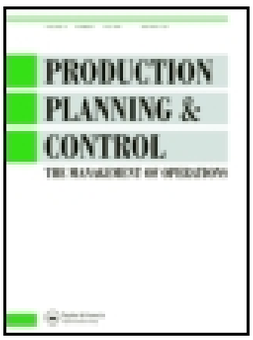

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The role of supplier information availability for construction supply chain performance

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ABSTRACT

The lack of coordination of the *construction supply chain* (CSC) creates a chain of problems. The purpose of this paper is to contribute to knowledge about coordination within CSCs and how the lack thereof can impact their supply chain performance. Coordination encompasses several different mechanisms, whereof focus here has been information sharing with the unit of analysis suppliers' information availability. Four suppliers active within the CSC, delivering to several different projects have been studied. These represent two different delivery patterns, continuous and intermittent deliveries. Based on the analysis of their information availability are two propositions made; (1) due to the loose couplings and the lack of understanding among main contractors of the value of information sharing, suppliers with continuous supply have an information advantage due to their presence on site, (2) suppliers can enhance their information availability, by increasing their service offering to customers.

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Information sharing; supply chain performance; construction industry

Introduction

Construction is an engineer-to-order (ETO) industry (Gosling, Naim, and Towill 2013) in which production is performed on a project-by-project basis in temporary organisations, which creates temporary supply chains (Dubois and Gadde 2000). The construction industry has a strong focus on the project and thereby tight couplings *within* the project organisation (Dubois and Gadde 2000). However, the strong focus on coordination within the project is not transferred to the supply chain, instead here the couplings are loose (Dubois and Gadde 2000). Aloini et al. (2012) reported that one of the most cited problems in construction relates to the absence of coordination with suppliers and subcontractors in the planning process (Al-Hussein et al. 2008; Ballard 2000; Dainty, Millett, and Briscoe 2001), lack of communication among supply chain members (Meng 2012; Dubois and Gadde 2002), and lack of trust (Doloi 2009). The lack of coordination of the *construction supply chain* (CSC) creates a chain of problems (Thunberg and Fredriksson 2018), resulting in poor delivery performance, in which Thunberg and Persson (2014) have highlighted that not even 40% of deliveries are flawless.

In response, CSCs clearly need improved coordination, not least because actors in them rely on the performance of the other actors (Kaipia 2009). According to Malone and Crowston (1994), *supply chain coordination* refers to the act of managing dependencies between actors and is to be seen as part of *supply chain management* (SCM). Furthermore, Tserng, Yin, and Li (2006) concluded, the coordination of CSCs often seems absent from studies on construction industry as well. It thus seems necessary to expand research on explicit, inter-firm CSC coordination (London and Kenley 2001; Dubois, Hulthén, and Sundquist 2019), and the purpose of this paper is to contribute to knowledge about coordination within CSCs and how the lack thereof can impact their supply chain performance. Coordination encompasses several different mechanisms (Martinez and Jarillo 1989) and among these, this study focus on information sharing (Tuomikangas and Kaipia 2014) with the intention to share knowledge (Carlile 2004) that results in a desired action. Therefore, the unit of analysis is the suppliers' information availability.

Theory development is a process and theorising is a mean by which theory is produced by considering input from established fields as well as new societal and industrial challenges (Halldórsson, Hsuan, and Kotzab 2015). The impact of information sharing on supply chain performance is not a novel subject within SCM research. However, SCM is an applied field that is constantly challenged by theoretical developments in related disciplines and emerging societal challenges (Halldórsson, Hsuan, and Kotzab 2015). These developments mean that the explanatory power for the academic and the problem-solving capacity of the practitioner is constantly challenged (Halldórsson, Hsuan, and Kotzab 2015). In this research, we see that societal challenges, such as an unproductive construction industry trigger new application

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of SCM and logistics concepts, as well as requirements on the development of SCM and logistics theories.

During the 1990s and early 2000s, the construction industry's lack of productivity due to shortcomings in logistics management was highlighted (Egan 1998; Josephson and Saukkoriipi 2007; Nicolini, Holti, and Smalley 2001). This led to the emergence of research and development efforts in construction logistics and SCM (Strategic Forum 2002; Vrijhoef and Koskela 2000). One of the most referred publications is Vrijhoef and Koskela (2000) presenting four roles of SCM and logistics in construction, which Ekeskär and Rudberg (2016) have further developed with a fifth role. These five roles are:

1. focus on clarifying the interface between the supply chain and site activities with the goal of reducing the duration and cost of site activities through improved reliability in the delivery of goods and resources,
2. focus on improving the supply chain with the goal of reducing lead times and costs of transportation and inventory,
3. focus on improving logistics at the construction site to streamline materials handling times and decrease costs on site,
4. transfer activities from the site to the supply chain to improve conditions on site or to achieve a wider concurrency between activities with the goal of reducing costs and time, and
5. manage the site and the supply chain as an integrated domain to accomplish integrated supply-chain planning and clear roles and responsibilities among actors (Ekeskär and Rudberg 2016).

However, as can be seen, the focus in this previous research has been on the physical logistics activities and from a main contractor perspective. Furthermore, the uptake of SCM in the construction industry has been low. Lately, a renaissance for construction SCM research has been seen, with a focus on coordination of CSCs, due to challenges faced by the main contractors coordinating a network of multiple supply chains in city development projects (Lundesjö 2015). This has forced major contractors to initiate the use of construction logistics setups in order to coordinate logistics processes to multiple projects (Lundesjö 2015). However, Janné and Fredriksson (2019) and Sundquist, Gadde, and Hulthen (2018) identified that there is a tendency among the main contractors to form these construction logistics setups without considering the needs of the supply chain actors, i.e. missing the loosely coupled actors within the CSC. This is a problem as the main aim of the construction logistics setups is to coordinate the construction project and the CSC (Sundquist, Gadde, and Hulthen 2018).

Thunberg and Fredriksson (2018) found that one of the main issues behind the many problems with coordination in CSC is due to the lack of information sharing from, the main contractor to suppliers, i.e. low information availability among the suppliers. This inability among main contractors to share information with the CSC lead to reduced supply chain performance (Love, Irani, and Edwards 2004). Thus, to develop construction SCM research in such a way that it actually solves the industry problems related to coordination, there is a need to increase understanding of construction suppliers' coordination needs and their present information availability.

Based on the above discussion, two research questions (RQ) were formulated:

> RQ1: How does information availability differ between suppliers with different types of delivery patterns and how does the lack of information availability impact on supply chain performance?
>
> RQ2: How have the suppliers acted to improve their information availability?

The paper is organised as follows. First, the theoretical framework focussing on information sharing and CSCs. Next, the methods are described, followed by the analysis and discussion identifying propositions for further research. In closing, conclusions are presented along with the limitations of the study.

Theoretical framework

The study rested upon three pillars: information sharing, the perspective of the suppliers and supply chain performance. Below we review earlier research within information sharing to identify factors by which information availability can be analysed. Then, we review the present state of coordination and information sharing research within CSCs with the aim to show the complexity and the importance of information sharing between the construction process and the actors in the CSC. Finally, we introduce construction supply chain performance measures.

