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Qualitative content analysis from the lean construction perspective: A focus on supply chain management

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Abstract

The performance of projects in terms of targeted objectives has always been a very contentious issue in the construction industry. The constant issue at stake is the inability of projects to satisfactorily meet agreed delivery targets. In order to address this quagmire, performance improvement tools such as supply chain management (SCM) were introduced into the industry.

The central theme of this discourse is thus concerned with the need to promote performance improvement in construction through the exploitation of the concepts inherent in SCM from the perspectives of lean construction researchers as documented in the annual International Group for Lean Construction (IGLC) conferences. The methodological approach adopted for the discourse is qualitative in nature as recent SCM literatures available on the IGLC web portal were subjected to a qualitative content analysis.

The research outcomes, which have implications for South African construction, attempt to offer solutions to the mirage of performance-related project management and/or supply chain problems, especially in terms of improving 'how organisations working together' overcome complexities and deliver value to stakeholders.

Keywords: Content analysis, lean construction, performance, research trends, supply chain management

Abstrak

Die vordering van projekte in terme van objektiewe was altyd 'n sensitiewe onderwerp in die konstruksie-industrie. Konstante aspekte wat normaalweg ter sprake is, is die onbevoegdheid van spesifieke projekte om voorafbepaalde afleweringsmylpale te behaal. Om hierdie onbevoegdhede teen te werk, is prestasieverbeteringshulpmiddels soos voorsieningsketting kennisbestuur in die praktyk voorgestel.

Die sentrale tema van hierdie aspekte is dus gemoeid met die behoefte om prestasie-verbetering in konstruksie deur middel van die eksplorasie (uitbuiting) van die konsepte inherent in prestasieverbeteringshulpmiddels uit die perspektiewe van *lean* konstruksie navorsers, soos gedokumenteer in die jaarlikse *International Group for Lean Construction (IGLC)*-konferensies, te

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bevorder. Die metode wat gevolg is, was kwalitatief van aard aangesien die nuutste literatuurnavorsing bekikbaar op die *IGLC*-webportaal kwalitatief van aard was.

Die navorsingsuitkoms van hierdie studie, wat implikasies vir die Suid-Afrikaanse konstruksie-industrie inhou, het gepoog om sekere oplossings aan te bied wat prestasie georiënteerde aspekte van projekbestuur en/of voorsieningsketting kennisbestuur probleme teen te kan werk en om alle betrokkenes behulpsaam te kan wees om saam te werk met die doel om afleweringsmylpale te behaal.

Sleutelwoorde: Konteksanalise, *lean* konstruksie, prestasie, bevoegdheid, navorsingspatrone, voorsieningsketting kennisbestuur

1. Introduction

Construction management research (CMR) findings reveal that construction is in need of improvement as many problems can be observed in the sector. Analysis of these problems has shown that a major part of them are supply chain problems, originating at the interfaces of different parties and functions (Vrijhoef, Koskela & Howell, 2001: 2). However, despite the attention that supply chain management (SCM) has attracted among researchers, the translation of its concepts and techniques into the construction industry is still a challenging issue (Isatto & Formoso, 2011: 1).

Vrijhoef & London (2009: 1) suggest that construction SCM is thus 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. According to them, reasons for the adoption of SCM in construction include among others:

- The organisation and sourcing of materials is becoming increasingly complex across the global construction industry;
- Global sourcing of materials and assemblies provided by advances in transportation technologies as well as a shortage of craft labour that force increasing amount of value-added work to be conducted off-site deep in the supply chain;
- 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.

In this sense, poor performance exemplified in current and past Construction Industry Development Board (cidb) Construction Industry Indicators (CII) reports amplifies the need for improvement in South African construction that is reportedly dominated by small and medium-size enterprises (SMEs) in the form of subcontractors

(Shakantu, Tookey, Muya & Bowen, 2007: 97). The proliferation of the number of such organisations in the industry calls for a holistic way of managing the construction process (Shakantu *et al*., 2007: 97). In addition, 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 the potentials of SCM in South Africa.

