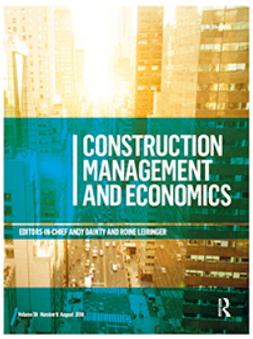

Routledge
Taylor & Francis Group

Construction Management and Economics

ISSN: 0144-6193 (Print) 1466-433X (Online) Journal homepage: https://www.tandfonline.com/loi/rcme20

Bringing planning back into the picture – How can supply chain planning aid in dealing with supply chain-related problems in construction?

Micael Thunberg & Anna Fredriksson

To cite this article: Micael Thunberg & 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

To link to this article: https://doi.org/10.1080/01446193.2017.1394579

CONSTRUCTION MANAGEMENT AND ECONOMICS, 2018
VOL. 36, NO. 8, 425–442
https://doi.org/10.1080/01446193.2017.1394579

Routledge
Taylor & Francis Group

Bringing planning back into the picture – How can supply chain planning aid in dealing with supply chain-related problems in construction?

Micael Thunberg and Anna Fredriksson

Department of Science and Technology, Linköping University, Norrköping, Sweden

ABSTRACT

There are several supply chain-related problems facing the construction industry, such as poor construction site logistics, lack of communication and trust. These problems can jeopardize construction projects through delays and cost overruns. Supply chain planning, a part of supply chain management (SCM), can be used as a tool to deal with these problems. The purpose of this paper is to study how linkages between common supply chain-related problems in construction can be illustrated and to demonstrate how they could be resolved through supply chain planning. Firstly, we identify how the linkages between common problems can be illustrated, and secondly the role of supply chain planning in resolving these problems. A conceptual model is developed that was verified using three cases with Swedish gypsum and kitchen supply chains. The model is shown to be useful in illustrating how supply chain problems occurring at executional level on-site are related to problems originating in lack of planning at company/pre-construction level. The study thus demonstrates how supply chain planning can aid in resolving supply chain problems. The paper contributes by bringing planning back into the picture and by showing how supply chain planning can help to adopt SCM in construction.

ARTICLE HISTORY
Received 28 June 2016
Accepted 11 October 2017

KEYWORDS
Planning; supply chain management; supply chain planning; Swedish construction industry

Introduction

The supply chain and its planning are often disregarded in construction (Tserng *et al*. 2006). Friblick's (2000) description of the interaction between the supply chain and the construction process indicates that improved planning of the supply chain can improve the efficiency of the construction process. This study focuses on how supply chain planning can be used to resolve common supply chain-related problems in construction, and thereby be a facilitator of supply chain management (SCM) adoption in the construction industry.

In the literature, several studies on construction management describe supply chain-related problems in the construction industry that result in low efficiency, i.e. poor construction site logistics (Said and El-Rayes 2011), supplier and subcontractor exclusion in the planning process (Ballard 2000, Dainty *et al*. 2001, Al-Hussein *et al*. 2008), lack of communication among supply chain members (Dubois and Gadde 2002, Meng 2012), and lack of trust (Doloi 2009). These problems can jeopardize construction projects through delays and cost overruns (Atkinson 1999). Using a simulation study, Hatmoko and Scott (2010) illustrated that supply chain issues can cause delays of up to 96 days in a 300-day long mid-sized project. There is an ongoing debate in construction management research regarding whether, and how, SCM can help overcome these problems (BIS 2013, Tennant and Fernie 2014). Furthermore, Vrijhoef and Koskela (2000) state that several of the problems are interlinked. For example, the relationship between the selection of materials from remote suppliers during the design phase and its possible effects on delivery reliability of materials on-site. The cause arises in the design phase but the problems/effects are not seen until work on-site commences. Improved knowledge of how problems are linked will improve the understanding of how to address them.

Supply chain planning integrates supply chain actors in planning the supply chain by sharing information to improve collaboration and trust (Fleischmann *et al*. 2008). Gajendran *et al*. (2013) argue that the method for sharing information is crucial for supply chain integration. As discussed by Tennant and Fernie (2014), contextual differences are one important reason that earlier attempts to adopt SCM in the construction industry have failed. Therefore, this study takes its starting point in common supply chain-related problems in the construction industry

CONTACT Micael Thunberg micael.thunberg@liu.se

and examines these from a supply chain planning perspective. It thereby becomes possible to show how supply chain planning could be used in the construction industry context. The purpose of the paper is to study how linkages between common supply chain-related problems in construction can be illustrated and to demonstrate how they could be resolved using supply chain planning. Conceptual modelling will be used as well as a multiple case studies of the supply chain for kitchens and gypsum boards in three construction projects, run by three different Swedish house and office building companies, with a design-build approach. There is a lack of studies adopting the main contractor perspective on supply chain planning in construction; the only previous study (Tserng *et al*. 2006) is based on a supplier perspective. However, in most cases, the main contractor is the actor who coordinates the supply chain in construction and, consequently, is the actor responsible for its planning.

The next section describes what SCM and supply chain planning is, and how it is used in construction. This is followed by a summary of supply chain-related problems in the construction industry. These two sections are used to develop the conceptual model for illustrating the linkages between the problems. The method section describes the research approach with data gathering and the analytical methods used. The conceptual model is then applied, followed by a discussion of how the research findings can affect the realization of SCM in construction, and the managerial implications of this study are discussed. Finally, the conclusions, contributions and further research are presented.

Theoretical framework

This section firstly presents what supply chain planning is, how it relates to SCM, and how it can be utilized in construction. Secondly, common supply chain-related problems in construction are presented. Thirdly, the section ends with a synthesis where the conceptual model is developed and research questions are presented.

Supply chain planning

Planning in this paper is perceived as hierarchical, with processes at different planning levels: strategic, tactical and operative. These planning levels each have a different horizon, planning object and frequency (Jonsson and Mattsson 2009). Strategic planning has a long-term horizon and sets the boundaries for the mid-term horizon tactical planning, which sets the boundaries for the short-term horizon operative planning. Planning object is defined as what is planned (Jonsson and Mattsson 2009). Long-term planning includes where to localize production (Jonsson and Holmström 2016), the markets on which to focus and the suppliers with which to have long-term relationships (Lambert and Cooper 2000). Mid-term planning includes production volume per product family, stock target levels and capacity utilization levels (Van Landeghem and Vanmaele 2002). Short-term planning includes daily distribution of different products and capacity usage per shift (Van Landeghem and Vanmaele 2002). Frequency refers to how often the plan is updated (Jonsson and Mattsson 2009).

