INTERFACES, FLOWS, AND PROBLEMS OF CONSTRUCTION SUPPLY CHAINS – A CASE STUDY IN BRAZIL

Diego Vinicius Souza de Souza[1] and Lauri Koskela[2]

ABSTRACT

This research investigates the interfaces, flows, and problems of construction supply chains in the infrastructure sector. The discussion focuses on how construction companies should manage different interfaces between suppliers and project sites, not only from a temporary project perspective but also from a long-term enterprise viewpoint. Such interfaces are studied according to the flows of information, capital, and materials connecting the different parties in supply chains. In this context, a framework comprising interfaces and flows is developed. Based on such framework, problems of construction supply chains are identified and positioned accordingly. Therefore, the main purpose of this paper is to develop and implement a framework for addressing interfaces, flows, and problems of construction supply chains.

This underlying research was developed in a Brazilian contractor, responsible for infrastructure projects such as tunnelling, earthworks, and highways construction. In addition, eleven of its suppliers were included in the empirical investigation. Data has been collected in semi-structured interviews, meetings, collection and analysis of documents, observation of meetings, workshops, site visits, and from the company's ERP database. It was found a lack of awareness regarding the existence of the abovementioned supply chains' interfaces and flows, the root causes of supply chain problems, and the implications of supply chain issues in project delivery. This research has two limitations: was developed in the context of infrastructure projects and investigates a single case-study. Implications from this paper are directed to the research field of frameworks for managing construction supply chains.

KEYWORDS

Construction, Supply chain management, Interfaces, Flows, Problems

INTRODUCTION

Construction supply chains tend to be fragmented due to the large number of different projects, suppliers, and other direct (i.e. work force) and indirect (i.e. rental equipment) required resources. In addition, construction companies, also named in this paper as contractors or enterprises, tend to be managed based on traditional project management methods. As the common understanding of project management

[1] PhD Student, College of Science & Technology, School of the Built Environment, The Crescent – Maxwell Building, 7th floor – Room 716, M5 4WT, Salford, UK, Phone +44 (0) 161 295 4748, d.v.souzadesouza@edu.salford.ac.uk

[2] Professor, College of Science & Technology, School of the Built Environment, The Crescent – Maxwell Building, 5th floor – Room 507, M5 4WT, Salford, UK, Phone +44 (0) 161 295 6378, l.j.koskela@salford.ac.uk

relies on its temporary nature, typical strategies, policies, and guidelines for managing construction supply chains have also been based on temporary approaches. In this sense, problems found in construction supply chains can be attributed to the joint impact of increased fragmentation and inefficient methods for managing construction.

Make-to-order supply chains typically present a number of problems, such as rushed orders, incomplete order specifications, long order processing times, lack of synchronization in components delivery, variability in delivery times of components and pre-assembled modules, and last-minute changes in schedule and specifications requested by the customer (Luhtala et al. 1994). Nevertheless, the investigation of problems and the proposition of potential solutions for them has been limited in the literature. Previous research developments such as Vrijhoef & Koskela (2000) and O'Brien et al. (2009) have addressed problems of construction supply chains mostly from the perspective of the project. However, there is a lack of research encompassing the enterprise perspective of construction supply chains.

This paper aims at proposing a framework comprising the interfaces and flows of construction supply chains both from an enterprise and a projects perspective. Such framework comprises three major interfaces: enterprise-projects, enterprise-suppliers, and projects-suppliers. Such interfaces are connected by three essential flows: information, materials, and capital. Based on such framework, problems of construction supply chains are identified and allocated appropriately to the interfaces and flows. Therefore, a map containing the problems of construction supply chains is outlined. The research method is based on previous findings from literature and on empirical research developed in partnership with a Brazilian contractor, including eleven of its tier-1 suppliers.

The next section of this paper outlines the research method. The subsequent section presents the main findings of this research, followed by a discussion, the concluding remarks, and directions for future research.