For instance, Bjornfot, Torjussen & Erikshammar (2011: 687) observed that an analysis of the economic data from the development of the national Swedish timber industry during the 2008-2010 economic crisis indicates that the amount of bankruptcies of 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: 687). In addition, it is notable that because, unlike certain other industrial contexts, construction supply chains are subject not only to sequential but also to 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, Bygballe, Dubois & Jahre, 2010: 391).

2. Literature review

2.1 Supply chain

A supply chain is 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: 3). According to Azambuja & O'Brien (2009: 3), understanding of 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. In other words, 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.

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, Ballard & Kamisky, 2009: 107). Managing the supply chain in construction is therefore important because contracts themselves tend to be broad commitments. For example, as uncertainty and complexity rise, 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: 15). In addition, 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: 12; Isatto & Formoso, 2011: 16).

The importance of the study is centred on the need to address the detrimental effects that inadequate management of the supply chain that always manifest as cost and time overruns, rework, and in worse cases, accidents is having on project performance. As a result of increased investments in the industry in the future, the management of subcontractors and suppliers by principal general contractors (GCs) is vital to the quest for the delivery of enhanced value to both clients of the industry and the end users of construction products in South Africa.

Moreover, the problem statement proposed for the study suggests that the lacklustre management of supply chains, in particular the supply chains of GCs, limits the extent of performance improvement in construction. The overall aim of this article is thus to highlight the utility of SCM for performance improvement, especially from the lean construction perspective. The article is structured as follows. In the next section a literature review focusing on lean construction research outputs and their focus area is presented, followed by a description of the research method. The actual qualitative content analysis and the findings are then presented in addition to a discussion of the findings. This is followed by the conclusions and recommendations.

2.2 Lean construction

Lean management principles can be regarded as fundamental prerequisites for continuous improvement activities (Meiling, Backlund & Johnsson, 2012: 152). Lean in the construction context entails the understanding of what the client wants in terms of cost, quality and time (value); identifying the hierarchy of processes required to deliver what the client wants, and recognising that individual steps may or may not add value (value stream); examining the steps holistically, understanding dependencies, balancing resources and planning work to avoid delays or rework at interfaces (flow); recognising that each step is not just an end in itself, but an input to the next stage that needs to be delivered at the right time, quantity and quality (pull), and continuously striving to be better (perfection) (Terry & Smith, 2011: 8). Eriksson (2010: 395-396) noted that the core elements of lean construction can be assumed to be waste reduction, process focus in production planning and control, end customer focus, continuous improvements, cooperative relationships, and systems perspective.

These descriptions of what lean construction entails are supported by quantitative analysis of contents sourced through articles delivered at IGLC conferences. Two articles "Review of lean research studies and relationships to the Toyota Production Research Framework" (authored by Jacobs, 2011) and "Lean construction – 2000 to 2006" (authored by Alves & Tsao, 2007) indicated the main research themes that have engaged the attention of lean construction researchers since 1996.

Content analysis (quantitative) was chosen as the research methodology for analysing 592 IGLC research studies from 1996 to 2009 against the Toyota Production System (TPS) framework (Jacobs, 2011: 3). The analysis revealed that lean research in construction did not align exclusively around the TPS framework. From the 592 studies analysed, 241 (40%) were classified within the four overarching TPS categories having the TPS principles, and 351 (60%) were classified outside the TPS framework as fitting in one of 15 lean-related proxy categories that were created during the course of the study by merging themes during the analysis process (Jacobs, 2011: 8). As indicated in Table 1, the TPS framework includes 4 categories of long-term philosophy, the right process, invest in people and partners, and continuous problem-solving, while the 15 lean-related proxy categories include theory, benchmarking, information technology, sustainability, organisational change, game simulation, design management, literature review, waste control, outside lean

focus, prefabrication, models and feedback, safety, and logistics. Out of these categories, process, people and partners, design management, waste control, prefabrication, and logistics suggest that a segment of lean research outputs addressed issues central to performance improvement by enhancing the interface and/or relationships between construction supply chain members.