According to Rudberg *et al*. (2002), the actual work on planning the supply chain can be divided into two parts: execution of the plan (i.e. supply chain execution) and the development of the plan (i.e. supply chain planning). Gupta and Maranas (2003) argue that supply chain planning "(…) is concerned with the coordination and integration of key business activities undertaken by an enterprise, from the procurement of raw materials to the distribution of the final products to the customer" (Gupta and Maranas 2003, 1219). This definition focuses, however, on the focal company and its integration of internal functions, and lacks integration of the supply chain. Jonsson and Holmström (2016), on the other hand, include the supply chain in their definition of supply chain planning, "as an implemented operations planning and control framework, system, process, or method with a supply chain scope" (Jonsson and Holmström 2016, p. 63). Rudberg *et al*. (2002) describe supply chain planning as including: demand planning, supply planning, promotion planning, transportation planning and product development. Supplementing this, Kaipia (2009) considers the essence of supply chain planning to be information sharing in the supply chain; Laureano Paiva *et al*. (2014) to be building trust among supply chain actors; and Pibernik and Sucky (2007) to be integrating the supply chain, all with the goal of creating value for the end-customer (Lummus and Vokurka 1998). Supply chain planning in this study can be described as integrating supply chain actors in the planning of supply and demand, by sharing information to improve collaboration and trust. It is important that supply chain actors such as suppliers are involved in the planning, and that information is shared (Fleischmann *et al*. 2008). The supply chain planning perspective can be summarized as a systemic view, in which supply chain execution is affected by the supply chain planning decisions made in the planning hierarchy.

Most earlier studies on supply chain planning have had a non-construction perspective; these studies have shown that well-implemented supply chain planning can lead to improvements for the supply chain as a whole. Jonsson *et al*. (2013), for example, studied how centralized supply chain planning at IKEA resulted in more reliable plans. Laureano Paiva *et al*. (2014) were also able to show that companies using supply chain planning experienced improved supply chain integration and increased levels of trust.

Supply chain planning as part of SCM

The Council of Supply Chain Management Professionals (2013) includes six important elements in SCM: planning, execution, logistics, coordination, collaboration and integration. The benefits of SCM are lower costs, improved customer value and improved competitive advantage (Mentzer *et al*. 2001). Lambert and Cooper (2000) describe how SCM consists of processes, management activities and a supply chain structure. Figure 1 illustrates how these three parts are linked; these three elements must be considered when adopting an SCM philosophy (Mentzer *et al*. 2001).

Mentzer *et al*. (2001) state that the adoption of SCM follows three stages. In the first stage, the focus is on the single company antecedents (see Figure 1) such as establishing a trustful climate, commitment and top management support, a vision of adopting SCM, and identification of key processes. To succeed with SCM adoption, it is necessary to establish supply chain orientation within the single companies so that they have a systemic and strategic view of the supply chain (Mentzer *et al*. 2001). To achieve this, it is important that each company in the supply chain strives to realize its single company antecedents.

When all companies in the supply chain have achieved a state of supply chain orientation, they should then work together as a supply chain to establish the SCM antecedents: coordination, the long-term relationship, integration, shared customer focus, cooperation, shared risk, and rewards and information sharing. The SCM antecedents can be grouped into the three SCM management activities: cooperation, coordination and integration (management activities, Figure 1). Cooperation with a long-term relationship for building trust (Edelenbos and Klijn 2007) and sharing risk and reward, coordination with sharing the same goal and customer focus and sharing information (Mintzberg 1979), and integration with both a behavioural and a process element (Gajendran *et al*. 2013).

SCM activities contain several tools for establishing the single company and SCM antecedents, such as just-in-time deliveries, supply chain planning, supply chain execution, supply chain integration and logistics. This paper focuses on the supply chain planning element of SCM, as this is an important tool for improving coordination, integration and cooperation in supply chains.

Supply chain planning and SCM in construction

Construction is a project-driven industry, where planning is conducted at a multitude of levels from portfolio planning to daily control on-site. Moreover, in construction the lower levels of planning are dependent on the decisions made at higher levels, such as the strategic or portfolio level, for example when resources are shared between projects in a common resource pool (Engwall and Jerbrant 2003). Because of this dependency between planning levels as well as between projects, it is important in multi-project environments to connect the planning of individual projects to planning at portfolio and strategic levels (Platje *et al*. 1994). However, in construction, the emphasis in planning has often been on developing robust