RESEARCH METHOD

There are two main stages in the proposed method. Stage 1 includes the development of a framework comprising the key actors of construction supply chains. Such framework represents how the aforementioned actors interact with each other based on different interfaces and flows. The framework's proposition captured previous findings in the literature and data from a case study developed in a Brazilian contractor, referred in this paper as Company A. In Stage 1 is presented the first phase of the case study, which took place between May/2013 and September/2013. Stage 2 comprises the application of the proposed framework in Company A in order to identify, position, and validate the problems of its supply chain. In Stage 2 is presented the second phase of the case study, which was developed in November/2013 and December/2013.

Company A is focused on infrastructure projects such as tunnelling, earthworks, and highways construction. The company is family-owned, operates in all regions of Brazil, and has approximately 70 years of continuous operations. Currently, the company has 2,400 employees, 26 concurrent projects, and expects revenue of £ 200 million for 2013. Presently, 70% of company's revenue is originated by projects from the private sector. All projects are geographically dispersed throughout Brazil, usually in remote locations, and they are managed independently from each other by local

Project Managers. The projects are characterized as one-of-a-kind, given that such projects are totally developed under an engineer-to-order production strategy. Eleven tier-1 suppliers of Company A participated in the empirical stage of this research.

STAGE 1

The approach adopted in Stage 1 is to develop a framework using previous findings from the literature and research outputs from the first phase of the case study in Company A. To build-up the framework, literature regarding construction supply chains was reviewed according to three streams: its unique nature, its multiple interfaces and flows, and its problems. The aforementioned theoretical topics were studied and consolidated into theoretical guidelines to be explored in practice. The first phase of the case study had an exploratory nature, in which the research was focused on obtaining a broader understanding of the characteristics of the supply chain of Company A. Table 1 lists the interviews with Company A personnel and Table 2 summarizes the information about the suppliers approached in this research.

Table 1: List of interviews in Company A (Stage 1)

Interview	Position of the Interviewee	Level
1	Procurement Manager	Enterprise
2	Procurement Associate	Enterprise
3	Senior Quantity Surveyor 1 and Quantity Surveyor 1	Enterprise
4	Procurement Associate	Enterprise
5	Maintenance Associate 1	Enterprise
6	Maintenance Associate 2	Enterprise
7	Procurement Manager and Procurement Associate	Enterprise
8	Inventory and Warehouse Manager	Enterprise
9	Administrative Manager	Enterprise
10	Quantity Surveyor 2	Enterprise
11	Quantity Surveyor 3	Enterprise
12	Senior Quantity Surveyor 2	Enterprise
13	Quantity Surveyor 4	Enterprise
14	Senior Quantity Surveyor 3	Enterprise
15	Material Management Associate	Enterprise
16	Material Management Associate	Enterprise
17	Senior Quantity Surveyor 1	Enterprise
18	Quantity Surveyor 1	Enterprise
19	Storeman	Project
20	Senior Quality Associate	Enterprise
21	Information Technology Associate	Enterprise
22	Operations Director	Enterprise
23	Administrative Director	Enterprise
24	Finance Director	Enterprise
25	Quantity Surveyor 5 and Storeman	Project
26	Regional Project Manager	Project
27	Project Manager	Project
28	Maintenance Manager	Enterprise
29	Regional Project Manager	Project
30	HR Manager	Enterprise
31	Information Technology Manager	Enterprise
32	Commercial Manager	Enterprise
33	Site Manager	Project

Table 2: List of interviews with suppliers

Supplier	Market Sector	Position of the Interviewee	Site Visit
1	Trucks	Commercial Manager (Parts), Commercial Manager (Specialty Maintenance)	Yes
2	Precast concrete tubes	General Manager	Yes
3	Precast concrete box culverts	General Manager	Yes
4	Diesel fuel	Commercial Associate	Yes
5	Excavators	Commercial Manager	Yes
6	Excavators	Commercial Manager	Yes
7	Pavement	Commercial Director	Yes
8	Specialty parts for equipment	Commercial Director	Yes
9	Asphalt	Commercial Manager, Services Manager	Yes
10	Drilling and blasting materials	Commercial Manager	No
11	Personal protective equipment	Commercial Director	No