Information sharing

Mohr and Nevin (1990) have defined four facets of information sharing. First, the *frequency* or *duration* of contact between actors refers to the amount of information sharing. Second, *direction* refers to the vertical and horizontal movement of information, distinguished as either unidirectional (i.e. one-way) or bidirectional. Third, the medium of information sharing, or its *modality*, refers to the method used to transmit information. Face-to-face meetings offer the most information richness, whereas formal, unaddressed documents offer the least, however also in most cases come at a lower cost. At the same time, spoken and rich information faces a higher risk of getting distorted than written information does. Modality can also include the distinction between formal and informal information-sharing channels. Fourth, the *content* of information sharing refers to the message being transmitted, which between customers and suppliers can represent two types of information: orders and forecasts (Forslund and Jonsson 2007; Gustavsson and Jonsson 2008). Building upon what Wikner and Rudberg (2005b) have reported, the order can be understood as the point when the dimensions of What, How much, When and Where are answered, e.g. when the uncertainty is 0%. By contrast, the

forecast is when the uncertainty of the order exceeds 0% but remains less than 100%. Although researchers have presumed that shared information is used (Jonsson and Myrelid 2016), such is not always the case and depends upon the receiver's willingness and ability to do so (Jonsson and Myrelid 2016). That in turn depends on the perceived information quality (Jonsson and Myrelid 2016).

All shared information should be relevant and meaningful (Kaipia and Hartiala 2006) – that is, of high quality and with the potential to improve supply chain performance. After all, too much information causes 'noise' that distorts or hides the intended information (Shannon and Weaver 1949). Gustavsson and Wänström (2009) define *Information quality* (IQ) in terms of 10 dimensions. The dimensions are; *Accessibility* determines to which extent information is easy to access when required, the *appropriateness of the amount* indicates the extent to which no filtration of the information is necessary (e.g. no noise is included), and *completeness*, the extent to which the information is comprehensive for the given task. *Conciseness* refers to the extent to which information can be used directly without needing to be reworked in terms of format, content or structure before use and *credibility* to the extent to which information is accepted or regarded as true, real, and believable. *Relevance* refers to the extent to which information is appropriate for given tasks and applications and *Reliability* to the extent to which information provided is accurate. *Timeliness* refers to the extent to which information is delivered on time and at correct intervals (i.e. not too often or too infrequently for the planning process), whereas *understandability* refers to the extent to which information is easy to use and learn as well as manipulate, aggregate and combine with other information and *validity* defines the extent to which information conveys the intended content of a message and thus implies a common language.

When analysing the IQ dimensions with the facets of information sharing, we identified some overlap, both within and between the frameworks. The facets direction, modality, and content supplement the IQ dimensions, whereas the facet of frequency is already captured by the IQ dimension of timeliness. Furthermore, based on their definitions, relevance can be combined with appropriateness of amount and accessibility to capture how easy the information is to get hold of and use. Validity can be combined with conciseness, completeness, reliability, and credibility to capture how useful the information is. Finally, content and modality are hard to separate as the message and the method to transmit it are intertwined. In summary, 6 factors are derived by which information availability can be captured, see Table 1.

The need of information sharing in construction supply chains

The construction project can be seen as containing two disjointed processes (Friblick 2000; Thunberg 2016); the supply process and the construction process, see Figure 1. The construction process and the supply process follow different logics (cf. Wikner and Rudberg 2005a). As an engineer-to-order (ETO) production, the construction process follows an ETO logic with focus on design of the building and how to execute that design (Hicks, McGovern, and Earl 2000). The construction process involves two primary actors: the developer who initiates construction and the main contractor who organises and executes it. Beyond that, the construction industry also consists of many small firms that act as subcontractors (Dubois and Gadde 2002; Miller, Packham, and Thomas 2002).

The suppliers in the supply process mainly follow either make-to-order (MTO), assemble-to-order (ATO) or make-to-stock (MTS) logic (Hicks, McGovern, and Earl 2000). In a case study, Ying, Tookey, and Seadon (2018) observed that supply chain performance varies between suppliers with different logics. On the one hand, construction planning put more effort into planning MTO and ATO suppliers, who have longer lead-times and the main contractors would like to avoid delays in construction production due to late deliveries. On the other, because the MTS type suppliers have products available in inventory, a construction site's management tends to exert minimal effort in planning MTS deliveries, resulting in less transport efficiency (i.e. many small deliveries). In their literature review, Seppänen and Peltokorpi (2016) identified conflicting goals between actors in CSCs due to their different logics. Whereas contractors may wish for just-in-time supply in small batches, MTS suppliers such as merchants usually want to deliver full trucks and minimise distances, while MTO producers typically want to keep set-up costs down and thus produce materials in large batches.

Earlier research within CSC have concluded that the CSC are often disregarded in construction process (Tserng, Yin, and Li 2006). This lack of focus on the CSC is shown in how construction planning is conducted. In construction planning, a main contractor focuses on the construction production – that is, scheduling on-site production activities to meet the developer's deadlines (Thunberg 2016), by creating a baseline schedule for the construction production (Ko, Azambuja, and Felix Lee 2016). Based on that schedule, the purchasing organisation sets up contracts with suppliers, from which the site management call off the materials in accordance with the progress of production (Ko, Azambuja, and Felix Lee 2016). Typically, the various suppliers and logistics service providers in the CSC thereafter perform their own planning (Azambuja and O'Brien 2009). However, the responsibility of coordinating the different actors within the CSC and the construction site still resides with the main contractor (Azambuja and O'Brien 2009), e.g. deliveries have to be coordinated with site management in order to ensure resources for unloading, etc.

In order to accomplish that coordination, main contractors need to share information about the progress of production in relation to plans and current inventory levels on-site with the actors in the CSC (Fellows 2009). Khan, Flanagan, and Lu (2016) describe how different interdependencies between activities at the construction site and in the CSC affects the performance of both the supply chain and the construction process. Such dependence stems from the suppliers' need to adapt delivery schedules, components and quantities in accordance with the progress of production and changes in

Table 1. Factors affecting information availability.

Factor	Dimension(s)	Definition
Direction	**Direction** (Mohr and Nevin 1990)	The vertical and horizontal movement of information, being either unidirectional or bidirectional
Content and modality	**Content** (Mohr and Nevin 1990) **Modality** (Mohr and Nevin 1990)	Refers to the message being transmitted The method used to transmit the message
Accessible	**Accessibility** (Gustavsson and Wänström 2009) **Appropriateness of the amount** (Gustavsson and Wänström 2009) **Relevance** (Gustavsson and Wänström 2009)	Extent to which information is easy to access when required Extent to which information does not need filtering (e.g. does not include noise) Extent to which information is appropriate for given tasks and applications
Complete, concise, and credible	**Completeness** (Gustavsson and Wänström 2009) **Conciseness** (Gustavsson and Wänström 2009) **Validity** (Gustavsson and Wänström 2009) **Credibility** (Gustavsson and Wänström 2009) **Reliability** (Gustavsson and Wänström 2009)	Extent to which information is comprehensive for given tasks Extent to which information can be used directly without needing to be reworked in terms of format, content, or structure before use Extent to which information conveys the intended content of a message and thus implies a common language Extent to which information is accepted or regarded as true, real, and believable Extent to which information provided is accurate
Timely	**Timeliness** (Gustavsson and Wänström 2009) **Frequency** (Mohr and Nevin 1990)	Extent to which information is delivered on time and at correct intervals (i.e. not too often or too infrequently for the planning process) The amount of information sharing
Understandable	**Understandability** (Gustavsson and Wänström 2009)	Extent to which information is easy to use and learn as well as manipulate, aggregate, and combine with other information