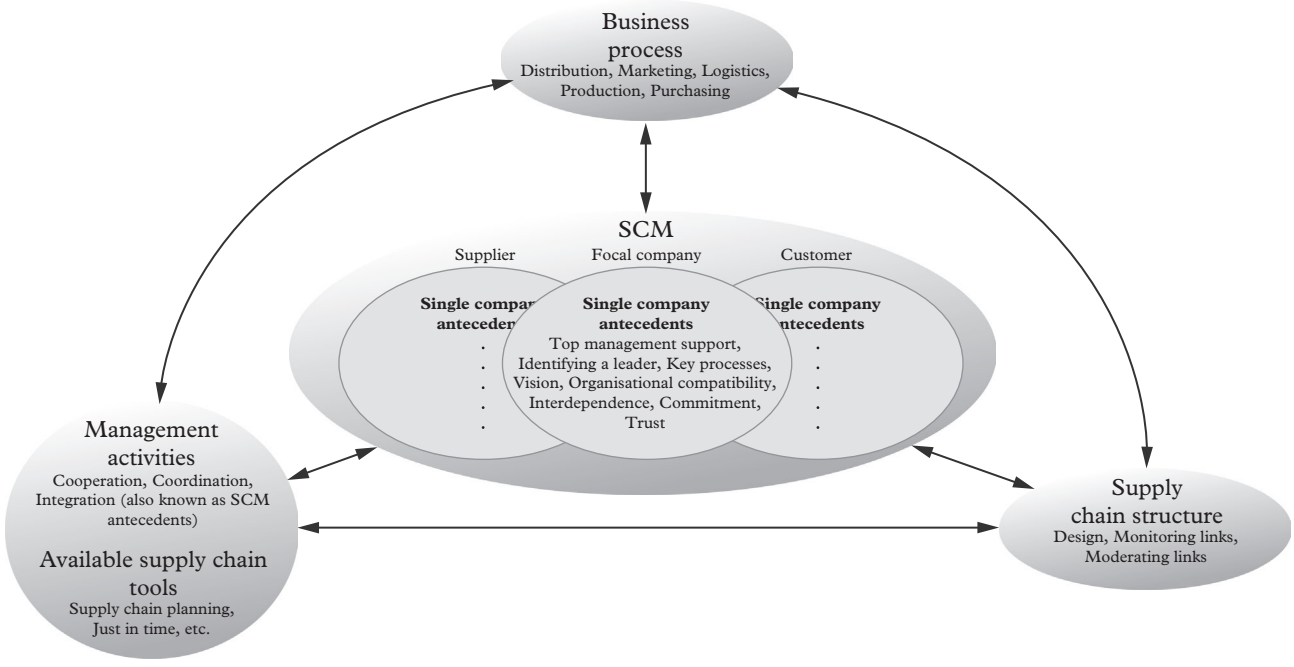

Figure 1. Supply chain management and its content.

production time schedules for single projects (Laufer and Tucker 1987, Thunberg 2016) rather than on integrating planning levels (Faniran *et al*. 1998).

A generic planning structure in construction can be said to include portfolio management, programme management, project planning and scheduling (Wysocki 2012). Portfolio management concerns managing all projects within a company to coordinate resources, whereas programme management concerns managing a larger project separated into several sub-projects (Walker 2015). According to Wysocki (2012), portfolio planning covers all projects managed by the company, and is considered to be the strategic plan. The strategic plan and demand forecasts are used as input to portfolio planning to identify projects suitable for running. Portfolio planning yields a long-term resource plan and is used as input in project planning. Winch and Kelsey (2005) propose a hierarchy for project planning, starting with a tender programme leading to a contract restraints programme. Gidado (2004) describes the planning in four phases: pre-project, pre-construction, construction and post-construction, where procurement is completed in the pre-construction phase. He also argues that project managers in the pre-construction phase need to fully understand the process to be able to develop clear plans that connect strategic and on-site plans. Otherwise, the construction on-site will be based on unrealistic plans and forced planning on-site. What is missing in both of the Gidado (2004) and Winch and Kelsey (2005) processes is the connection between the project planning and the strategic plans and portfolio planning. This issue is also true for Ballard (2000) and his last planner system. The risk with this lack of connection is that it enhances the decentralization of decision-making and sub-optimization of each project. The effect is an increased work load for the site managers, who must deal with planning and coordination issues on-site that could have been resolved in planning processes prior to start of on-site work.

Project planning can also be separated into two planning processes, often referred to as pre-construction and on-site planning (Johansen and Wilson 2006). The pre-construction planning process consists of: selection of the project team, creation of the project documentation system, initiating materials procurement, development of time schedules and milestones, and other pre-project-execution activities (Menches *et al*. 2008). On-site planning, on the other hand, is operationally focused, and covers completion of planned activities, schedule adherence, materials procurement and weekly check-up meetings (Johansen and Wilson 2006).

Supply chain-related problems in construction

This section presents common problems in construction from a supply chain perspective. Thunberg *et al*. (2017) identified four categories of common problems facing the construction industry: material flow, internal company communication, project communication and complexity (Thunberg *et al*. 2017).

Collaboration with suppliers and subcontractors is a key concept in SCM. Long-term relationships and collaboration with subcontractors and suppliers are important in improving the overall performance of the construction project and the supply chain. Akintoye *et al*. (2000) have observed that most contractors understand the importance of a long-term relationship with suppliers and subcontractors in improving quality of materials and reducing costs. Lack of collaboration with project members is described by Thunberg *et al*. (2017) as a project communication problem, and can cause problems with material flow. Logistics costs can be lowered through reduced vehicle movement (Vidalakis *et al*. 2011) and improved materials delivery reliability (Wegelius-Lehtonen 2001). Diran Wickramatillake *et al*. (2007) urge for better inter-organizational collaboration, cooperation, and learning between contractors and suppliers to achieve these cost savings. Dainty *et al*. (2001) nonetheless report that subcontractors often join the projects too late. The result is loss of important knowledge. The importance of supplier involvement early in projects is further emphasized by the lack of long-term relationships in construction. Nonetheless, Akintoye *et al*. (2000) report that major contractors in UK focus on developing long-term agreements with clients rather than with suppliers and subcontractors. Surprisingly, subcontractors also rank teamwork, planning and supplier communication as less important than contractual knowledge for improving long-term relationships and supply chain excellence (Briscoe *et al*. 2001). This is interesting as teamwork constitutes an important element of SCM (as in top management commitment and trust), planning and communication. Briscoe *et al*. (2001) suggest that the responsibility for accomplishing this resides with the main contractor. Cox and Ireland (2002) argue that there is no intrinsic value in involving suppliers and subcontractors early per se. The nature of the project dictates how much and when they should be involved. An awareness about these contextual issues is important, but it does not contradict the importance of investigating how they can be involved at an early stage. Alreshidi *et al*. (2016) describe how collaboration can improve with the help of tools such as building information modelling, but conclude that socio-organizational barriers such as resistance to change and incomplete information input prevent successful implementation.

Other types of problems in construction concern different forms of complexity. Modig (2007) argues that the temporary nature of the supply chains poses additional difficulties in implementing SCM concepts in the industry. The reason is that without stable supply chains it is difficult to develop collaboration, trust and continuous improvement (Meng 2012). For example, Bankvall *et al*. (2010) and Khan *et al*. (2016) describe how complexity through different interdependencies between activities affects the performance of the supply chain and the construction process. Delays are unavoidable if these dependencies are not dealt with through effective planning. 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. It can also aggravate the decoupled systems described by Dubois and Gadde (2002). They argue that there are different coupling points in a project, where organizations must compete both with others and with themselves. The loose couplings may, however, be advantageous as they encourage decentralized decisions based on local knowledge of the project. However, according to Dubois and Gadde (2002) it also complicates coordination, both within the supply chain as well as within the project.