The first phase comprised semi-structured interviews, collection and analysis of documents, observation of meetings, three workshops, and site visits. In addition, the relevant database of Company A ERP was compiled and scrutinized. The suppliers were appointed by the procurement manager of Company A based on three criteria: long-term relationship, financial relevance, and the operational impact of their products and services in projects. The documents collected were primarily related to the procurement process such as purchase orders, request for proposals, internal procedures, and approval forms, among others. In addition, two meetings in the procurement department and one in the maintenance department were observed. Three workshops were developed aiming at: (i) providing an overview of the research aims to the procurement department, (ii) discussing and investigating problems with suppliers, and (iii) presenting and validating findings with the board of directors of Company A. The main output of Stage 1 is the framework representing interfaces and flows of construction supply chains.

STAGE 2

The approach adopted in Stage 2 is to implement the framework developed in Stage 1 in order to attend the following objectives: identify, position, and validate supply chain problems of Company A. In order to address such objectives, the second phase of the case study was then established after a period of data analysis in October/2013.

The second phase of the case study comprised two workshops, meetings, and the compilation and analysis of relevant database of Company A ERP. Meetings with the company's procurement, costs, and quality representatives were conducted in order to brainstorm problems, categorize them, and allocate them to the respective interfaces and flows proposed in the framework. Two workshops were then carried out aiming at: (i) presenting the framework to the procurement department and (ii) discussing and validating findings with the board of directors of Company A. Table 3 lists the meetings with Company A personnel. Finally, a matrix positioning the supply chain problems found in Company A is presented.

Table 3: List of meetings in Company A (Stage 2)

Meetings	Position of the Interviewee	Level
1	Procurement Manager and Procurement Associate	Enterprise
2	Procurement Associate	Enterprise
3	Procurement Associate and Senior Costs Associate	Enterprise
4	Procurement Associate and Senior Quality Associate	Enterprise
5	Procurement Associate	Enterprise
6	Procurement Associate	Enterprise
7	Procurement Manager and Procurement Associate	Enterprise
8	Procurement Associate	Enterprise
9	Procurement Associate	Enterprise
10	Procurement Manager and Procurement Associate	Enterprise
11	Procurement Associate and Senior Quality Associate	Enterprise
12	Procurement Manager and Procurement Associate	Enterprise

STAGE 1 – DEVELOPMENT OF THE FRAMEWORK

LITERATURE REVIEW

Construction supply chains tend to be fragmented environments (Gosling & Naim 2009; Dainty et al. 2001) in which the management focus has been mainly placed on the project (Bankvall et al. 2010). The aforementioned focus extended the temporary nature of projects towards supply chain: construction supply chains have also been managed on a temporary basis. In addition, construction supply chains present themselves not only as temporary and fragmented entities but also as convergent in terms of material flow (Luhtala et al. 1994) and unique in terms of their characteristics (Vrijhoef & Koskela 2000).

Vrijhoef & Koskela (2000) stated that managing supply chain interfaces produces significant improvement in project delivery due to enhanced information, materials, and capital flows. Problems located at interfaces interfere in the continuous flow, and consequently they generate waste. Managing interfaces produces increased performance for delivering projects at the construction site, as stated by (Vrijhoef & Koskela 2000), due to improved flows. Continuous flow constitutes an important feature to reduce inventory of finished goods or work-in-process.

Construction supply chains must be observed from two perspectives: enterprise and project. Project supply chains are temporary and are related to a particular project. However, a construction company has a number of concurrent projects, and its supply chain comprises all of its project supply chains. In this sense, the second perspective is then introduced: an enterprise supply chain. Thus, two management levels (enterprise and project) require an specific and contextualized approach for supply chain management (Ayers 2004). In this sense, integration efforts should be prioritized in order to improve project delivery and enterprise's performance (Souza & Koskela 2013).