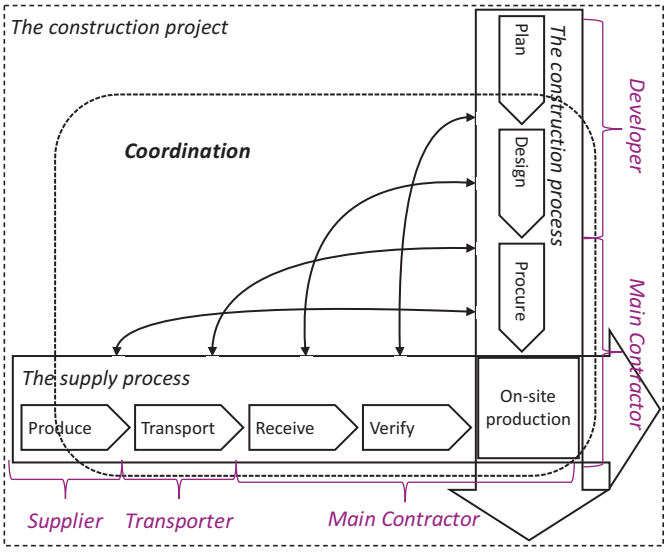

Figure 1. Relationship between a construction project, and its construction process and supply process, adapted from Friblick (2000) and Thunberg (2016).

the process (Shin et al. 2011), as well as what on-site conditions may affect delivery options (Murphy 2013). Doloi (2009) notes that information sharing between the construction process and the actors in the CSC leading to a better chance of the building object being delivered on time and at the right quality to developer. Although information thus plays a profound role in construction environments (Titus and Bröchner 2005), sharing such information is challenging (Titus and Bröchner 2005; Shin et al. 2011) and seldom prioritised by main contractors (Thunberg and Fredriksson 2018).

Modig (2007) and Dainty, Moore, and Murray (2006) argue that the temporary nature of the CSCs poses additional difficulties to information sharing. The temporary nature has made the construction industry favouring adversarial contracts and arm's length relationships (Fernie and Thorpe 2007; Green, Fernie, and Weller 2005; Kristiansen, Emmitt, and Bonke 2005). The reason is that without stable supply chains it is difficult to develop collaboration and trust (Meng 2012). Friblick (2000) points out that the practice of viewing the supply process and construction process as two disjointed processes is in part to blame for this problem. This view causes lack of understanding of the effects of decisions, such as the relationship between design decisions and materials supply (Thunberg and Fredriksson 2018). Due to the lack of information, suppliers often make available what they believe that the main contractor want (Proverbs and Holt 2000). However, such guesswork is possible for MTS components only. Another reason to the problems of information sharing is elaborated by Ellegaard and Koch (2012), who show that low coordination between the purchasers and operative personnel within the main contractor company are common, and can result in inadequate information sharing with suppliers (Aloini et al. 2012). Strategic purchasing, responsible for making contracts with suppliers, are often part of the main contractor's central organisation, while operational purchasing, making call-offs, is part of the on-site project organisation (Thunberg and Fredriksson 2018). According to Thunberg and Fredriksson (2018), this leads to low supply chain performance such as delayed and uncomplete deliveries.

According to Akintoye (1995), some CSC actors make continual deliveries to a construction site during a project mainly for MTS components, whereas others make only a few, intermittent deliveries mainly for MTO or ATO components. Thus, depending on the delivery pattern, suppliers are present on-site at different frequencies and thus have varying capacities to know about a project's progress without active information sharing from the main contractor. Although such information gathering may seem trivial, because the construction industry ranks among the least

digitalised, most information is collected, recorded, and conveyed manually (Ko, Azambuja, and Felix Lee 2016).

Thus, existing research of information sharing between main contractors and CSC show on the importance to accomplish coordination between the construction process and the actors in the CSC and how this can impact supply chain performance. Furthermore, also the hindrances to information sharing in form of temporary organisation and lack of focus on the CSC in construction planning have been explained. Though, there is a lack of research regarding how information sharing can be accomplished as well as the supplier's part in this. This paper thereby follows Jonsson and Myrelid (2016) by taking the perspective of suppliers. That viewpoint aligns with Kaipia and Hartiala (2006) fifth proposition: that OEMs (in this study main contractors) should understand suppliers' real need for information. However, this has, in this study, been put into the context of construction.

Supply chain performance

Having studied supply chain performance in construction, Thunberg (2016) has shown that previous research on CSCs has focussed on the performance of construction projects, not their supply chains, by measuring aspects such as waste levels and developer satisfaction. In response, Thunberg (2016) suggested that CSC performance should be measured in terms of supply chain reliability, supply chain responsiveness and costs. By comparison, in work addressing industrial supply chains, Jonsson (2008) has summarised supply chain performance in terms of four aspects: customer service, costs, tied-up capital and environmental impact. Among them, customer service involves the speed and dependability of deliveries (Slack, Chambers, and Johnston 2001), which correspond to Thunberg's (2016) measures of supply chain responsiveness and supply chain reliability. By contrast, environmental impact comes into focus in assessing transports according to CO_2 emissions (Jonsson 2008). However, because the system that we studied also encompasses the construction site, waste levels are also important. Taken together, this paper discusses the performance of CSCs in terms of delivery speed, delivery dependability, costs, tied-up capital, and environmental impact, referring to both CO_2 emissions and waste).

Method

To fulfil the purpose of the study, a multiple-methods approach was adopted, depicted in Figure 2.

In devising that process, we drew from two research areas – construction logistics and the information-related requirements of suppliers – respectively represented by the two authors. We decided to combine our knowledge and started the work on this paper. Initially, we had independently identified the same problems: main contractors complain about the poor delivery performance of CSC suppliers and the suppliers complain about lack of information availability. These insights to the practical problem are thus based on longitudinal immersion in the field (Wells and Nieuwenhuis 2017) by collaborative research. The purpose of analytical conceptual research, which our study represented, is to offer new insights into traditional problems by way of identifying logical relationships. Such research usually involves conducting case studies as examples to illustrate those conceptualisations (Wacker 1998).

Case selection and data collection

When combining empirical experiences in the two areas mentioned above, a possible pattern between suppliers was detected; the problems with information availability seemed to differ between suppliers who continually supplied materials to the site (i.e. *continual suppliers*) and suppliers who did so only intermittently (i.e. *intermittent suppliers*). Hence, two types of supplier scenarios with different delivery patterns were identified. To represent the scenarios, we performed purposive sampling (Williamson 2002) with the aim of identifying two illustrative cases for each scenario. Sampling was based on a meta-analysis of above-mentioned collaborative research and six companies were initially sampled. In order to focus this study, two of the companies delivering services and non-tangible products were excluded and the final sample consists of four suppliers that all deliver materials and/or tools for production: Supplier A, C, D, and F. Supplying continually during the project, was defined as a minimum of two deliveries per week and supplying intermittently during the project, as a maximum of five deliveries during a project. These suppliers are all part of many different CSC, where one CSC is to be seen as related to one construction project. Sometimes the suppliers have been part of the same CSC, however, it has not been the purpose to gather data from a single CSC. Instead the purpose has been to gather the suppliers long term experiences of being part of several CSCs which is representative for actors in a temporary supply chain (Dubois and Gadde 2000).

Table 2 shows an overview of the demographics of the selected suppliers and data collection. The empirical data was collected through company meetings, on-site observations (at both suppliers sites and main contractors construction sites), interviews, project workshops (for two of the cases also including main contractors), and e-mails involving a number of people with different roles. During the studied period, the suppliers have been supplying a number of different construction projects. The gathered data have been summarised in a case study protocol, which has served as a basis for developing Appendix 1.