Communication is of the utmost importance for an effective SCM (Lambert and Cooper 2000). In a literature review, Aloini *et al*. (2012) show that two of the most cited problems in construction are inadequate communication and late involvement of supply chain members. Dainty *et al*. (2006) discuss how the short-term focus in construction and the project environment complicate communication. The inability to share updated plans and documents and knowledge with all members of the supply chain can lead to reduced supply chain performance (Love *et al*. 2004). Doloi (2009) notes that communication has an important role in establishing good relationships with subcontractors, leading to a better chance of the building object being delivered on time and at the right quality. According to Doloi (2009), one antecedent for effective communication is trust. It can also be said that efficient communication and long-term relationship are a good basis for creating trust. Efficient communication is not only necessary between the main contractor and the external members of the supply chain, it is equally important internally within the main contractor company (Dainty *et al*. 2006). Inefficient communication can lead to decreased knowledge sharing between projects. This is elaborated by Ellegaard and Koch (2012), who show that low integration and coordination between the purchasers and operative personnel are common in construction, and can result in selection of unsuitable suppliers and inadequate information sharing with suppliers (Aloini *et al*. 2012). Arditi *et al*. (2017) also mention that organizational culture plays an important role in finishing projects on time. They argue that a "clan" culture, focusing on teamwork and loyalty, improves the likelihood of finishing projects on time. A "market" culture, focusing on goal-oriented competition, tends to delay projects.

Synthesis

The purpose is to study how linkages between common supply chain-related problems in construction can be illustrated to demonstrate how they can be resolved using supply chain planning. In line with Jonsson and Mattsson (2009), planning in this paper is viewed as a hierarchical process, with a long-term, mid-term and short-term level. These levels have different planning objects. In regard to existing planning in construction, pre-construction planning can be seen as a mid-term planning process due to the type of decisions made, i.e. identifying *what activities* should be *done when* and *what, and how much, materials are required* for the project as a whole. On-site planning, with its focus on production and activity control through weekly meetings and schedule adherence, can be viewed as having a short-term focus. Finally, supply chain execution is where the plans are executed on-site, e.g. materials deliveries to site. The common supply chain-related problems facing the construction industry can be categorized as problems with material flow, internal company communication, project communication or complexity (Thunberg *et al*. 2017). Several of the problems in these categories arise as a consequence of improper planning (Laufer and Tucker 1987). There is a need to study how the four categories of problems are interlinked and where in the planning hierarchy they originate. Construction today treats SCM, logistics and supply chain planning-related issues mostly at the project level, as the tendency is to focus on hands-on problems on-site. This means that the industry spends substantial efforts on fire-fighting. Planning in construction today is generally decoupled and focused on technical details in scheduling at the on-site project level. The effect is supply chain-related problems reoccurring from project to project. Vrijhoef and Koskela (2000) also argue that several of the supply chain-related problems are interlinked, but without specifying how. If the industry is to become more proactive and start dealing with the root-causes of on-site problems, it is necessary to understand the intricate linkages between the on-site problems and long-term and mid-term planning. Knowledge of where in the planning hierarchy a problem is located is important, as the location enables different management activities and tools to be used. Based on the above discussions, the purpose of the study was split into two research questions (RQ):

RQ1: How can the linkages between common supply chain problems at different planning levels be illustrated?

RQ2: What role does supply chain planning play in resolving common supply chain related problems in construction?

To answer the first research question a conceptual model is developed, Figure 2. This conceptual model is thereafter verified through the case studies. The case studies also help to answer the second research question. The conceptual model combines the hierarchical view of planning from the supply chain planning literature with the four categories of common supply chain-related problems in construction. This enables illustration of the linkages between the problems and the planning levels. The conceptual model includes the three supply chain planning levels (company level, pre-construction level and on-site), the executional (supply chain execution) level, and the four problem groups (material flow, company communication, project communication and complexity). Knowing how problems at a company or pre-construction level are linked to an executional effect on-site increases the understanding of how these can be resolved. However, it is difficult to distinguish between company level and pre-construction level because some of the pre-construction level planning is undertaken at company level. According to Gadde and Dubois (2010) some problems should be dealt with at an overarching company level not at project level, e.g. lack of collaboration could be associated with both company level and pre-construction level because collaboration has to be established with supply chain members at both these levels. Therefore, in the conceptual model, company level supply chain planning and pre-construction level supply chain planning are grouped together.

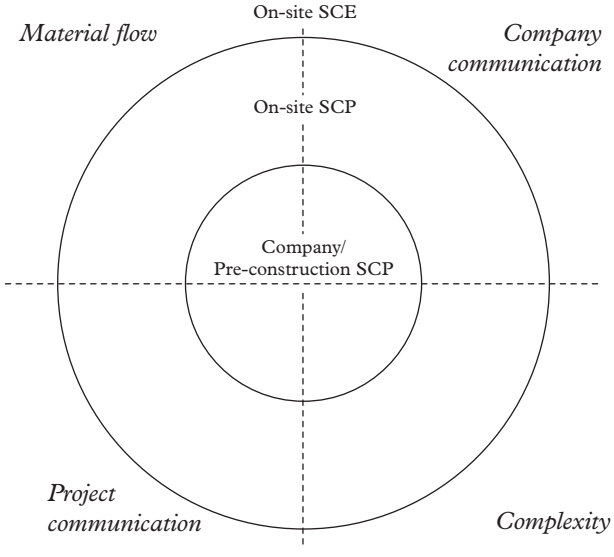

Figure 2. Conceptual model for linking common supply chain problems.

Method

Little research has been conducted regarding supply chain planning in construction, and the focus in this paper is therefore theory building. The research process was iterative, and conceptual modelling was used together with a case study approach. Figure 3 illustrates the research process. To achieve the purpose of the study, a conceptual model for studying how supply chain planning can address common problems was developed (Figure 2). A conceptual model aims to describe the concepts but does not explain how they interact or why (Meredith 1993).

The paper was based on a subjectivist standpoint, where understanding of the context can only be built on the collective understanding of the people within it. Case study is a suitable methodological approach for studying a phenomenon in its context (Yin 2009). A multiple case study of three cases was performed. The cases represented a variety of projects and project sizes to improve generalizability. However, all three cases covered house building with a design-build contract form in Sweden, limiting the opportunities to generalize beyond this context. To cover various sections of the supply chain, the supply chains for kitchens and gypsum boards were studied. These two represent different types of supply chains: building product suppliers (such as gypsum board) and suppliers of products designed and manufactured specifically for a certain project (such as a kitchen).