Construction supply chains comprising multiple organizations and embracing a massive set of activities have an increased level of complexity. Such activities occur basically in three streams, namely information flow, materials flow, and capital flow (Luhtala et al. 1994). For connecting such flows, there are different interfaces, which are the links between contractors, suppliers, and concurrent projects. O'Brien et al. (2009) characterized construction supply chains' flows as poorly integrated, created

and recreated several times during the project in an unsorted way, and lacking of Information Technology (IT) tools for their support. Equally important, previous research has found the problems of construction supply chains mostly located at the interfaces between different parties of the supply chain (Luhtala et al. 1994; Vrijhoef & Koskela 2000).

O'Brien et al. (2009) stated that project supply chains are unstable due to the lack of reliability of site production systems. In addition, information flow is limited and therefore material orders, construction schedules, among others, are not regularly available for supply chain parties (Naim & Barlow 2003; O'Brien et al. 2009). Again, such lack of stability spreads throughout the concurrent projects of a construction company.

Childerhouse et al. (2003) studied the causal chain of problems in a construction supply chain. Causal elements were separated in three parts: suppliers, the company itself, and customer. The chain of events derives from and converges to a so-called unsatisfied customer. Interestingly, the chain of events comprises many poorly developed activities, ultimately affecting project delivery. As proposed by Childerhouse et al. (2003), rethinking or improving supply chain management at the level of the enterprise produces significant organizational achievements. Propositions in the fields of business process reengineering and supply chain governance might lead to improvements at the enterprise level and ultimately at the project level (Childerhouse et al. 2003; Ayers 2004).

INTERFACES OF CONSTRUCTION SUPPLY CHAINS

Company A has more than 4,000 active suppliers in its supplier base and 26 concurrent projects dispersed across Brazil. Although project sites are related with Company A, they are seen as independent parties as a typical premise of traditional construction management. In such a complex environment, the number of interfaces for each project could be massive, considering that projects have 500 different suppliers on average. From the perspective of the project, much of the suppliers are temporary, given that they are small and medium local companies which attribution is to supply materials and services while the project is in course.

The two management levels, enterprise and project, were found in Company A. In this sense, it was also discovered that they increase the number of supply chain links: there are permanent and temporary links in both levels. In this sense, the traditional approach for mapping supply chain links in a construction supply chain proved inefficient, once there are too many links, and a significant part of them are temporary. In addition, many of these links are relevant only for the enterprise or for the project. Thus, a more simplistic and strategic viewpoint becomes necessary for approaching construction supply chain management.

As stated before, literature has primarily investigated construction supply chains from the project's perspective. Those investigations have focused on operational aspects such as the synchronization of activities with suppliers, materials handling at the construction site, among others. Much of the enterprise aspects of construction supply chains have been neglected, which affect supply chain strategies in the long run. In addition, managing construction supply chains based solely in the project's perspective does not provide basis for simplification. In addition, the project's perspective also can be perceived as biased, given the autonomy of the project sites as

units of production. It was found that Project Managers have different interpretations regarding the impacts of their supply chain decisions in performance of Company A.

One example is related to the fleet of heavy equipment owned by Company A. Such fleet is maintained by a private maintenance department, which adds-up to a cost of £25 million per year. Although the maintenance of such equipment is centralized, there are some spare-parts that should be stored on site. It was found that Project Managers have different inventory policies for storing spare-parts on site. Some Project Managers prefer reduced inventories, so that they order parts from the suppliers when necessary. These Project Managers rely on demand patterns for spare parts, which are provided by the maintenance department. Other Project Managers prefer increased inventory levels, so that they do not have to wait for the delivery of spare-parts. The first group of Project Managers contributes for reducing inventory levels in Company A. However, they have an increased risk of disruptions in their operations, especially those located far away from the suppliers. The second group of Project Managers do not contribute for reducing inventory levels, but they are not likely to have disruptions in their construction sites due to stock-out of spare-parts. Certainly, both strategies produce significant implications in the supply chain of Company A.

As part of the decision making is concentrated at the enterprise level and the other part at the project level, the definition of specific interfaces connecting such levels with the suppliers proved to be necessary. In this sense, three interfaces are proposed for conceptualizing construction supply chains, namely (i) enterprise-project interface, (ii) enterprise-supplier interface, and (iii) project supplier interface.