Data analysis

To manage a structured analysis of construction suppliers' information availability, earlier literature on information sharing and information quality was reviewed and factors capturing information availability and the value of the available information were summarised in Table 1. Thereafter an empirical within-case analysis of the factors in Table 1 was conducted in order to identify what factors seem to create the most problems and how they impact on supply chain performance, summarised in Table 3. The last issues were answered by searching for logical explanations about how

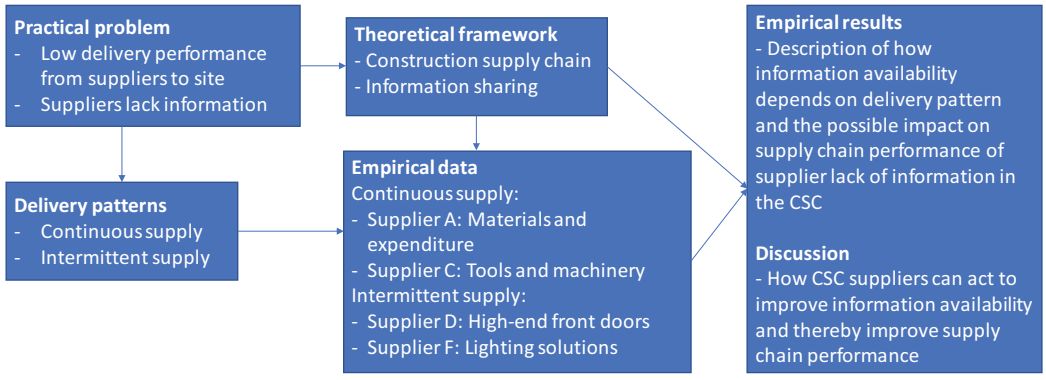

Figure 2. Research process.

Table 2. Case demographics and data collection.

	Continual supply		Intermittent supply	
	Supplier A	Supplier C	Supplier D	Supplier F
Material or services supplied	Materials and expenditure items	Tools and machines	High-end front doors	Lighting solutions
Number of employees, as of December 2017	2905	832	22	560
Number of manufacturing sites or delivery hubs	100+	100+	1	1
Research focus	Dyadic	Dyadic	Supplier	Supplier
Collaboration with author since year	2017	2018	2016	2009
Number of informants within the supplier	2 Main	2 Main	2 Main	5
Roles of informants	Construction logistics service manager and KAM	Construction logistics service manager and KAM	CEO Sales	SC manager Production Manager Logistics Manager Planner Purchasing Manager
Total number of interviews	6	2	6	10
Number of workshops	4 (whereof 3 including both suppliers and main contractors)	1 (suppliers and main contractors both included)	11	22
Number of site visits	2	2	2	8

and when supply chain performance was affected in the individual cases (Eisenhardt 1989; Craighead, Ketchen, and Cheng 2016; Stank et al. 2017). Next, a cross-case analysis was conducted to identify commonalities and differences between the suppliers in order to pinpoint the mechanisms behind the availability of information for suppliers and to see how the different suppliers had worked to improve their information availability. Hence, the unit of analysis is the suppliers' information availability.

Analysis

Table 3 shows the summary of the present state regarding information availability for the suppliers according to the factors summarised in Table 1 and how the identified problems impact the supply chain performance.

Discussion

Below the answers to the research questions are elaborated upon based on the analysis presented in Table 3.

> RQ1: How does information availability differ between suppliers with different types of delivery patterns and how does the lack of information availability impact on supply chain performance?

Table 3 shows that information availability is a true problem for CSC suppliers. By showing the impact on the supply chain performance of several actors and the links between them (Figure 3), we herein make a contribution to research on CSC and highlight the importance of capturing several actors' perspectives on the performance of CSC. According to Azambuja and O'Brien (2009), Akintoye (1995) and Proverbs and Holt (2000), the main contractors are the ones responsible for coordinating the CSC, because they both have ownership and an overview of the information needed by different parties. However, today the main contractors neglect their responsibility to create and maintain an overall view, in line with the findings by Thunberg and Fredriksson (2018) and an interesting finding from our study was the apparent lack of value that the main contractors see in sharing information, i.e. they do not see the effects of low information availability among the actors in the CSC. Figure 3 indicates that the supply chain performance effects are to be found both at the suppliers and on-site. Thus, the information does have value within the CSC, and it should be viewed as a worthwhile investment among main contractors to ensure that their suppliers have access to relevant and meaningful information.

Table 3. Summary of information-sharing activities between the construction site and the suppliers in terms of the 6 factors affecting information availability (Table 1).

	Continual supply		Intermittent supply	
Factor	Problems	Supply chain performance effects	Problems	Supply chain performance effects
Direction	From site management to supplier, however mainly initiated by suppliers. Suppliers A and C are both wholesalers of MTS products, are locally based and present at the construction site on a regular basis and can thereby follow the progress of the construction work. Thus, they know of delays and changes to the production time plan and the design first-hand. Furthermore, they attend start-up meetings, discussing the delivery conditions on-site and determining what services and products the main contractor needed. Suppliers A and C also use checklists to ensure necessary information.	*Since the suppliers take responsibility for acquiring information, no negative supply chain performance effects have been identified*	From central purchasers at the main contractor to the suppliers. In the cases studied, the main contractors had a central purchasing organisation responsible for strategic purchasing issues and a long-term supplier relationship management focus, whereas the local project organisation on-site was responsible for operational call-offs. The suppliers did not know who to contact at site.	This one-way communication risks to lead to wrong deliveries or late/too early deliveries, leading to waste or express transport. This will have a negative effect on SC performance in terms of lessened delivery dependability, increased costs and tied-up capital and negative environmental impact in terms of CO_2 emissions and waste.
Content and modality	Orders mainly via phone, however web shops increase in importance Suppliers obtain incomplete forecasts from start-up meetings.	Suppliers A and C deliveries vary with the production phases, and they would like to forecast demand for longer periods for several customers in order to increase resource utilisation and decrease tied-up capital.	Orders and drawings. Information can be accessed digitally (e.g. via Dropbox), meaning that face-to-face contact and direct contact by email or phone are rare.	The lack of rich communication lessens the ability to ask questions at an early stage of the order. This might lead to waste at a later stage.
Accessible and appropriate amount	No, have to ensure their own information. Information about the project's progress is accessed as they visit site, whereas overviews of information (e.g. updates on project time plan and production phases) are difficult to obtain.	Both suppliers A and C need to have the local stores to have possibility to attend in start-up meetings and visit sites regularly. This increase costs, however, improve delivery reliability.	The suppliers usually gain access to all information in the beginning of the project, leading to information overflow, which negatively affects the other dimensions. Overviews of information (e.g. updates on project time plan and production phases) cannot be accessed remotely.	The lack of updated project time plan often leads to materials being delivered on time according to initial order conformation but too early in relation to the current construction phase. This will have a negative effect on delivery dependability, tied-up capital and might lead to damages or waste.
Complete, concise, and credible	No, suppliers usually lack relevant information about, for example, delivery conditions and standard materials selected. Orders are often incorrect (e.g. contain the wrong types of products or the wrong locations). Furthermore, delivery times are not updated according to production plan and to get hold of an updated production plan is hard as they are available only on post it.	The wrong type of transport or unloading equipment and address cause delayed deliveries. For the suppliers, the inability to plan their work well had increased their tied-up capital, for they need to have more goods available to be able to deliver.	The suppliers perceive the information as being fragmented instead of comprehensive Information needs reworking in line with the appropriateness of amount. Furthermore, delivery times not updated according to production plan	Delayed deliveries, a lack of goods and delays in project production or else deliveries made too early, with had caused problems with storing and handling materials while waiting on-site, which risked waste due to damaged or lost goods. Inability to unload deliveries which cause delays to site.
Timely	Very late, mainly 24 hours in advance.	For the suppliers, the inability to plan their work well had increased their tied-up capital, for they either had to have more goods available to be able to deliver.	Yes, in the beginning of the project, however it is difficult to know who to contact at later stages to get credible and concise information about delivery times and site conditions.	Suppliers experienced disturbances in the production schedule by creating overtime or delayed deliveries to other customers. This increases the costs.
Understandable	The target for the information generated by the construction site is the construction project (i.e. construction process, Figure 1). Thus, the information produced by the construction project is not intended for the CSC's actors.	Risk of wrong deliveries or late deliveries, leading to waste and express transport.	The target for the information generated by the construction site is the construction project (i.e. construction process, Figure 1). Thus, the information produced by the construction project is not intended for the CSC's actors.	Risk of wrong deliveries or late/too early deliveries, leading to waste and express transport.