The unit of analysis was the project and the problems identified in these two supply chains of the project. The studied projects and supply chains were chosen assisted by contacts in the three Swedish construction companies running the projects. The case studies were to include purchasers and site managers experienced in on-site house building. The cases were also selected to include purchasers and site managers of different ages to allow for different perspectives on the problems. The cases were also to include both a strategic and a project purchaser to broaden the understanding of the problems.

Taking a subjectivist standpoint, observations and interviews were used to collect knowledge from the individuals in the context. Observations included attending weekly planning meetings on-site and taking part in a guided on-site tour of the project. Other types of data were also gathered, such as work site disposition plans. Interviews are useful for both broadening and deepening knowledge about a topic (Bryman and Bell 2015). Semi-structured interviews in particular can be a suitable method by which to obtain the respondents' perspective on a topic (Flick 2009). The selection of respondents was based on purposive sampling. To capture the problems throughout the supply chain, three types of actors involved in planning the supply chain in construction were interviewed: site

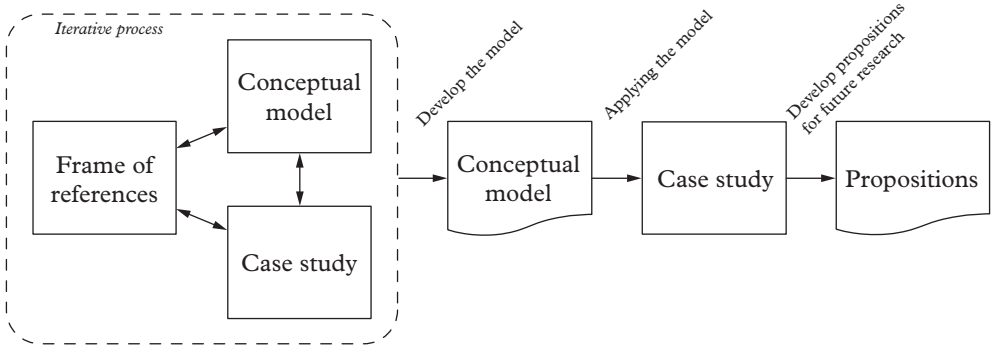

Figure 3. The research process.

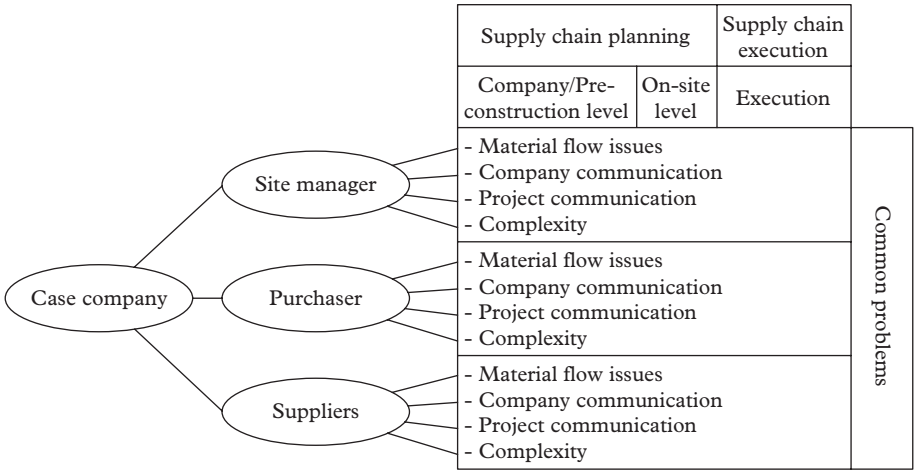

Figure 4. The research approach applied in this study.

managers, purchasers and suppliers. The purchasers contribute with valuable information on planning the supply chain, and on supply chain problems early in the construction process. The suppliers, on the other hand, contribute with the perspective of the supply process. Finally, site managers and on-site production act as an intersection between the construction process and the supply process, where the site manager sees the effects (on-site) of the previous supply chain problems. Figure 4 illustrates the different perspectives on the problems studied in this paper.

A total of 14 respondents were included in the study. Case Company 1 did not use project purchasers in its projects. The interviews were semi-structured, lasting between one and four hours. The interviews focused on supply chain-related problems (material flow, company communication, project communication and complexity), in line with Thunberg *et al*. (2017). The respondents were asked open questions about the problems they perceived in these four areas; company communication was excluded from the interviews with the suppliers. The respondents were also asked open questions on the causes of the problems mentioned, and any potential effect of that particular problem. This facilitated finding interlinkages between the problems. The interview guide is presented in Table 1. The interviews were conducted by the first author during 2015. During the interviews the interviewer took notes which were then entered into an interview database. The respondents were able to read the interview summaries and comment on them. Although the interviewees were selected based on their connection to a particular project, they were encouraged during the interviews to think beyond the specific project.

Analysis was performed after identifying supply chain problems, their origin, and effects, through interviews and by reading through the contents of the notes taken during the interviews. The Flick (2009) method of thematic analysis was utilized. The analysis was conducted in four steps, the first three were a within-case analysis for each case, and the fourth step was a cross-case analysis between the three cases. The first step was to code the interviews based on whether the identified problems were related to the (long-term) company level, a (mid-term) pre-construction level, a (short-term) on-site level, or executional level decision-making in supply chain planning. The second step consisted of coding the identified problems as either material flow, internal company

Table 1. Interview guide.

Question	Follow-up questions
What are your opinions on the problem categorization?	
What problems with the material flow do you experience?	Why does that problem occur? What might the effects be?
What problems with the internal company communication do you experience?	Why does that problem occur? What might the effects be?
What problems with the project communication do you experience?	Why does that problem occur? What might the effects be?
What complexity problems do you experience?	Why does that problem occur? What might the effects be?