Table 1: Clarification of categories of lean research outputs from 1996 to 2009

Category	*Description*
Long-term philosophy	Toyota Production System
The right process	Toyota Production System
Invest in people and partners	Toyota Production System
Continuous problem-solving	Toyota Production System
Theory	Theory development research associated with lean construction
Benchmarking	Compared construction processes and performances with those of other industries
Information technology	Use of computers and telecommunication in construction
Sustainability	Architectural property which allows continued viability in construction
Organisational change	Undergone internal transformations with organisations
Game simulation	Various activities in 'real life' in the form of games
Design management	Integration of construction design into management
Finance	Construction activities concerned with providing capital
Literature review	Body of lean text that reviewed critical points of lean construction
Waste control	Measures of wastes in construction
Outside lean focus	No relevance to other 18 categories in lean construction
Prefabrication	Manufacturing of sections of a building at a factory off-site
Models and feedback	Lean production models and feedback on applied applications in construction
Safety	Safety systems in construction
Logistics	Handling of operations in construction

Adapted from Jacobs (2011: 6)

The second quantitative content analysis publication was based on IGLC papers from 2000 to 2006. Alves & Tsao (2007: 50) analysed abstracts and keywords of all 357 papers presented at 7 IGLC conferences from 2000 to 2006. They collected a total of 1.710 keywords from 329 papers (92.2% of all IGLC papers from 2000 to 2006). They grouped major keywords with their related terms into keyword clusters, and then gathered clusters with 10 or more keywords appearances as indicated in Table 2. 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 postulates 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: 53) 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 papers addressed theoretical models and analysis 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: 54) 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: 54). Thus, despite the high frequency of SCM keywords in the papers analysed (Table 2), the IGLC community has a long way to go in terms of the implementation of SCM in construction.

Table 2: Frequency of keywords and related keywords in 2000 to 2006 IGLC papers

Keyword cluster	*Keyword instances*	*Related keywords*	*Total keywords*	*Percentage (%)*
Lean construction	94	0	94	5.5
Design management	10	61	71	4.2
Culture and human aspects	5	55	60	3.5

Keyword cluster	*Keyword instances*	*Related keywords*	*Total keywords*	*Percentage (%)*
Production management	11	49	60	3.5
Value	13	39	52	3.0
Scheduling	12	36	48	2.8
Supply chain management	20	24	44	2.6
Process	5	33	38	2.2
Last planner	14	23	37	2.2
Cost	2	33	35	2.0
Prefabrication	14	18	32	1.9
Information technology	5	26	31	1.8
Safety	7	19	26	1.5
Project management	18	6	24	1.4
Performance measurement	11	11	22	1.3
Construction	17	4	21	1.2
Waste	10	8	18	1.1
Complexity	11	6	17	1.0
Implementation	13	3	16	0.9
Theory	6	9	15	0.9
Lean production	14	0	14	0.8
Client / customer	3	10	13	0.8
Quality	3	9	12	0.7
Work structuring	10	0	10	0.6
Subtotal	328	482	810	47.4
Total keywords 2000-2006			1710	

Adapted from Alves & Tsao (2007: 51)

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: 751). To be succinct, the articles based on content analysis evidently show that the lean construction studies have addressed SCM, albeit at varying degrees. While these studies were conducted with quantitative content analysis method, the next section will present findings and discussions that arose from a qualitative content analysis effort.

3. Research

This study can be considered an empirical research undertaking that emphasises deductive coding. Though qualitative content analysis can take the form of either inductive or deductive reasoning, deductive content analysis is often used in cases where the researcher intends to cast existing data in a new context (Elo & Kyngas, 2008: 111; Zhang & Wildemuth, 2009: 310). This may involve testing categories and concepts based on earlier research findings documented as models, mind maps and literature review (Zhang & Wildemuth, 2009: 310).

Categories and a coding scheme can thus be derived from previous related studies and theories. Two basic steps put forward by Elo & Kyngas (2008: 111) in terms of deductive content analysis entail the development of a categorisation matrix and coding of the data according to the categories. After a categorisation matrix has been developed, all the data are reviewed for content and coded for correspondence with identified categories.

