ON IMPROVEMENT IN CONSTRUCTION SUPPLY CHAIN MANAGEMENT

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ABSTRACT

The aim of this paper is to provide a discussion on improvement in construction supply chain management. The study is based on a literature review regarding the evolution of supply chain management theory within the construction environment and a review of the current findings of supply chain management in industrial engineering.

The paper presents five managerial practices to be studied and implemented in construction supply chain management. Such managerial practices are traditionally adopted by manufacturing companies and they reflect best practices for improvement in a multi-organizational environment. Even though this paper has a theoretical approach, it also aims to bring a contribution to practitioners by providing directions for improving construction supply chain management.

KEYWORDS

Supply chain management, Theory, Lean construction, Strategic planning, Flexibility.

INTRODUCTION

Supply Chain Management (SCM) has been widely discussed in the literature, especially in operations management. Such discussion is focused on quantitative and qualitative approaches. On the one hand, quantitative modeling is applied to inventory management, demand forecasting and routing optimization. These studies are highly related to data analysis from case studies in manufacturing processes. On the other hand, qualitative, managerial or soft aspects of SCM are usually related to the definition of frameworks, which are applied within industry and after that are validated through empirical research. Such frameworks are usually applied in performance measurement, strategic planning and governance in SCM. Both quantitative and qualitative approaches have been published in a variety of journals related to operations management.

However, the discussion of SCM in construction has been developed in isolation from industrial engineering based on two reasons. First, construction management has unique characteristics related to its nature such as an intermittent flow and non-repeated projects. Continuous flow it is an important process feature to reduce inventory of finished goods or work-in-process. Also, it also influences on demand forecasting, which consequently impacts on stock levels. Non-repeated projects take

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along difficulties to production standardization and modularization, not contributing to obtain gains of scale in production systems. Thus, quantitative and modelling studies are not easily applied within construction environment due to its complexity. Second, construction management presents a lack of integration between suppliers, contractors and developers. Integrated efforts are key aspects to improve performance, not only to deliver better projects to the final customers, but also to reduce waste and to promote cost reduction throughout the supply chain (SC). Nevertheless, industrial engineering has experienced significant developments in supply chain management and they might bring a contribution to construction industry. Such contribution can be directed implemented or adapted from the practices of supply chain management in industrial engineering.

The purpose of this paper is to propose a set of managerial practices to improve construction supply chain management. Such proposition is based on a literature review of SCM, considering mainstream journals of construction/industrial engineering and the proceedings of the last nineteen conferences of the International Group for Lean Construction (IGLC). The literature review discusses the evolution of the lean SCM theory in the construction industry over the last years and introduces research findings from traditional manufacturing as possible approaches for the improvement of construction supply chain management.

This paper has four further sections. The second and the third sections review the literature of supply chain management and its interface with construction and industrial engineering. The fourth section presents a discussion of improvement in construction supply chain management. Finally, a concluding section includes research limitations and a brief description of future work.

REVIEW OF SUPPLY CHAIN MANAGEMENT IN CONSTRUCTION

In this section, the literature of construction supply chain management is reviewed throughout the time. The mainstream journals, books and the proceeding of the last nineteen IGLC conferences were revisited in order to drawn an evolutionary line of the research in supply chain management. Initially, O'Brien (1995) highlighted the trade-offs between transportation, inventory and production costs, discussing the importance of integrated frameworks and models to manage supply chain. Such integration was pointed as a key aspect for cost reduction in construction. Egbu *et al.* (1996) developed a study regarding project management for refurbishment, establishing a comparison between construction and shipping industries, that, among other issues, discussed procurement systems. Pietroforte (1997) conducted a study discussing governance in construction supply chains. Also, a review conducted by Alarcón *et al.* (1999) proposed a framework to evaluate and improve the procurement process in construction projects. Such studies constituted the embryo for an understanding of supply chain issues in construction management.