- **Interface A - Enterprise-projects:** is the boundary at which the contractor manages multiple and concurrent projects, usually geographically dispersed. In addition, such projects are typically one of-a-kind and they demand a wide range of materials, high-skilled workers, and diverse resources to be allocated at the project site. In addition, projects have a temporary nature and contractors tend to have a pipeline of upcoming projects, which requires the continuous conception of new supply chains.
- **Interface B - Enterprise-suppliers:** is the interface at which the contractor manages multiple suppliers from the enterprise perspective. Construction companies have permanent and temporary suppliers, which should be managed in different ways. From this viewpoint, contractors need to establish a long-term system for managing suppliers in the long run, aiming at strategic objectives for improving the supply chain. **Error! Reference source not found.**
- **Interface C - Projects-suppliers:** is the boundary at which the contractor manages suppliers from the project perspective. At this level, construction companies have to cascade enterprise policies, procedures and guidelines for the project level, manage permanent suppliers and coordinate temporary suppliers. Such coordination must occur at the project level, once temporary suppliers will be used only in particular projects due to location close to the project site or due to their technicalities.

FLOWS OF CONSTRUCTION SUPPLY CHAINS

Based on the literature, three flows found in supply chains were investigated: information, material, and capital. However, such flows were studied in accordance with the interfaces proposed in the previous sub-section.

It was found that Interface A is mainly concerned about the information flow, which is critical for the entire supply chain, given that information from projects is the main input for planning subsequent processes and activities (i.e. purchasing, producing, and delivering). The major challenge in managing Interface A is to aggregate information from projects, once construction companies tend to give managerial autonomy for the projects. Managerial autonomy at project level has one major drawback: fragmented information. Such drawback leads to poor synergy and decreased aggregation between projects. Once information flow at Interface A is improved, the level of uncertainty is decreased from projects to enterprise to suppliers. Decreased uncertainty contributes for reducing inventories, rushed orders, and ultimately costs.

It was explored that Interface B is mostly focused on information and capital flow, based on inputs from the projects. Purchasing orders, shipping instructions, and payment reports flow via Interface B in a two-way relationship between the enterprise and suppliers. The major challenge in managing Interface B is to provide qualified and on-time information for suppliers, once construction companies tend to place an increased amount of rushed and imprecise orders to their suppliers.

It was discussed that Interface C is mainly concerned with the material flow, although the information flow is also relevant for coordination purposes. Materials are delivered at project sites according to orders' requirements, and they should comply with technical specifications, delivery and quality performance, and packaging requirements. The information flow at Interface C should be managed as a communication channel for coordinating activities at the project site, once unexpected conditions may require changes (i.e. anticipation of deliveries, different packaging, product returns).

The proposed framework, comprising the interfaces and flows of construction supply chains is presented in Figure 1.