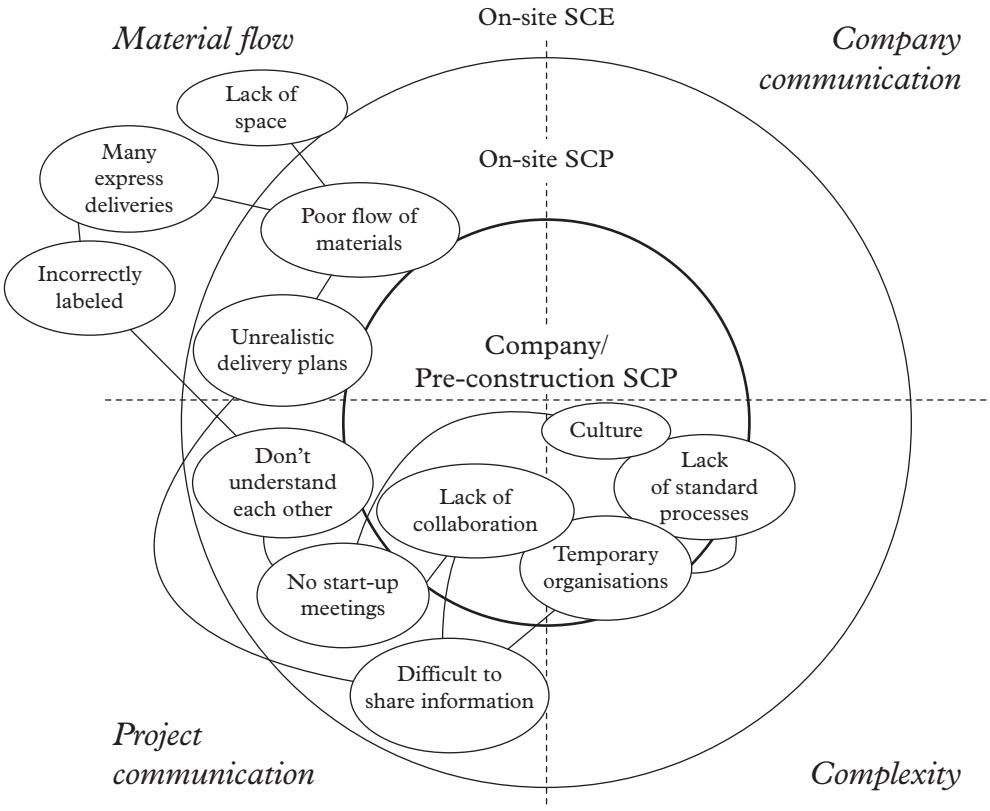

Figure 5. Problem linkages in case 1.

communication, project communication, or complexity. In the third step, some of the most common problems were mapped to the corresponding position in the conceptual model (Figure 2) for each case (Figures 5–7). The fourth and final step was to perform a cross-case analysis of the interviews to identify common patterns in the relationship between on-site problems and long-term planning decisions.

Several ways of improving validity have been used. First, the use of three types of respondents representing different aspects of the project and the supply chain helped to improve internal validity. Different perspectives were thereby gathered, reducing the potential bias of interviewing only one type of project/supply chain member. Second, external validity was improved by having multiple cases, as the presence of the same problem and linkages within several cases helped to confirm the analysis. Third, construct validity was improved because the interview guide was based on already published papers. The validity of the study has also been improved through examination of the field and interview notes by the second author. The different data gathering methods (interviews, observations and secondary data) allowed for triangulation and improved internal validity.

Case descriptions

Each subsection below is based on the interviews with the site managers, purchasers and suppliers for each case. The subsections below describe extracts of the responses and cover the different views on what problems exist and why they arise from a supply chain planning perspective. The subsections end with a within-case analysis aimed at answering RQ1.

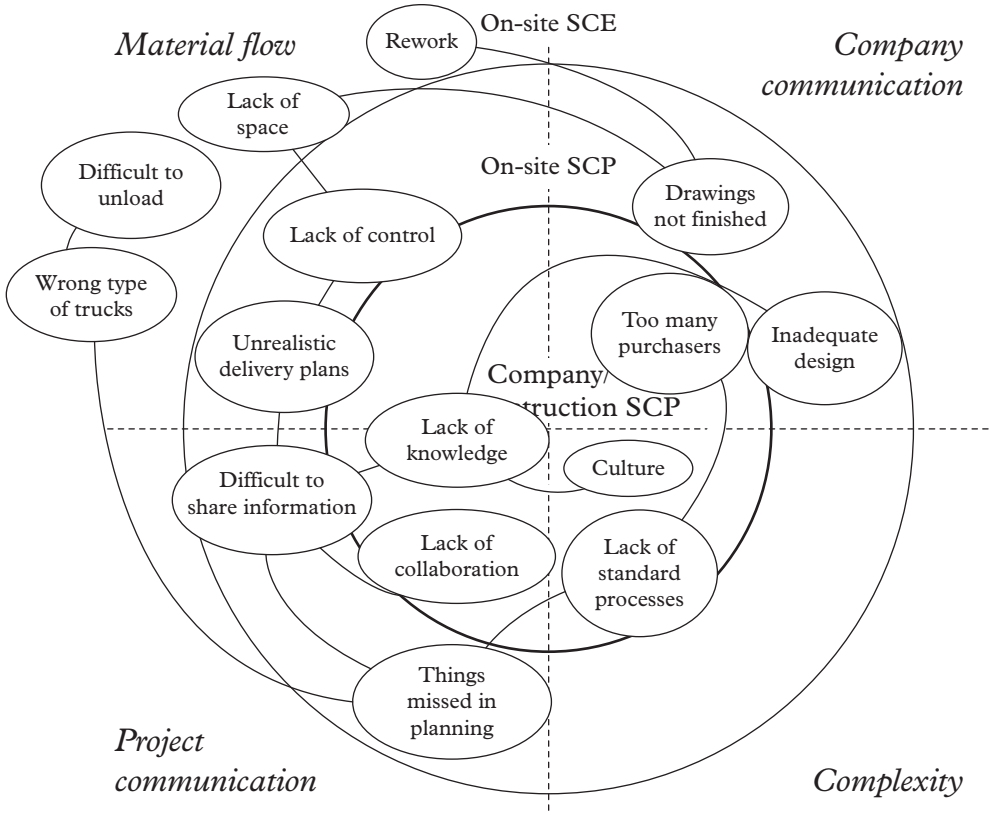

Figure 6. Problem linkages in case 2.

