination process to other stakeholders at operational levels (Isatto & Formoso, 2011). As individuals or firms are awarded more autonomy, the overall coordination burden grows, demanding organisational structures that are able to manage commitment loops in terms of project completion (Azambuja & O'Brien, 2009; Isatto & Formoso, 2011).

SUPPLY CHAIN DECISIONS IN LEAN CONSTRUCTION

Descriptions of what lean construction entails are supported by quantitative analysis of contents sourced through papers delivered at IGLC conferences. An article authored by Alves & Tsao (2007) shows major research themes that have engaged the attention of lean construction researchers. The quantitative content analysis was based on IGLC papers from 2000 to 2006. Alves & Tsao (2007) analysed abstracts and keywords of 357 papers presented at 7 IGLC conferences from 2000 to 2006. They collected a total of 1710 keywords from 329 papers. They grouped major keywords with their related terms into keyword clusters, and then gathered clusters with 10 or more keywords appearances. This effort accounted for a total of 810 keywords, which suggest that the analysis covers 47.4% of all IGLC keywords from 2000 to 2006. The exercise was embarked upon based on the assumed hypothesis that *a keyword analysis combined with a review of IGLC papers is sufficient to reveal the primary research areas in the IGLC community from 2000 to 2006* (Alves & Tsao, 2007: 58).

Alves & Tsao (2007) observed that in the group of papers analysed, the papers on SCM are in most cases theoretical or descriptions of how organisations work within their supply chains. The SCM papers addressed theoretical models with the intention

of providing explanations related to how construction supply chains work, their peculiarities, and what should be done to effectively implement SCM in construction. Alves & Tsao (2007) further noted that some papers described how specific supply chains work concerning how actors in a specific supply chain interact, how the supply chain operates and what its main problems are, opportunities for improvement, and good practices that can be replicated to other supply chains in construction. However, it was observed that papers related to cases about the implementation of SCM concepts across 4 or more organisations were lacking among the examined IGLC papers. The authors suggest that this may be due to the fact that the construction industry may be learning slowly about the need to manage not only their firms, but also their supply chains (Alves & Tsao, 2007). In brief, the article obviously shows that the lean construction studies have addressed SCM, albeit at varying degrees.

While Alves and Tsao (2007) used a quantitative content method, a recent study relied on a qualitative content analysis effort. The qualitative content study by Emuze (2012) analysed 8 IGLC papers, from 2007 to 2010, in order to identify emergent themes related to SCM through process analysis. The dates were chosen in order to unearth meanings of recent SCM-related findings documented in the IGLC proceedings. The 2011 papers were excluded, because they were not readily available on the IGLC web portal during data mining. The number of papers was arrived at by focusing on articles that were published under the IGLC conference theme "*Supply Chain Management*" from 2007 to 2010.

In addition, only papers that have SCM as a keyword were chosen for analysis. As one would expect from SCM-related papers delivered at IGLC conferences, the term 'supply chains' tops the list of codes. The use of open coding method (descriptive) led to the compilation of 62 quotations. Descriptive coding relates to a word or short phrase, which is the basic topic of a passage of text. The analysis indicates that codes such as supply chains, logistics management, and integration of functions, lean thinking, inventory management, and coordination of flow gathered 64.6% of the quotations, which suggest that these issues dominate the findings presented in the analysed IGLC papers. In line with the qualitative analysis procedure documented in the literature (Elo & Kyngas, 2007), the categories were derived through deductive content analysis. The deductive approach is based on previous findings, and therefore it moves from the general to the specific concerning the emergent themes indicated in Table 1.

The identified categories, namely construction logistics, flow coordination, merger of supply chains, and complexity and value-related discourse suggest that the principal theme among the analysed IGLC papers is '*how to ensure project success based on supply chain decisions*'. Such decisions could be made by an upstream or downstream actor in the network as long as it eliminates NVAAs and delivers value to the client. Among the quotations that led to the occurrence of construction logistics as a distinct category, the use of logistics centres (preferably for large projects), reduction of inventory cost through material aggregation, just-in-time (JIT) delivery of materials, tracking of materials in transit (on-site and off-site), reliable location and delivery of on-site items as well as the ability to make equipment requisitions with ease when they are needed, were cited as benefits of lean SCM concerning logistics.

Among others, the elimination of warehouse management problems, creation of instant and consistent visual communication networks, integration of activities across

firms, and increased production planning and control were advantages of flow coordination that were empirically revealed by the IGLC researchers. Concerning the need to merge supply chain functions among project partners, the lean construction researchers were of the opinion that reduction of individual organisational risks, elimination of duplication, coordination of activities, and managing processes beyond the focal firm justify the call for the use of SCM concepts in construction. Value-driven processes and the use of lean thinking methods both at the strategy and operational levels were also cited as reasons why SCM may be useful in the industry in terms of project complexity.