3.1 Research methods

The findings reported and discussed in this article relate to SCM from the lean construction perspective. These primary data were generated through a qualitative analysis of content. Qualitative content analysis was chosen because it emphasises an integrated view of speech/texts and their specific contexts; goes beyond merely counting words or extracting objective content from texts to examine meanings, themes and patterns that may be manifest or latent in a particular text, and allows researchers to understand social reality in a subjective but scientific manner (Zhang & Wildemuth, 2009: 308). In brief, a total of 8 IGLC research studies, from 2007 to 2010, were analysed for 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. Figure 1 presents the research steps taken in this study. The scale on which the research project took place required the utilisation of a qualitative data analysis software package. Atlas.ti was used for analysing the papers that were downloaded from

the IGLC website. Figure 2 illustrates the Atlas.ti interface used while analysing the papers. Basically, all the 8 files (in 'pdf' format) were assigned to Atlas.ti, and each research study was then viewed electronically during analysis, as illustrated by Figure 2.

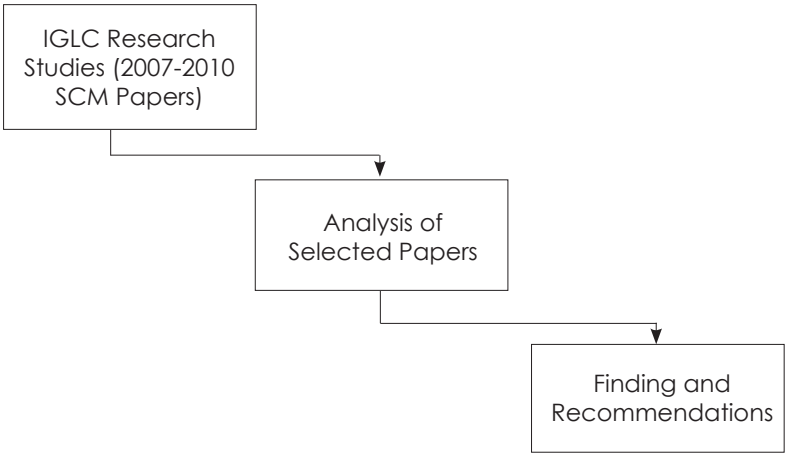

Figure 1: Representation of the research steps

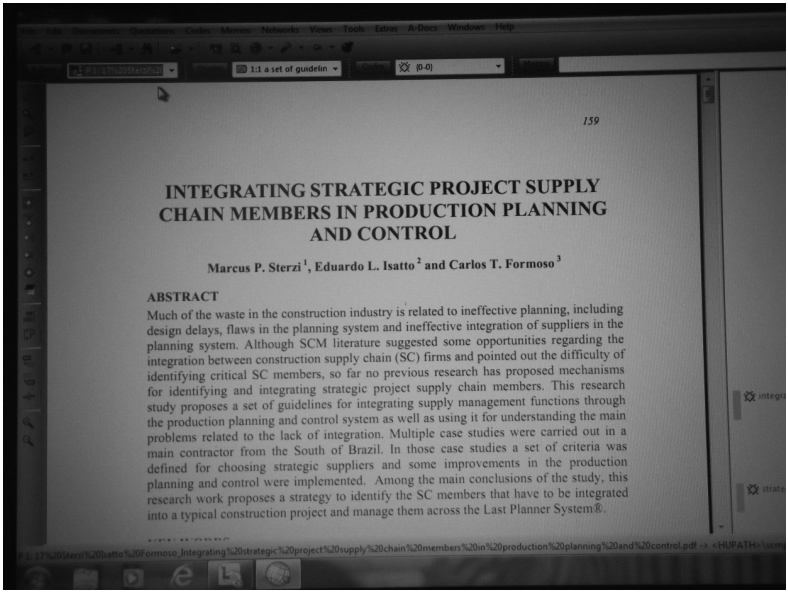

Figure 2: Display of Atlas.ti interface

4. Results

As one would expect from SCM-related papers delivered at IGLC conferences, the term 'supply chains' tops the list of codes (Table 3). The use of open coding method (descriptive) led to the compilation of a total of 62 quotations. Descriptive coding relates to a word or short phrase, which is the basic topic of a passage of text. The table 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: 109-112), the categories presented in Table 4 were derived from the data 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 theme indicated in Table 4. 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'. These decisions could be made by an upstream or downstream actor in the network as long as it eliminates non-value-adding activities (wastes) and delivers value to the client.