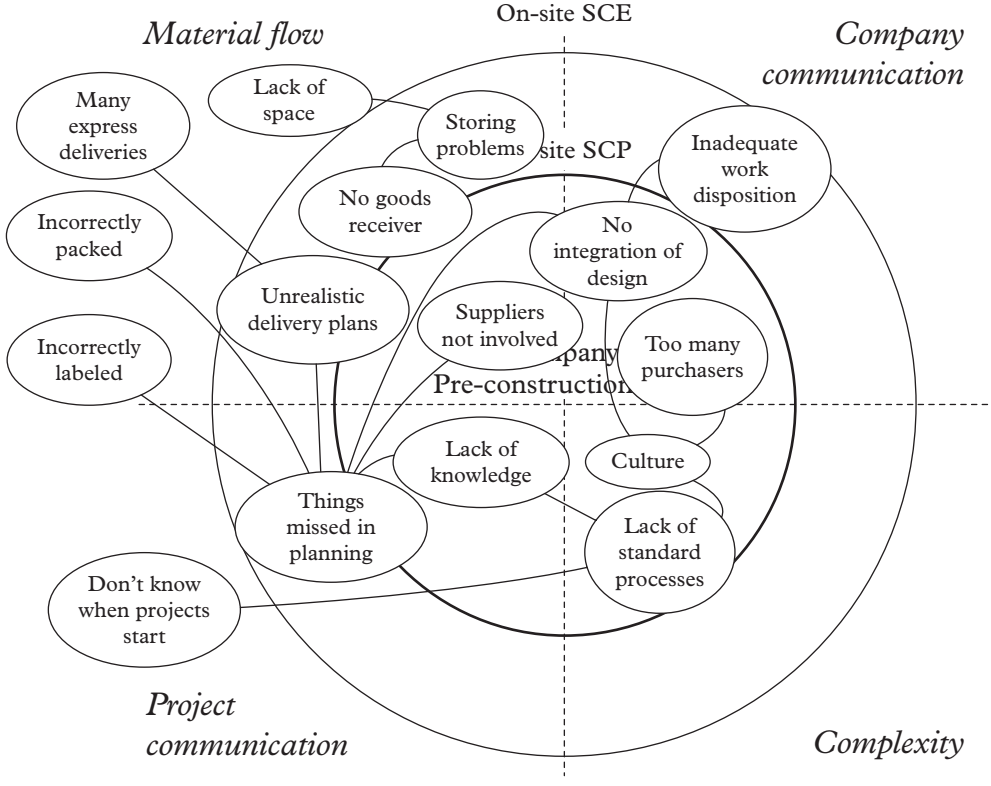

Figure 7. Problem linkages in case 3.

Case company 1

Case Company 1 is a construction company focusing on construction management and office building projects. This means that they do not supply the client with their own resources such as craftsmen, instead offering the client a project management function. All work and materials are sourced from subcontractors and suppliers. As of 2015, Case Company 1 had a turnover about €140 million, and all its projects are located within the Stockholm region. The company has a framework agreement with one of the largest kitchen suppliers in Sweden, which is part of a European kitchen group. Kitchen materials are often sourced via local agents by the site manager. One of the gypsum board suppliers is a local builders' merchant. Planning the supply chain is divided between the strategic purchaser and the site manager. The former establishes framework agreements with suppliers while the latter decides which supplier and subcontractor to use in a given project. Planning on-site is done weekly, including a coordination meeting involving all on-site supervisors to obtain an overview of the present status. During this meeting, the site manager delegates the work with contacting suppliers and subcontractors to on-site supervisors.

Site manager

The site manager in this case believes that suppliers and subcontractors should not be hired based on long-term contracts with strategic purchasing, as it is more important for him to hire the right person than a specific company. By always hiring the same person (regardless of where he or she works), he ensures efficient communication and better understanding. The site manager argues that a lack of communication and understanding of each other's work leads to problems such as mislabelled materials and lack of space on-site. Mislabelled materials make it difficult to execute production plans, as it takes a long time to identify whether materials have been correctly delivered.

Strategic purchaser

The strategic purchaser argues instead for long-term contracts to ensure long-term relationships, but believes that to avoid sub-optimization, they as the main contractors should take the responsibility for managing the subcontractors' material flows as well. If everyone cares only about their own materials, there is a risk of non-optimal utilization of space and other resources on-site. If one actor is responsible for coordinating the flow, there will be better space utilization, labelling and delivery reliability. He also argues that temporary organizations result from a lack of standardized logistic processes, and lead to difficulties in sharing information. He feels that it would be better if the main contractor also planned the subcontractors' material flows.

Gypsum board supplier

The gypsum board supplier agrees with the purchaser and argues for long-term contracts to enable long-term relationships. He also believes that long-term agreements and collaboration are necessary, as the arms-length culture of today has led to few early start-up meetings at the beginning of the project and little improvement of logistics. If a long-term relationship exists between the supplier and contractors, it is easier to demand early start-up meetings, which will improve communication and enable the creation of more realistic delivery plans because input from the supplier can be included in development. This, in turn, will lead to improved delivery reliability and allow for discussions on how to label materials according to the customer's wishes. The difficulty of sharing information often leads to unrealistic delivery plans and poor material flows, resulting in delays, etc.

Kitchen supplier

Similarly to the gypsum board supplier, the kitchen supplier argues for more early start-up meetings and being involved as early as in the design phase. Questions such as labelling can be dealt with if the suppliers are involved in the planning process. The kitchen supplier also argues that long-term collaboration and early involvement are important as they allow drawing mistakes to be identified. He mentions that drawings are not always realistic because the architect lacks knowledge on kitchens. They, as the supplier, have better knowledge, and can easily see whether drawings are realistic or not. The partner-like form of procurement applied in this project adds extra communication issues, as they, as retailers, are hired by the main contractor but work for the construction subcontractor. This means that they are involved in the project later than they would be normally. Late involvement of key actors makes it difficult to develop plans because important information is lost, resulting in several drawing deficiencies as the drawings cannot be revised early in the process. He also mentions that express deliveries are a problem, as the material flow is often not well planned from the contractor's side. One reason for this is that there are several purchasers, each with their own perspective on logistics and planning.