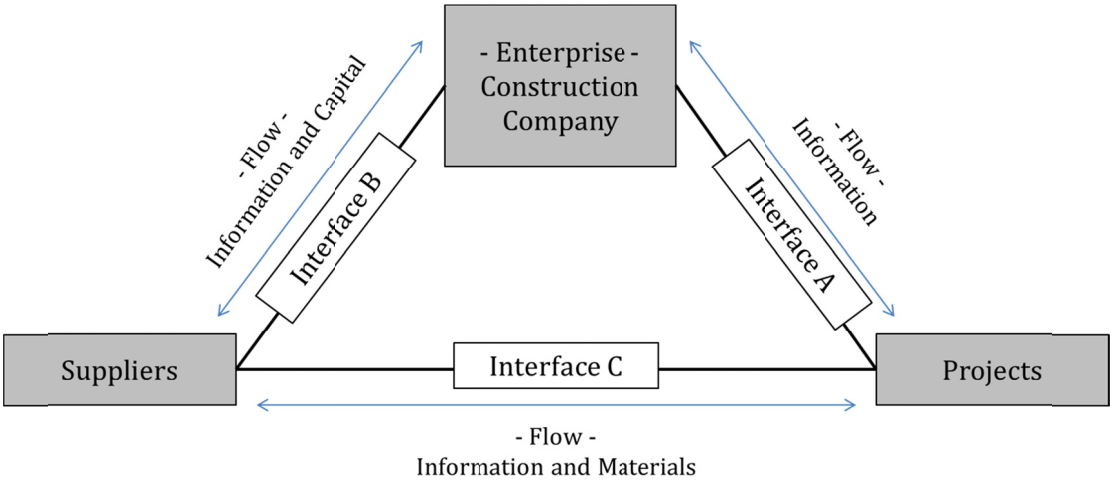

Figure 1: Interfaces and flows of construction supply chains

STAGE 2 – IMPLEMENTATION OF THE FRAMEWORK

This stage was focused on identifying supply chain problems in Company A, and positioning them according to the different interfaces and flows shown in Figure 1. However, Company A presented an increased lack of awareness regarding its supply chain problems, and therefore an additional number of interviews and data analysis was necessary in order to gather a significant body of information.

Prior to the implementation of the framework, Company A believed its overall performance was not affected by its supply chain. According to the opinion of different representatives, all problems and wastes generated by suppliers were quickly resolved by the procurement department without producing indirect effects. The first part of the sentence proved to be correct, once the procurement department demonstrated significant ability to solve problems quickly. On the other hand, the indirect supply chain's implications in Company A showed themselves as critical.

PROBLEMS OF CONSTRUCTION SUPPLY CHAINS

First, the flow of information at Interface A was examined. A large number of Requests for Proposals (RFP) from the project sites were observed in Company A. Such number (4,000 RFPs of materials per month on average) was perceived as too high because it approximately corresponds to the same amount of Purchases Orders (PO) of materials. This certainly indicates a problem, because it shows that RFPs are not planned appropriately: it was found that many POs for the same items were placed to suppliers without aggregating internal demand. In addition, RFPs classified as rushed reached 33% on average. Company A does not measure RFPs rework, but it was found a large number of RFPs that are "typically fixed or adjusted" in order to comply with internal procedures. Finally, the project sites provide a poor or non-existing evaluation of suppliers to Company A.

Second, the flow of information at Interface B was investigated. It was found that there is too much waste at this interface due to waiting for a delayed reply of RFPs. In addition, also there is increased rework in RFPs caused by poor specifications. Again, Company A does not measure rework or time wasted in waiting for delayed reply of RFPs. Due to the reasons previously discussed, an increased number of POs of materials was found (4,000 POs per month on average), and 33% of them were classified as rushed on average. Rework of POs is perceived by Company A "as common", and they do not have measures for it. In one workshop conducted with the procurement team, it was estimated that 50% of the POs require rework. A sensitive Information Technology (IT) problem was found: poor reliability in transmitting POs to suppliers. In this sense, quantity surveyors and buyers of Company A have to double check by phone whether or not the suppliers have received their POs, producing an enormous amount of monthly hours of rework. Limited tracking of POs and provision of feedback to suppliers was also found. It was also found that suppliers are poorly selected, and there is no structured method for qualifying future suppliers according to a pre-defined set of specifications. Finally, it was found in Company A an extensive supplier base comprising more than 4,000 active suppliers. Company A has no awareness about the potential impacts of large supplier bases, namely increased indirect costs, and decreased strategic alignment, among others.

Third, the flow of capital at Interface B was explored. Although the flow of capital has indirect impacts on supply chain, many problems were found in this flow.

First, many orders were delayed because of waiting in the approval process. Company A defined a specific financial range that requires orders above the range to be approved by managers and directors depending on their total amount. Although this practice is quite standard in the market, if the approval process does not occur as expected severe delays are realized. In addition, another problem was found due to delayed approval processes: in many cases, orders are released to supplier's prior internal approval in order to "expedite" the process. Many suppliers reported how inappropriate such practice is for their business, given that it increases uncertainty in supply chains. Rework, poor IT reliability for transmitting invoices, delayed payment of suppliers was also found in the flow of capital. Time consuming and stressful negotiations were also pointed out by Company A as a "typical" problem. Finally, reduced economies of scale were observed in the company.