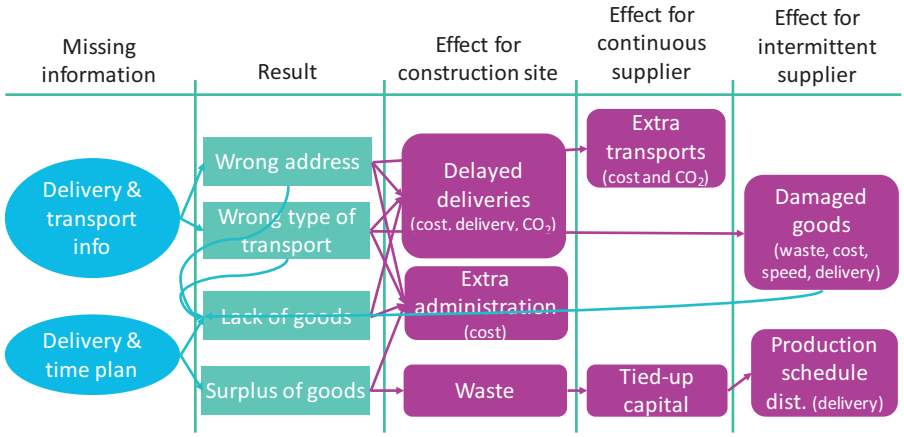

Figure 3. A summary of the relationship between the lack of information availability and supply chain performance identified in the cases.

As stated earlier, the construction industry is an ETO industry with a focus on projects and both tight and loose couplings: tight within the construction process but loose in relation to other parts (e.g. Dubois and Gadde 2000). As a result, each project is unique and thus requires certain information to be given each time and to each new supplier entering the project. The last is a tiresome task for site management that is exacerbated by the low level of digitalisation in construction (Ko, Azambuja, and Felix Lee 2016). Due to a lack of digitalisation, updates to time plans are made with the help of weekly meetings and Post-It notes, not easily shared outside the project and hence only available for parties entering the site. However, such hindrances to supply chain performance have been overlooked in earlier studies due to their focus on the main contractors instead of suppliers. Main contractors are typically within the sphere of tight couplings in the construction project (Dubois and Gadde 2000), focus on planning and coordinating the work on-site and are therefore unaware of the negative effects of the lack of shared information.

Table 3 revealed that the type of delivery pattern of the suppliers affects both the information available to and the information needed by them and in Appendix 1, the suppliers named two types of information that they would like to access:

1. Information about delivery and transport conditions (e.g. turning circles, type of machinery needed to unload, exact addresses of the gate and phone numbers of the freight or goods receiver); and
2. Updated time plans or delivery schedules (i.e. fulfilling the IQ dimensions or relevance and timeliness) that can be accessed remotely (i.e. with the right modality and the IQ dimension of accessibility), instead of current updates, which are made on Post-It notes at the local on-site project office.

One problem experienced by the suppliers with an intermittent delivery pattern, Suppliers D and F, is when a product or function ordered by the customer is not producible by them, or that, with minor changes, could be produced far more cheaply and that they could thereby supply both a better and cheaper product. Thus, they wish for a more continual information exchange and would like to be involved in the design phase as a means to improve their services and product deliveries. Furthermore, the intermittent suppliers have developers as their customers and communicate with central purchasers within the main contractors. The loose couplings mentioned earlier have resulted in a lack of information sharing also between the central and project purchasers within the construction process (Thunberg and Fredriksson 2018). Not only do the suppliers with intermittent supply have less access to the existing information on-site due to their lack of presence there; they also depend upon information from a central purchasers within the main contractors and/or developers that also not are present at site. In such a fragmented CSC (Dubois and Gadde 2000), they do not have up-to-date information about the progress on-site due to poor internal communication. Therefore, the loose couplings within the construction industry seem to be an even greater problem for suppliers providing intermittent supply than the ones providing continual supply.

At the same time, as observation in relation to RQ1 revealed and in line with Ying, Tookey, and Seadon (2018) findings, the information shared about the construction process to suppliers was available to the MTO suppliers only, who had long lead times and require product-specific information to be able to deliver the requested products. However, that information is not updated in accordance with project progress. Thus, the following proposition was formulated:

Suppliers who are continually present on-site have an information-gathering advantage over suppliers providing intermittent deliveries once construction commences

RQ2: How have the suppliers acted to improve their information availability?

However, the reason why suppliers who are continually present on-site have an information-gathering advantage over suppliers providing intermittent deliveries is that the former can take responsibility for their own information availability, see Table 3. These suppliers use start-up meetings and checklists to acquire complete and concise information. Furthermore, both see an opportunity to increase the number of services that they provide to the contractors – for

instance, a VMI service (i.e. Supplier A) and planning help (i.e. Supplier C). It is not only the potential of selling more that makes those suppliers want to develop those services; it is also that those enhanced services enable them to improve their existing products and services as well as to become a more central supplier to the contractors. The more that they are present on-site, the better their unidirectional information sharing works (Proverbs and Holt 2000) and the better opportunities that they have to improve their supply chain performance and, in turn, be viewed as preferred suppliers. Thus, in comparison to what has occurred in the evolution of third-party logistics service offerings that take place in relation to the customers' demands (Halldórsson and Vural 2019), the offerings examined in our study have been developed in relation to the suppliers' opportunities to improve supply chain performance as well. Considering all of the above, a second proposition was developed:

> Suppliers providing continual supply increase their service offerings to main contractors in order to better control their information availability and become preferred suppliers.

Conclusions

This paper has analysed the construction suppliers' information availability, in order to contribute to knowledge about coordination within CSCs and how the lack thereof can impact their supply chain performance. Suppliers and their impact on performance in construction have rarely received attention from researchers (Pan, Lin, and Pan 2010), which is rectified by taking the suppliers' perspective in this study. Several of the coordination-related challenges observed in earlier studies and problems related to CSC performance (e.g. Thunberg and Fredriksson 2018) was identified also here, however a contribution is the description of these from the supplier's perspective.