Childerhouse *et al.* (2000) and London and Kenley (2000) debated more structural concepts regarding SCM in construction. The authors investigated the links between strategies and operations frameworks to manage supply chain in construction. Childerhouse *et al.* (2000) discussed four different strategies for house building supply chains. After that, such strategies were positioned in a matrix with three dimensions, namely customer lead time requirements, degree of customization and relative logistical costs. Thus, each strategy was allocated in accordance to the so-

called dimensions, enabling a smoother decision making regarding SCM strategy selection. London and Kenley (2000) proposed a method for analysing and describing SCM in construction. Such method incorporated a horizontal and a vertical structure to manage supply chain issues. Horizontally, the different tiers of suppliers were grouped upstream and downstream as primary consultants, prime contractors, subcontractors, sub consultants, and service/material suppliers. Vertically was established the degree of competition among suppliers in the same tier. At this point, the paper highlighted issues related to market competition and differentiation between suppliers. Such issues might be analysed by performance measurement techniques in order to select, certify, assess and provide feedback for suppliers.

As an evolution regarding the views of construction theory, Vrijhoef and Koskela (2000) defined four roles of SCM in construction. Such roles are concerned about (i) the interface between the supply chain and the construction site, (ii) the supply chain itself, (iii) the transference of activities from construction site to the supply chain and (iv) the management integration of the construction site and the supply chain. The definition of such specific roles complements strategy selection and positioning proposed by London and Kenley (2000). In this sense, the understanding of each role of SCM in construction provides basis for strategy definition with suppliers and contractors. In addition, Vrijhoef and Koskela (2002) discussed the importance of applying lean techniques throughout the supply chain, given that most of the problems spread across the many tiers of supply chain.

O'Brien *et al.* (2002) presented a comprehensive literature review regarding supply chain in construction. Such development provided basis for a robust understanding of the intrinsic issues of construction in a multi-organizational process. As a result, the paper delivers a synthesis of four research directions, namely sourcing and make-versus-buy decisions, supply chain structures, incentives for improvement throughout the many tiers of supply chain, and behavioural actions for suppliers from a normative perspective. Isatto and Formoso (2006) presented a set of relevant research findings in SCM theory in construction. The study discussed the joint use of three conjectural methodologies in order to investigate multi-organizational management in construction SCM. O'Brien *et al.* (2009) presented a handbook discussing a wide set of key-issues related to SC in construction. Such publication covered operational and organizational aspects of supply chain management. Roehrich and Lewis (2010) discussed the relevance of governance models in complex inter-organizational systems. Schoenwitz *et al.* (2012) discussed the matters of mass customization, presenting a framework to implement such initiative, which is an emergent research topic in construction.

The majority of such publications were developed by the lean construction academic community based on case studies, and they covered a large number of supply chain management topics. These studies emerged from an operational point of view to a more structured perception, in which the discussion become more focused on organizational issues such as planning, governance, market, among others. It is clear that research in construction supply chain management has evolved throughout the time, but there is still a lack of discussion regarding supply chain management as a process.

TENDENCIES FROM SUPPLY CHAIN MANAGEMENT IN INDUSTRIAL ENGINEERING

With the purpose of organizing the aspects of SCM, the further discussion will be divided in three categories, namely design, operation and improvement of supply chain, as shown in Figure 1. Such categorization has been adopted by mainstream books and journals in industrial engineering.

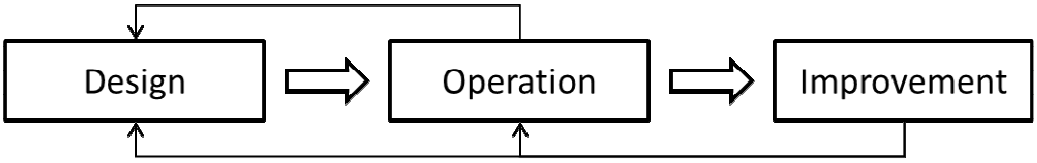

Figure 1: Supply Chain Management process

The design process provides basis for the operation process, which is determinant for the improvement. Nevertheless, operation delivers feedback for design and improvement offer feedback both for operation and for design. Such configuration is essential in order to promote continuous improvement in SCM. Also, this approach reinforces the view of SCM as a managerial process.