Table 3: Codes used for qualitative content analysis

Code	*Number of quotations*	*Percentage %*
Supply chains	10	16.1
Logistics management	8	12.9
Integration of functions	6	9.7
Lean thinking	6	9.7
Inventory management	5	8.1
Coordination of flows	5	8.1
information technology	4	6.5
Coordination complexity	4	6.5
Value delivered to client	3	4.8
Production activities	3	4.8
Coordinate actions	3	4.8
Material tracking	1	1.6

Code	*Number of quotations*	*Percentage %*
Interdependence	1	1 6
Plant hire/lease	1	1 6
Quality	1	1 6
End-to-end visibility	1	1 6
Total	62	100.0

Among the quotations that led to the emergence 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 discovered by the IGLC researchers.

Concerning the need to merge supply chain functions among project partners, the lean construction researchers are of the opinion that reduction of individual organisational risks, elimination of unnecessary efforts (duplication), coordination of activities and processes, and managing processes beyond the focal company justify the call for the adoption 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 and value creation.

Table 4: Coding of the primary data into the categorisation matrix

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

5. Discussion

Given that the majority of the active contractors on the cidb register of contractors are located between grades 1 and 5 (Emuze & Smallwood, 2011: 112), which indicated limited contracting capacities, it can be argued that concepts inherent in SCM may be beneficial to contractors in South Africa. Not only will the contractors become more competitive, the client satisfaction levels could also improve further as increased value is delivered to them.

The need to improve performance through proper coordination of multilayer subcontracting is not particular to South Africa. 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, Shen & Kong, 2011: 115). The case for the SCM implementation from the lean construction perspective is equally reinforced by the perception that lean in construction projects entails (Eriksson, 2010: 401):

- Safe work environment;
- Good site cleaning;
- High comfortableness (fun to work);
- Commitment and participation;
- Good communication and feedback;
- High trust among participants;
- Good collaboration;
- Focus on continuous improvement;
- Focus on reducing waste;
- Focus on function and life cycle costs, and
- Fast decisions about design changes.

Furthermore, ETO or BTO (build-to-order) has emerged as a major operation strategy for improving organisational competitiveness (Gunasekaran & Ngai, 2005: 447). Although both lean and agile strategies have been proposed in the literature as strategies for the ETO and the BTO sector, some of these studies suggest that agility may be more suited to ETO supply chain, while leanness may be well suited to a ship-to-stock (STS) supply chain (Gosling & Naim, 2009a: 752). However, the findings of this particular study reiterate the potential that lean offers the construction industry. Even pertaining to the ETO sector, Gosling & Naim (2009a: 751) suggest that certain strategies could enact performance improvement.

Such strategies include shift between supply chain structures, supply chain integration, information management, business systems engineering, flexibility, time compression, and the development of new product process improvement. As an illustration, 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, 2009b: 821). The study conducted by Gosling & Naim (2009b: 818-821) shows that sources of supply chain uncertainties relate to control, demand, process, and supply. For example, they revealed that deliveries that are unable to access site, the speed of construction and the 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: 817).

Gosling, Naim & Towill (2012: 11) went further to develop a four-step framework that provides a structured route map for organisations 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 organisations to collectively consider uncertainties and flexibilities in the supply chain, and then encourages them to make use of a collaborative approach for problem identification and solution.

6. Conclusions and recommendations

This article started off by identifying the need to adopt concepts inherent in SCM for the purpose of improving performance at both the strategic and operational level of project implementation. The proliferation of subcontracting businesses and the number of contractors with limited contracting capacities that necessitate the use of joint ventures and short- or long-term relationships with larger firms amplified the need for lean SCM in South Africa.

The qualitative analysis of content conducted with the 8 SCM-based papers accessed through the IGLC website indicates that a number of benefits could be harnessed through the adoption of SCM concepts from the lean perspective. Based on the findings of the study, it can be advised that project stakeholders should embrace lean construction, especially the theme that is related to SCM, because the examined papers demonstrate or promote how to ensure project success based on supply chain decisions. 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 supports this argument.

Meanwhile, future research projects should analyse the veracity of each category in Table 4 in the South African context. This should boost the quest for lean construction maturity in the industry. Through case study research endeavours, the application of lean SCM principles and practices should be observed, mapped, analysed and improved in South Africa.

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