This supplier perspective allows to make theoretical implications to the construction management area by detailing the understanding of how the loosely coupled actors in construction, i.e. suppliers, are impacted in the sense of information availability. Earlier research within this area has seen all suppliers as a mass, where all things are equal. However, we can based on our study propose that due to the loose couplings and the lack of understanding among main contractors of the value of information sharing, suppliers with continuous supply have an information advantage due to their presence on site and thereby ability to observe construction project progress. Thus, this emphasises the need for further research from the supplier perspective within construction management. Furthermore, we also make a theoretical implication to the supply chain management area by proposing that suppliers actually can enhance their information quality, i.e. information availability in this case, by increasing their service offering to customers. Thus, the more services delivered, the higher information availability and the less dependence on the customer's ability to share information. This is a highly interesting proposition as it twists the perspective of earlier research on information sharing in supply chains since earlier research has seen the supplier as just a receiver of information, not a gatherer. This proposition requires further research for validation outside construction industry but also on how information gathering, and availability, can be a driver for service differentiation. It would also be interesting to conduct more in-depth case studies of the service developments of the construction suppliers, especially as they move into the business area of third-party logistics service providers, and how the main contractors can improve supply chain planning. Because this study has been conducted exclusively within Sweden, it remains necessary to confirm those propositions by conducting surveys of several countries at once.

The managerial takeaway from this study relate to the a lack of understanding among main contractors regarding how their absence of information sharing affects supply chain performance (Figure 3). The managerial contribution lies in the identification of what information suppliers would benefit from receiving. Here we found some very low hanging fruits such as information about correct address. Furthermore, we also provide examples of how suppliers can take ownership of their lack of information availability and improve this.

Disclosure statement

No potential conflict of interest was reported by the author(s).

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References

Akintoye, Akintola. 1995. "Just-in-Time Application and Implementation for Building Material Management." *Construction Management and Economics* 13 (2): 105–113. doi:10.1080/01446199500000013.

Al-Hussein, M., D. Kung, D. P. Alex, and S. Fernando. 2008. "Application of Lean Thinking to Improve the Productivity of Water and Sewer Service Installations." *Canadian Journal of Civil Engineering* 35 (4): 418–430. doi:10.1139/L07-136.

Aloini, Davide, Riccardo Dulmin, Valeria Mininno, and Simone Ponticelli. 2012. "Supply Chain Management: A Review of Implementation Risks in the Construction Industry." *Business Process Management Journal* 18 (5): 735–761. doi:10.1108/14637151211270135.

Azambuja, Marcelo, and William J. O'Brien. 2009. "Construction Supply Chain Modeling: Issues and Perspectives." In *Construction Supply Chain Management Handbook*, edited by William J. O'Brien, Carlos T. Formoso, Ruben Vrijhoef and Kerry London. Boca Raton: Taylor & Francis Group.

Ballard, G. 2000. "The Last Planner System of Production Control." Doctoral thesis, University of Birmingham.

Carlile, Paul R. 2004. "Transferring, Translating, and Transforming: An Integrative Framework for Managing Knowledge across Boundaries." *Organization Science* 15 (5): 555–568. doi:10.1287/orsc.1040.0094.

Craighead, Christopher W., David J. Ketchen, Jr, and Li Cheng. 2016. ""Goldilocks" Theorizing in Supply Chain Research: Balancing Scientific and Practical Utility via Middle-Range Theory." *Transportation Journal* 55 (3): 241–257. doi:10.5325/transportationj.55.3.0241.

Dainty, Andrew, David Moore, and Michael Murray. 2006. *Communication in Construction - Theory and Practice*. 1st ed. Abingdon, Oxon: Taylor and Francis.

Dainty, Andrew R. J., Sarah J. Millett, and Geoffrey H. Briscoe. 2001. "New Perspectives on Construction Supply Chain Integration." *Supply Chain Management: An International Journal* 6 (4): 163–173. doi:10.1108/13598540110402700.

Doloi, H. 2009. "Relational Partnerships: The Importance of Communication, Trust and Confidence and Joint Risk Management in Achieving Project Success." *Construction Management and Economics* 27 (11): 1099–1109. doi:10.1080/01446190903286564.

Dubois, Anna, and Lars-Erik Gadde. 2000. "Supply Strategy and Network effects - Purchasing Behaviour in the Construction Industry." *European Journal of Purchasing & Supply Management* 6 (3–4): 207–215. doi:10.1016/S0969-7012(00)00016-2.

Dubois, Anna, and Lars-Erik Gadde. 2002. "The Construction Industry as a Loosely Coupled System: Implications for Productivity and Innovation." *Construction Management & Economics* 20 (7): 621–631.

Dubois, Anna, Kajsa Hulthén, and Viktoria Sundquist. 2019. "Organising Logistics and Transport Activities in Construction." *The International Journal of Logistics Management* 30 (2): 620–640. doi:10.1108/IJLM-12-2017-0325.

Egan, John. 1998. *Rethinking Construction*. London, United Kingdom: Department of Trade and Industry.

Eisenhardt, Kathleen M. 1989. "Building Theories from Case Study Research." *Academy of Management Review* 14 (4): 532–550. doi:10.5465/amr.1989.4308385.

Ekeskär, Andreas, and Martin Rudberg. 2016. "Third-Party Logistics in Construction: The Case of a Large Hospital Project." *Construction Management and Economics* 34 (3): 174–191. doi:10.1080/01446193.2016.1186809.

Ellegaard, Chris, and Christian Koch. 2012. "The Effects of Low Internal Integration between Purchasing and Operations on Suppliers' Resource Mobilization." *Journal of Purchasing and Supply Management* 18 (3): 148–158. doi:10.1016/j.pursup.2012.06.001.

Fellows, Richard. 2009. "Culture in Supply Chains." In *Construction Supply Chain Management*, edited by Stephen Pryke, 42–72. Hong Kong: Wiley-Blackwell.

Fernie, Scott, and Anthony Thorpe. 2007. "Exploring Change in Construction: Supply Chain Management." *Engineering, Construction and Architectural Management* 14 (4): 319–333. doi:10.1108/09699980710760649.

Forslund, Helena, and Patrik Jonsson. 2007. "The Impact of Forecast Information Quality on Supply Chain Performance." *International Journal of Operations & Production Management* 27 (1): 90–107. doi:10.1108/01443570710714556.

Friblick, Fredrik. 2000. "Supply Chain Management in the Construction Industry - Opportunity or Utopia?" Thesis, Lund University.

Gosling, Jonathan, Mohamed Naim, and Denis Towill. 2013. "A Supply Chain Flexibility Framework for Engineer-to-Order Systems." *Production Planning & Control* 24 (7): 552–515. doi:10.1080/09537287.2012.659843.

Green, Stuart D., Scott Fernie, and Stephanie Weller. 2005. "Making Sense of Supply Chain Management: A Comparative Study of Aerospace and Construction." *Construction Management and Economics* 23 (6): 579–593. doi:10.1080/01446190500126882.

Gustavsson, Mattias, and Patrik Jonsson. 2008. "Perceived Quality Deficiencies of Demand Information and Their Consequences." *International Journal of Logistics Research and Applications* 11 (4): 295–312. doi:10.1080/13675560801952987.

Gustavsson, Mattias, and Carl Wänström. 2009. "Assessing Information Quality in Manufacturing Planning and Control Processes." *International Journal of Quality & Reliability Management* 26 (4): 325–340. doi:10.1108/02656710910950333.

Halldórsson, Á., and C. A. Vural. 2019. "Servitization and Logistics: Building a Service-Based Typology." Paper Presented at the the 26th Annual EurOMA Conference: Operations Adding Value to Society, Helsinki, Finland.

Halldórsson, Árni, Juliana Hsuan, and Herbert Kotzab. 2015. "Complementary Theories to Supply Chain Management Revisited – From Borrowing Theories to Theorizing." *Supply Chain Management: An International Journal* 20 (6): 574–586. doi:10.1108/SCM-06-2015-0228.