DESIGN

Strategic issues in SCM were early discussed in Vollmann and Cordon (1998) by building successful customer-supplier alliances. This study brought a contribution to knowledge related to the view of supply chain as a virtual organization composed by many companies. Lambert and Cooper (2000) delivered a conceptual framework of supply chain management. This paper clearly described network structure linkages to represent interactions in different supply chains tiers, not only for material flow but also for information flow.

Lee (2004) discussed three main features for modern supply chains, namely agility, adaptability and alignment (triple-A). Agility was defined as a response to short-term changes in demand or supply quickly, handling external disruptions smoothly. Adaptability was demarcated as an adjustment in supply chain's design to meet structural shifts in markets, modifying supply network to newer strategies, products and technologies. Alignment was conceptualized as the creation of incentives to achieve better performance throughout supply chain. Simchi-Levi (2010) also presented the concept of flexibility as the major supply chain strategy in modern companies.

In this sense, flexibility in SCM must be one of the guidelines when defining a supply chain strategy, and consequently its governance. A supply chain strategy based on flexibility will incorporate in its operation the changes in demand patterns, the climate influences and its impacts in the infrastructure, the fluctuations of inventories, and the natural inefficiencies of the process. Flexible SCM strategies must be tailored for each company, and sometimes, for each single product or product line within the same company, referring also to the abovementioned alignment. The main output of SCM flexible strategies must be the elimination of disruptions throughout the supply chain. As a consequence, all efforts developed by the different companies within the same supply chain must follow the same direction, based on a

so-called governance model. Such governance model defines the strategic policies and guidelines from the focal (major) company perspective, and these guidelines and policies should be followed by all the companies within the supply chain.

OPERATION

Supply chain operation has been widely investigated by researchers and practitioners. Such developments were mainly related to inventory management, demand forecasting and routing optimization. Nevertheless, some managerial aspects were not investigated in depth such as management frameworks and the influence of lean concepts in SCM.

Management frameworks

Supply chain operations reference (SCOR) model was presented by Stewart (1997) as the first cross-industry framework for integrated supply chain management. Such study discussed SCM as a set of processes, namely plan, source, make and deliver. After that, other approaches were developed based on SCM as a process. Zhou *et al.* (2011) discussed the relevance of integration and the applicability of the SCOR model. Also, this study developed the first empirical effort in validating the SCOR model by using data from 125 North America manufacturing companies.

Whitten *et al.* (2012) performed an investigation with 132 SCM professionals in order to clarify which dimensions within triple-A supply chains must be defined and developed. This study recalled to the abovementioned publication of Lee (2004) which was discussed under the section of strategy and governance in this paper. At this section of the paper are presented the operational implications of agility, flexibility and alignment from the framework proposed by Lee (2004). Firstly, agility was adopted by successful companies through synchronizing flow of real-time information throughout the many tiers of supply chain, developing long-term relationships with suppliers, designing production process to facilitate postponement, building inventory buffers of inexpensive key components, developing a dependable logistics system and drawing up contingency plans and developing crisis management teams. Likewise, Whitten *et al.* (2012) stated that agility incorporates the ability of supply chain partners to work together in responding to changes in customer demand. Secondly, flexibility (adaptability) was fostered by companies over monitoring economies to identify new supply bases and markets, using intermediaries to develop fresh suppliers and logistics infrastructure, evaluating the needs of the immediate and the ultimate customers, creating flexible products design and determining where products stands in terms of technology and product life cycles. Such initiatives must be operationalized in SCM procedures. Thirdly, alignment was nurtured by companies by exchanging information with suppliers and customers, laying out roles and responsibilities for suppliers and customers, and sharing risks, costs, and gains of improvement (Whitten *et al.*, 2012).