Fourth, the flow of information at Interface C was studied. Company A keeps limited information about the performance of suppliers. In general, such limitation was attributed to the "informality" and "speed" in which inventory and warehouse staff tends to solve problems. Poor synchronization between suppliers and project site scheduling was observed. Finally, the flow of materials at Interface C was analysed. Overall, this interface presented significant problems in the service level: transportation damages, poor delivery and quality performance. Nevertheless, the major highlight was the lack of awareness about problems at this interface. Limited performance measures were found.

The supply chain problems found in Company A are presented in Table 4.

Table 4: Supply chain problems found in Company A

Interface	Information	Capital	Materials
A	- Increased RFPs - Rushed RFPs - Rework in RFPs - Poor evaluation of suppliers	N/A	N/A
B	- Delayed reply of RFPs - Rework in RFPs - Increased POs - Rushed POs - Rework in POs - Poor IT reliability in transmitting POs - Poor selection of suppliers - Expansive supplier base - Limited tracking of POs - Limited feedback to suppliers	- Delayed approval process of POs - POs released to suppliers prior to internal approval - Rework in invoices - Stressful negotiations - Reduced economies of scale - Poor IT reliability in transmitting invoices - Delayed payment of suppliers	N/A
C	- Limited information about suppliers' performance - Limited synchronization with site scheduling	N/A	- Increased transportation damages - Poor delivery performance - Poor quality performance

DISCUSSION AND CONCLUSION

This research has reinforced what has been often stated in prior studies: there are many problems in construction supply chains. Such problems derive from the increased complexity of such supply chains: the presence of multiple actors (equipment and resources, suppliers, crews), the geographical dispersion of the project sites, and the different types of flow. However, previous research has not indicated how to manage the actors, understand their interrelations, approach the different supply chain flows, and address the demands of multiple and concurrent projects.

It was found that representatives of Company A have a lack of awareness about its supply chain problems. For example, the company has a price-driven procurement strategy, in which lower prices are prioritized in the decision making process. Such strategy has contributed to increase significantly the supplier base of Company A over the years, which produced high indirect costs for managing procurement. A second example: increased inventory levels were found in many materials stored by Company A. Such inventory levels were adopted over the last years and produce increased working capital costs. However, Company A failed to relate them with poor delivery performance of the suppliers. Given that suppliers do not deliver on time, project sites increased their inventory levels in order to maintain operations.

A framework for simplifying the management function of construction supply chains has become necessary. The framework proposed in this research addressed the gap in the literature: construction supply chains must encompass both the enterprise and the project perspective. The strategic perspective prioritizes a long-term view of the supply chain, given that there are upcoming projects in a typical contractor's pipeline. Three interfaces are proposed: enterprise-projects, enterprise-suppliers, and projects-suppliers. To each of these interfaces the traditional supply chain flows were added where relevant according to what was found in Company A. The composition of interfaces and flows has provided the underpinnings of the framework proposed in this research.

Interface A has its focus in the information flow. Poor communication between projects sites and the enterprise was found. In addition, increased problems in RFP specifications produce significant rework throughout supply chains. Interface B has its focus on the information and capital flows. Many problems were found, including rushed POs, rework in POs, expansive supplier base, and stressful negotiations with suppliers. Typically, suppliers are selected based on their price and tend to be highly specialized, which contributes to increasing the supplier base. Interface C has its main focus in the information and materials flows. Significant problems regarding service level (delivery and quality performance) and limited synchronization with site scheduling were found at this interface.

The development and application of the proposed framework was concentrated in a particular context: the infrastructure sector. Such sector has intrinsic characteristics such as the low level of repeatability and increased customization of the projects, which are typically co-designed along with clients. In addition, this research was limited to one in depth case study: therefore the findings are contextualized according to the characteristics found in Company A.

Future developments should comprise an in-depth evaluation of the root causes of the problems of construction supply chains. Such root causes should be mapped in

order to assess not only their relation with the problems but also their implications in construction supply chains. In addition, future research should incorporate a cross-case analysis in order to validate and provide basis for generalising the interfaces, flows, and problems of construction supply chains.

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