Hicks, Christian, Tom McGovern, and Chris F. Earl. 2000. "Supply Chain Management: A Strategic Issue in Engineer to Order Manufacturing." *International Journal of Production Economics* 65 (2): 179–190. doi:10.1016/S0925-5273(99)00026-2.

Janné, Mats, and A. Fredriksson. 2019. "Construction Logistics Governing Guidelines in Urban Development Projects." *Construction Innovation* 19 (1): 89–109. doi:10.1108/CI-03-2018-0024.

Jonsson, Patrik. 2008. *Logistics and Supply Chain Management*. Maidenhead: McGraw-Hill.

Jonsson, Patrik, and Paulina Myrelid. 2016. "Supply Chain Information Utilisation: Conceptualisation and Antecedents." *International Journal of Operations & Production Management* 36 (12): 1769–1799. doi:10.1108/IJOPM-11-2014-0554.

Josephson, Per-Erik, and Lasse Saukkoriipi. 2007. *Waste in Construction Projects: Call for a New Approach*. Gothenburg, Sweden: The Centre for Management of the Built Environment, Chalmers University of Technology.

Kaipia, Riikka. 2009. "Coordinating Material and Information Flows with Supply Chain Planning." *The International Journal of Logistics Management* 20 (1): 144–162. doi:10.1108/09574090910954882.

Kaipia, Riikka, and Helena Hartiala. 2006. "Information-Sharing in Supply Chains: Five Proposals on How to Proceed." *The International Journal of Logistics Management* 17 (3): 377–393. doi:10.1108/09574090610717536.

Khan, Khurram Iqbal Ahmad, Roger Flanagan, and Shu-Ling Lu. 2016. "Managing Information Complexity Using System Dynamics on Construction Projects." *Construction Management and Economics* 34 (3): 192–204. doi:10.1080/01446193.2016.1190026.

Ko, Hoo Sang, Marcelo Azambuja, and H. Felix Lee. 2016. "Cloud-Based Materials Tracking System Prototype Integrated with Radio Frequency Identification Tagging Technology." *Automation in Construction* 63: 144–154. doi:10.1016/j.autcon.2015.12.011.

Kristiansen, Kristian, Stephen Emmitt, and Sten Bonke. 2005. "Changes in the Danish Construction Sector: The Need for a New Focus." *Engineering, Construction and Architectural Management* 12 (5): 502–511. doi:10.1108/09699980510627180.

London, Kerry A., and Russell Kenley. 2001. "An Industrial Organization Economic Supply Chain Approach for the Construction Industry: A Review." *Construction Management and Economics* 19 (8): 777–788. doi:10.1080/01446190110081699.

Love, Peter E. D., Zahir Irani, and David J. Edwards. 2004. "A Seamless Supply Chain Management Model for Construction." *Supply Chain Management: An International Journal* 9 (1): 43–56. doi:10.1108/13598540410517575.

Lundesjö, Greger. 2015. "Consolidation Centres in Construction Logistics." In *Supply Chain Management and Logistics in Construction: Delivering Tomorrow's Built Environment*, edited by Greger Lundesjö, 225–242. London, United Kingdom: Kogan Page.

Malone, Thomas W., and Kevin Crowston. 1994. "The Interdisciplinary Study of Coordination." *ACM Computing Surveys* 26 (1): 87–119. doi:10.1145/174666.174668.

Martinez, Jon I, and J. Carlos Jarillo. 1989. "The Evolution of Research on Coordination Mechanisms in Multinational Corporations." *Journal of International Business Studies* 20 (3): 489–514. doi:10.1057/palgrave.jibs.8490370.

Meng, Xianhai. 2012. "The Effect of Relationship Management on Project Performance in Construction." *International Journal of Project Management* 30 (2): 188–198. doi:10.1016/j.ijproman.2011.04.002.

Miller, Christopher J. M., Gary A. Packham, and Brychan C. Thomas. 2002. "Harmonization between Main Contractors and Subcontractors: A Prerequisite for Lean Construction?" *Journal of Construction Research* 3 (1): 67–82. doi:10.1142/S1609945102000059.

Modig, Nina. 2007. "Material Flows Incurred by Activities at Project Sites." Doctoral thesis, Chalmers University of Technology.

Mohr, Jakki, and John R. Nevin. 1990. "Communication Strategies in Marketing Channels: A Theoretical Perspective." *Journal of Marketing* 54 (4): 36–51. doi:10.2307/1251758.

Murphy, Róisín. 2013. "Strategic Planning in Construction Professional Service Firms – A Study of Irish QS Practices." Construction Management and Economics 31 (2): 151–166. doi:10.1080/01446193.2012.736026.

Nicolini, Davide, Richard Holti, and Mark Smalley. 2001. "Integrating Project Activities: The Theory and Practice of Managing the Supply Chain through Clusters." *Construction Management and Economics* 19 (1): 37–47. doi:10.1080/014461901452067.

Pan, Nai-Hsin, Yung-Yu Lin, and Nang-Fei Pan. 2010. "Enhancing Construction Project Supply Chains and Performance Evaluation Methods: A Case Study of a Bridge Construction Project." *Canadian Journal of Civil Engineering* 37 (8): 1094–1106. doi:10.1139/L10-047.

Proverbs, David G., and Gary D. Holt. 2000. "Reducing Construction Costs: European Best Practice Supply Chain Implications." *European Journal of Purchasing & Supply Management* 6 (3–4): 149–158. doi:10.1016/S0969-7012(00)00011-3.

Seppänen, Olli, and Antti Peltokorpi. 2016. "A New Model for Construction Material Logistics: From Local Optimization of Logistics towards Global Optimization of on-Site Production System." Paper Presented at the 24th Annual Conference of the International Group for Lean Construction.

Shannon, Claude E., and Warren Weaver. 1949. *The Mathematical Theory of Information*. University of Illinois Press.

Shin, Tae-Hong, Sangyoon Chin, Su-Won Yoon, and Soon-Wook Kwon. 2011. "A Service-Oriented Integrated Information Framework for RFID/WSN-Based Intelligent Construction Supply Chain Management." *Automation in Construction* 20 (6): 706–715. doi:10.1016/j.autcon.2010.12.002.

Slack, Nigel, Stuart Chambers, and Robert Johnston. 2001. *Operations Management*. Harlow: Pearson Education.

Stank, Theodore P., Daniel A. Pellathy, Joonhwan In, Diane A. Mollenkopf, and John E. Bell. 2017. "New Frontiers in Logistics Research: Theorizing at the Middle Range." *Journal of Business Logistics* 38 (1): 6–17. doi:10.1111/jbl.12151.

Strategic Forum. 2002. "Accelerating Change." In edited by *Strategic Forum for Construction*, 44. London, Great Britain: Strategic Forum for Construction.

Sundquist, V., L. E. Gadde, and K. Hulthen. 2018. "Reorganizing Construction Logistics for Improved Performance." *Construction Management and Economics* 36 (1): 49–65. doi:10.1080/01446193.2017.1356931.

Thunberg, M., and Anna Fredriksson. 2018. "Bringing Planning Back into the Picture – How Can Supply Chain Planning Aid in Dealing with Supply Chain-Related Problems in Construction?" *Construction Management and Economics* 36 (8): 425–442. doi:10.1080/01446193.2017.1394579.