Lean concepts and SCM

Hines *et al.* (2004) discussed the contemporary aspects of the lean thinking by differentiating lean thinking from lean production. First, the study associated lean thinking to the understanding of value. Second, the study related lean production to the elimination of waste. Pires and Neto (2008) investigated supply chain

configuration in automotive industry. Such study confirmed that supply chain design is a determinant element for industry and its suppliers. Also, the study highlighted the importance of the industrial condominiums[3] in order to reduce waste in SCM. A study promoted by Souza & Pires (2010) brought a solid contribution to SCM theory based on lean philosophy. The study discussed the impact of the Theory of Constraints (TOC) in dealing with the traditional trade-offs between logistics costs and stock-out levels.

Certainly lean concepts can influence SCM positively, based on two reasons. First, lean philosophy is directed to waste elimination in production. Considering supply chain as a system, the same principle is suitable in order to improve such system. Nevertheless, the complexity and the multi-organization characteristic of this system must be considered. Second, lean management promotes integration and multi-tasking within the processes. Such initiatives are also appropriate for SCM given that a variety of companies with different maturity levels are spread within the same supply chain. Thus, knowledge transfer through integration it is vital in order to achieve zero defect or reduced inventory levels, two main aspirations of lean thinking. In practical terms, effective supply chain management will only be achieved based on lean philosophy.

IMPROVEMENT

There is a lack of academic discussion in terms of improvement of supply chain as a process. In fact, many publications were developed in order to propose metrics and frameworks to evaluate and measure supply chain, but they failed to study the integrated performance of the many tiers that comprise a supply chain. Nevertheless, some publications provided basis for future developments.

Beamon (1999) presented one of the first studies related to SCM metrics. Such study brings a large contribution for the academia by reviewing the early literature about the topic and depicting research directions for further studies. Gunasekaran *et al.* (2004) presented a framework that links supply chain processes and its levels. The paper brought a contribution to knowledge by relating the formal processes of supply chain, namely plan, source, make/assemble, and deliver. Such processes are then evaluated under different time perspectives, from the operational, tactical and strategic level. Vachon *et al.* (2009) developed a study by revisiting the topic of competitive priorities and the deployment of metrics from them. The study proved to be robust based on the positive response from its application in industry. Garcia *et al.* (2012) delivered a framework for measuring logistics performance in the wine industry by applying a multi-criteria method based on competitive priorities.

The application of performance measures in supply chain has demonstrated to be an emerging topic. Such matter requires the development of frameworks that provide efficient and accurate measures. In terms of implications, these frameworks should be developed under an easy-to-implement perspective. In this sense not only academics but also practitioners will be capable of implement them within the industry environment. Performance measurement is the key issue of decision making,

[3] A set of small industrial plants located within the same ground. Such small factories supply a major plant, which is physically located also in the same site. The condominium approach, also known as a special case of supplier parks, is highly used by the automaker industry.

especially in a dynamic atmosphere involving different suppliers, numerous customers and many conflicting requirements. Also, performance measurement is a means to establish a continuous improvement strategy.

A DISCUSSION OF IMPROVEMENT IN CONSTRUCTION SUPPLY CHAIN MANAGEMENT

Design and operations have been widely discussed in the literature of supply chain management, especially in industrial engineering. Nevertheless, the view of supply chain as a management process requires further investigation regarding improvement. In addition, the development of a set of propositions for improving construction supply chain management would be helpful to develop structured approaches between the construction companies and their contractors, resulting in better results for the entire supply chain.

The definition of the following five managerial practices for improving construction supply chain management is related to older and newer topics in construction and industrial engineering, respectively. First, a discussion concerning suppliers' development and benchmarking is presented. Second, a debate regarding performance measurement, knowledge management, and waste identification and elimination is pointed. The managerial practices are listed in the following topics.

The proposition of these managerial practices also promotes a different discussion in terms of supply chain improvement in construction. First, these practices are focused on the strategic level, in which there is a lack of research. Second, the shift from an operational to a strategic view places supply chain improvement as a corporate matter that should be taken in consideration for strategic planning purposes.