Table 1:Coding of the data (IGLC SCM papers) into the categorisation matrix
Source: Emuze (2012: 13)

Theme	*How to ensure project success based on supply chain decisions*			
category	*Construction logistics*	*Flow coordination*	*Merger of supply chains functions*	*Complexity & value*
Descriptions of benefits	A case for the use of logistics centres	Eliminates warehouse management problems	Reduces individual organisational risks	Transformation of processes through lean thinking
	Reduction of inventory cost through material aggregation	Creates instant and consistent visual communication networks	Eliminates waste and unnecessary efforts across the chain	Value-driven purchasing can simplify the production line
	Just-in-Time delivery of materials	Brings high levels of accountability	Coordination of activities and processes	Value-driven purchasing provides consistent workflow
	Tracking of materials in transit	Improves production planning and control	Improves the efficiency of the production process as a whole	Centralisation of information can lead to end-to-end visibility
	Reliable on-site location and delivery of items	Integrates activities across firms	Design and management of process that goes beyond the focal company boundaries	Evaluation of the supply chain in order to identify members that could be integrated
	Ability to make equipment requisitions with ease		May prevent managerial problems including lack of cooperation and insufficient role definition of the SC agents	Improves supply chain configuration and control based on factors such as integration of business processes

GAINS OF LEAN SUPPLY CHAIN DECISIONS IN A DEVELOPING ECONOMY

Major barriers to the implementation of lean construction principles and techniques in a developing country (Ghana serves as an example) include the fragmented nature of the industry, extensive use of subcontractors, lack of long term relationship with suppliers, delays in decision making, and the acceptance of NVAAs in the construction process (Ayarkwa *et al*., 2013b). These principal barriers can be address by stakeholders when they properly consider how their project related decisions would affect the entire supply chain and project objectives. In Southern Africa that contractors' inability to perform has been cited as a major cause of project failure (Valention & Vorster, 2012), the appropriation of lean construction principles is also crucial.

As an illustration, structural flexibility in a supply chain results in shared resources and capabilities among collaborating entities apart from the logistics and supply competencies that are available within the chain (Bjornfot & Torjussen, 2012). The need to understand risk and uncertainties pertaining to construction SCM shows that 'flexibility' could be a significant competitive factor in the construction industry (Gosling & Naim, 2009). The study conducted by Gosling & Naim (2009b) shows that sources of supply chain uncertainties relate to control, demand, process, and supply. They contend that deliveries that are unable to access the site, the speed of construction and volatility of workflow required the most flexibility types concerning process uncertainties. In this context, process flexibility is the ability to structure the project process so that it can accommodate late changes in design criteria and intermediate schedule milestones (Gosling & Naim, 2009b). Gosling et al. (2012) went further to develop a four-step framework that provides a structured route map for firms operating in the construction industry to consider the uncertainties in their supply chains and the types of flexibilities required to mitigate them. The framework includes: classify the supply chain; identify and analyse uncertainties; optimise pipelines, and develop strategic flexibility. The strength of the framework is that it emphasises the bringing together of firms to collectively consider uncertainties and flexibilities in supply chains, and then encourages them to make use of a collaborative approach for problem identification and solution.

Therefore, a firm in a developing country should be able to decide to apply the lean construction philosophy across its entire business and project practises as vividly described by Morrey et al. (2013). The decision to enact lean across a supply chain should be able to address a number of problems that are synonymous with construction in developing economies where small and medium sized (SME) firms are hugely involved in the construction industry. Adopting a strategy of small wins that form a pattern towards a new system design can effectively renew mental, procedural and system level requirements for an undertaking (Vrijhoef et al., 2001). The ability to make appropriate decisions that are SCM focussed should engender situations whereby lack of cohesion and coordination in supply chains and corresponding variability in the production process are checkmated so as to enhance the management of the business and projects of construction. A case history based on the experience of the Highways Agency in the UK can serve as an example for willing firms in developing countries. The paper by Chen et al. (2012) presents examples of projects within the agency's supply chain that have demonstrated that a

broad range of lean practices are relevant to the working practices in the area. By actively looking for ways to improve by examining activity, asking how much of it is adding value, finding root causes of problems and using formal problem-solving techniques, positive changes can be made and firms can achieve their aim of delivering value with minimum NVAAs (Chen et al., 2012).

CONCLUSIONS

The proliferation of subcontracting businesses and the number of contractors with limited contracting capacities that necessitate the use of collaborative working arrangement with large contracting firms amplified the need for lean SCM in developing economies. The plethora of problems that have been mentioned in the literature in terms of construction performance, especially in developing economies, justify the argument that call for a paradigm shift in the way the business and project of construction is managed in the region. The drive for '*more for less*' is now a must for developing economies. This is based on the premise that enhanced supply chain decisions could reduce NVAAs, and ensure that delivered products achieve expected ends in construction.

A synthesis of the literature showcase the utility and benefits of lean SCM based decisions in construction. Decisions that are made in the interest of all actors involved in a project undertaking have the tendency to enhance performance in construction. These supply chain decisions could allow benefits related to construction logistics, coordination of the flow of products and services, integration of functions, and value creation to accrue to project stakeholders. The ability to evolve flexibilities that could mitigate a range of risks and uncertainties inherent in processes and supplies associated with construction activities back this argument.

According to the construction management literature in Southern Africa (see proceedings of the Built Environment Conferences [1-6] and NMMU Construction Management Conferences [1-2]), the increased number of stakeholders, especially at the operational phase of project execution necessitates the negotiation of improved decision making abilities within supply chains. The interfaces between suppliers, subcontractors and contractors imply that supply chain decisions affect the finished product. These interfaces may either accelerate or decrease the rate of production on sites based on project specific actions.

The enhancement of how supply chain decisions are made and the 'quality' of such decisions could drive out / reduce wasteful activities, and then ensure that the finished product achieve expected ends. This discourse contributes to performance improvement related initiatives that are already on-going in the industry, especially as it affects developing economies. A future case study research endeavors should examine how supply chain decisions are made and their implications for construction in developing economies. The exercise would be conducted in a developing country where the industry is structured in terms of few large general contractors and many SME firms.

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