Thunberg, Micael. 2016. "Developing a Framework for Supply Chain Planning in Construction." Doctoral, Linköping University.

Thunberg, Micael, and Fredrik Persson. 2014. "Using the SCOR Model's Performance Measurements to Improve Construction Logistics." *Production Planning & Control* 25 (13–14): 1065–1078. doi:10.1080/09537287.2013.808836.

Titus, Silas, and Jan Bröchner. 2005. "Managing Information Flow in Construction Supply Chains." *Construction Innovation* 5 (2): 71–82. doi:10.1108/14714170510815186.

Tserng, H. P., S. Y. L. Yin, and S. Li. 2006. "Developing a Resource Supply Chain Planning System for Construction Projects." *Journal of Construction Engineering and Management* 132 (4): 393–407. doi:10.1061/(ASCE)0733-9364(2006)132:4(393).

Tuomikangas, Nina, and, Riikka Kaipia. 2014. "A Coordination Framework for Sales and Operations Planning (S&OP): Synthesis from the Literature." *International Journal of Production Economics* 154: 243–262. doi:10.1016/j.ijpe.2014.04.026.

Wacker, J. G. 1998. "A Definition of Theory: research Guidelines for Different Theory-Building Research Methods in Operations Management." *Journal of Operations Management* 16 (4): 361–385. doi:10.1016/S0272-6963(98)00019-9.

Wells, Peter, and Paul Nieuwenhuis. 2017. "Operationalizing Deep Structural Sustainability in Business: Longitudinal Immersion as Extensive Engaged Scholarship." *British Journal of Management* 28 (1): 45–63. doi:10.1111/1467-8551.12201.

Wikner, Joakim, and Martin Rudberg. 2005a. "Integrating Production and Engineering Perspectives on the Customer Order Decoupling Point." *International Journal of Operations & Production Management* 25 (7): 623–641. doi:10.1108/01443570510605072.

Wikner, Joakim, and Martin Rudberg. 2005b. "Introducing a Customer Order Decoupling Zone in Logistics Decision-Making." *International Journal of Logistics Research and Applications* 8 (3): 211–224. doi:10.1080/13675560500282595.

Williamson, Kirsty. 2002. "Research Methods for Students, Academics and Professionals: Information Management and Systems." In *Topics in Australasian Library and Information Studies*, edited by Ross Harvey and Stuart Ferguson. Wagga Wagga, NSW, Australia: Centre for Information Studies, Charles Sturt University.

Vrijhoef, Ruben, and Lauri Koskela. 2000. "The Four Roles of Supply Chain Management in Construction." *European Journal of Purchasing & Supply Management* 6 (3–4): 169–178. doi:10.1016/S0969-7012(00)00013-7.

Ying, Fei, John Tookey, and Jeff Seadon. 2018. "Measuring the Invisible: A Key Performance Indicator for Managing Construction Logistics Performance." *Benchmarking: An International Journal* 25 (6): 1921–1934. doi:10.1108/BIJ-11-2016-0176.

Appendix 1

Table A. Summary of empirical data.

Supplier A	Supplier C	Supplier D	Supplier F
1. Who is the customer?			
Contractor	Contractor	Developer	Subcontractor
2. What do you supply?			
Expenditure items such as clothes, tools, and concrete pipes.	Tools and infra-structure to projects.	Handmade customised wooden front doors.	Indoor and outdoor lighting fittings
3. How do you deliver			
Uses a structure of a central and local or regional DCs and stores. From the central DC there is 24 h delivery time to whole of Sweden.	Delivers from local depots with milk runs. Small customers usually come and pick up their products at the depots.	The doors are shipped directly from the factory to constructions all over Sweden.	For smaller projects one delivery is used, whereas larger projects can have scheduled deliveries over several years.
4. How do you plan the deliveries?			
Need information about contact person and project specific delivery conditions. For larger projects 3 weeks ahead to secure supply. Rescheduling is accepted 48 h before delivery. The customers have been spoiled by ordering the night before.	Do not really feel that they need any specific information. Like to have the information 24 h before delivery but they can deliver within a couple of hours. The start-up meeting should preferably be 1 month ahead of project start.	The front door should be the last thing that is installed in order to minimise damages. Deliveries are thus often squeezed between the last subcontractor delivery and final inspection. Time from order to delivery varies between years to a few weeks.	Deliveries are planned based on customer demand. Larger projects have dictated slot-times for delivery. Smaller projects have wider time windows for delivery. Standard products are delivered from stock, customised products within 14 days.
5. What information do you receive from the customer?			
Try to have start-up meetings with larger projects. Sellers uses a checklist. In general contractors are lousy at sharing information. Though, when customers see that we are interested they get more willing to share as well.	Use pro-active project surveillance. Have a start-up meeting to know the phases of the project. Thereafter the customer centre follows the project and call and check. They would like the customers to share project plan	The delivery date is set by a centralised purchasing function of the contractor. Delivery performance is measured towards this date even if the site supervisor wants the door earlier/later in order to fit to the progression of the construction.	Need updates about installation schedule. This information might be available at the sales department but not always shared.
6. What do you do to improve your performance?			
To go from supplying only products to services. VMI services, kitting, removal of wrapping. Decreases problems of customer's employees ordering the wrong products. Deliveries without physical receiver. Improving labels and improve customer interface for online ordering including planning services.	Today C know resource utilisation, but not when and how. C also would like to start delivering more services, be a more integrated part of the customer's value chain. Together with supplier A, they have something called the kitchen wagon, were C supply the tools and A supply the nuts and bolts needed.	D would like to be involved earlier to provide feedback. The tendering could reflect a product that cannot be built. Information sharing means that ALL documentation is included, and ALL changes are pushed to ALL suppliers. This creates information overload.	For standard orders deliveries are calculated with ATP available-to-promise. For customer adaptions the delivery time is dependent on the adaptions and if materials are in stock or not (might require the identification of a completely new supplier).
7. Supply chain performance effects:			
The consequences of lacking transport, delivery and planning information are that A arrive with the wrong type of transport, hindering A to unload or that the wrong type of goods is available at the inventory leading to more transports as these have to be delivered later. Furthermore, when the goods receiver is not reached it creates longer handover times and delayed transport also for the next person as well as a risk for waste as the goods reception is not registered. Lack of coordination between workers at the same site creates extra transports as the same site can have several deliveries the same day.	The consequences of lacking transport and delivery information are that they are driving to the wrong address or come with a transport that cannot physically fit in to the construction site, delaying the delivery and increasing transport costs. Furthermore, the lack of planning information creates a risk that they bring the wrong type of machinery or they do not have the right machinery available close by, leading to long delivery times and extra transports. This also make it hard for C to plan its own resources in an efficient way increasing tied up capital and transport costs. The lack of digitalised handling of the information regarding hired machinery creates unnecessary information when invoicing.	The consequences of lack of updated time plans are that they prioritise the wrong customer in the production, which creates delays for other customers. Often the deliveries come according to delivery plan to the site, but the time plan of the construction is delayed. This leads so that the doors are stored in such a way at site that they become damaged or that the front door is mounted before e.g. large other objects have been taken into the building. This creates waste and extra costs for the construction company and production planning problem for D because they have to deliver a new door based on a rush order.	Currently F might expedite a priority-order with use of overtime and weekend work, just to find that the project is delayed. One of the effects is that it becomes hard to motivate the personnel to commit to overtime for this customer. Priority-orders can be expedited faster through production, but Production at F are not allowed to down-prioritise another order just because one is prioritised up. It is unclear what is required to be seen as a priority-order.