SUPPLIERS' DEVELOPMENT

The interaction between construction companies and their contractors is continuous over time during a project. In this sense, the performance delivered by the contractors influences the overall performance of the project. Major companies related to manufacturing have developed initiatives concerned about suppliers' development. Such initiatives comprise structured programs based on classes, consulting, and feedback provided to the suppliers. In general, these programs are led by the focal (major) company within the supply chain, which invest capital to support these programs in order to obtain better results in terms of cost, quality, dependability, among others, from its suppliers. Usually, such initiatives are cyclical, taking 18 to 24 months to develop each cycle. After this period, the suppliers are ranked and some of them are conducted to a higher level of development in a new cycle.

PERFORMANCE MEASUREMENT

Measure the performance of the processes is an ongoing challenge for companies from all sectors. Research regarding performance measurement is recent and provided frameworks that provide guidelines for managers in implementing performance measurement. Usually, the difficulties are first concentrated in defining the metrics and second in using the information provided by them for improvement. Nevertheless, the use of performance measurement systems proves to be crucial in order to face the current market competition. The use of standardized metrics to

assess the performance of suppliers and provide feedback for them is a powerful approach for supply chain management improvement. Such approach refers to the traditional view of PDCA cycle (Plan, Do, Check, Action), in which "Check" is totally related to performance measurement and give directions to correct the course of action.

BENCHMARKING

The development of benchmarking is still incipient in supply chain management. Benchmarking is based on best-practices exchange between companies in order to obtain improvement in their processes. Also, benchmarking can also be directed to compare the performance of metrics in order to establish goals to be reached in a determined period of time. In this sense, it would very helpful for the construction companies to promote benchmarking in their sector, considering the best practices for management and identifying the gap between their internal practices and the benchmarks. Nevertheless, the implementation of a benchmarking program is a complex initiative, requiring efforts to align expectations and develop trust within the entire supply chain.

KNOWLEDGE MANAGEMENT

In a typical supply chain, the suppliers develop knowledge not only about their products and services but also about supply chain management. Even though there are many suppliers in a single supply chain, it is rare to observe a focal (major) company that gather knowledge from its suppliers. In this sense, clearly is established an opportunity for implementing knowledge management in supply chain. The establishment of an integrated platform for knowledge sharing can deliver substantial results for supply chain improvement, especially in construction companies that are used to have internal knowledge management practices.

WASTE IDENTIFICATION AND ELIMINATION

Research about waste identification and elimination is still incipient. However, the adoption of practices aiming at identifying non value added activities or processes and eliminate them can improve supply chain management. An investigation of the processes in a detailed way can produce a total redesign of their flows and lead to optimized processes. Also, at the operations level (purchasing, stocking, handling, etc.) some efforts could be done in order to identify redundant activities and eliminate them. The application of this philosophy throughout the many tiers of supply chain can deliver great results from a systemic point of view, given that the interaction between the companies is constant and their individual results influence the overall performance of supply chain.

CONCLUSIONS

The discussion of improvement in construction supply chain management proves to be necessary in order to orient research developments in this topic. This study was motivated by providing new directions for upcoming studies that were not explored by academics or practitioners. The need for CSCM studies was also driven by recent

market competitiveness, which is demanding better results from construction companies.

The paper concludes that there is a lack of discussion in terms of improvement in construction supply chain management. Previous developments were focused on the design and operation of the supply chain management process, but they have not investigated in depth improvement in such environment. In this sense, the paper provides a discussion of improvement in CSCM based on set of managerial practices. Such practices are well developed in industrial engineering and they are recommended to be implemented in construction management. Even though a differentiation must be placed for SCM in construction, the recommended practices are generalist and they can be further investigated in CSCM. The paper also argues that qualitative research regarding managerial issues of SCM should be deeply developed in the construction industry in terms of soft social and conceptual research. Thus, this paper brings contributions for academics and practitioners, respectively. First, the paper proposes a set of managerial practices of improvement in CSCM. Second, the paper promotes a better understanding of practical directions to improve supply chain within the construction environment.

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