Within-case analysis case 1

Figure 5 is based on the conceptual model in Figure 2, and depicts the problems identified by the respondents as related to supply chain planning in Case 1. The site manager argued that lack of space and mislabelled materials occurred because contractors, subcontractors and suppliers did not understand each other's work. As the main responsibility for the work on-site lies with the site manager, he naturally has an operational planning

level perspective. The issues raised by him are therefore positioned at an on-site level in Figure 5. Some of his standpoints, such as considering long-term cooperation with suppliers and subcontractors as unimportant, even conflict with strategic level work. On the other hand, the strategic purchaser says that a lack of standardized logistics processes and temporary organizations leads to difficulties in information sharing. These issues are true if the suppliers are continuously changed between projects. This issue should be dealt with at a company level and are thus positioned in Figure 5. The gypsum board supplier has a more strategic viewpoint, analysing the problems as a lack of collaboration resulting in a lack of start-up meetings, for example. The site manager also discussed the lack of start-up meetings and concluded that this lack can result in problems with understanding each other on-site. Thus, the long-term collaborative issues can be linked to incorrectly labelled materials on-site. The kitchen supplier stressed the importance of dealing with pre-construction issues such as drawings. He argued that lack of collaboration early in the project resulted in difficulties in sharing information and developing realistic delivery plans for the project. To summarize the main linkages identified in Case 1, lack of a holistic perspective on supply chain planning leads to executional problems originating in company or pre-construction issues.

Case company 2

Case Company 2 is a construction company focusing on direct labour and multifamily dwelling projects. This means that dwellings are built without a client order and before all the apartments are sold. Most work, except construction work and materials, is outsourced to subcontractors. As of 2015, Case Company 2 had a turnover of about €1,300 million, and most of their projects are located in the cities of Stockholm, Gothenburg and Malmo. The company has a framework agreement with one of the largest kitchen suppliers in Sweden, which is one of the main competitors of the kitchen supplier in Case Company 1. Kitchen materials are often sourced directly from the supplier by a project purchaser via a project coordinator at the kitchen supplier. One of the gypsum board suppliers is a Norwegian building materials supplier. Planning the supply chain is divided into three planning levels. The strategic purchaser establishes long-term framework agreements with suppliers. The project purchasers are supposed to follow these agreements; however, he or she can overrule them and select other suppliers for a specific project. Thereafter it is up to the site manager to source non-key materials such as gypsum boards. Finally, the on-site supervisors are responsible for call-off of materials from suppliers. On-site planning is weekly coordination meetings with on-site supervisors from the subcontractors.

Site manager

The site manager describes how many of the problems he observes on-site are due to the lack of standardized processes and a lack of knowledge in regard to planning logistics. He also argues that communication problems are worse when there is a lack of standardized procedures to develop plans (such as production plans and delivery plans). This often results in suppliers using trucks that are difficult to unload on-site, potentially resulting in delays or even production stops. He thinks it is important for the suppliers to visit the site so that they can understand the project's circumstances.

Project purchaser

The project purchaser believes that planning is often difficult, and that several problems arise because architects are left alone to design features. These can often become unrealistic, making it difficult to procure suppliers and subcontractors. The inadequate design also leads to inadequate drawings, which can affect logistics on-site and increase the number of re-works. According to him, this is a generational issue, as young project managers are unsure of how to manage the design process. A team of experienced site managers and project managers should be consulted in every project. He also argues that the culture in the industry results in a lack of knowledge of logistics, as these questions are not discussed during the design phase, and that this lack of discussion is the source of many problems.

Strategic purchaser

The lack of standardized processes and knowledge is also recognized by the strategic purchaser. He argues for fewer project purchasers, to avoid adding an extra communication node which in addition has too much freedom to select suppliers. This prevents both standardization and long-term relationships, as strategic framework agreements in many cases are overturned. Communication itself can also be troublesome; an example of a communication issue caused by lack of standardization: when the suppliers contact the purchasers with important information about potential delivery delays, it is up to the purchaser to distribute this knowledge to the site managers. This communication issue exists because the purchasers have different working methods, and there is no clear definition of how communication should take place.

Gypsum board supplier

The gypsum board supplier argues for closer collaboration, beginning in an early stage of the project. When the retailer is able to review schedules early on, delivery

plans are more realistic. Early involvement and collaboration also make it easier for the contractor to know what services the retailer offers. Currently, the contractor often buys items from different retailers to achieve the lowest price, thus not benefiting from consolidation opportunities and flexibility. The retailer argues that this can increase construction costs. Early involvement also ensures there can be a discussion on what kind of trucks to use, easing unloading on-site.

Kitchen supplier

The kitchen supplier also argues for early involvement in discussing aspects such as truck types, which is an executional problem observed by the site mangers. She describes a lack of understanding of the suppliers' perspective, where work disposition plans are not thought through and adapted to the large delivery quantities required by kitchen supply. This results in the removal of construction elevators before the kitchens are delivered, making it difficult to unload the materials and resulting in a lack of space for storing materials. Because the suppliers cannot revise the drawings at an early stage, the drawings become outdated. This in turn causes the contractors to buffer materials, leading to even greater lack of space on-site.

Within-case analysis case 2

The purchasers and the site manager in this case are focussed on finding solutions that can be implemented throughout the company. All three highlight the importance of standardized processes for planning and logistics. This is possibly a result of the company history involving direct labour projects, and an overarching company philosophy of standardization. Figure 6 illustrates how the different problems identified in Case 2 can be linked to each other. The three levels of purchasers can, as indicated by the strategic purchaser, result in a lack of standardization in planning the supply chain. If the planning processes are not standardized, important aspects of planning may be omitted, such as which type of truck to use (gypsum board supplier) or a lack of space due to unrealistic delivery plans (kitchen supplier). As indicated by the site manager, the unrealistic delivery plans can also be linked to the lack of collaboration and knowledge sharing because information is hard to share when standardized processes are lacking.

Case company 3

Case Company 3 is one of the three largest construction companies in Sweden, with several types of projects and constellations. The company is divided into different regional functions each with their own project management department and purchase department. However, the task of establishing framework agreements is allocated to the centralized strategic purchasing department. As of 2015, Case Company 3 had a turnover of about €4,500 million. The company has a framework agreement with one of the largest kitchen suppliers in Sweden, the same as that for Case Company 2. Kitchen materials are often sourced directly from the supplier via a project coordinator at the kitchen supplier. The company also has framework agreements with one of the largest gypsum board suppliers in Scandinavia, and materials are sourced by a project purchaser via a salesperson at the supplier. The planning procedure in Case Company 3 is similar to Case Company 2 with three levels, except that the strategic purchaser has less influence over the specific project, and the site manager has more power to decide from whom to buy materials.

Site manager

According to the site manager, several of the problems observed on-site arise because many projects lack a goods receiver, which means that each subcontractor places and stores materials on-site as they please. According to the site manager, this causes chaos and a lack of space on-site. It should be the site manager's decision whether to have a goods receiver or not, due to the extra cost that the project will have to carry. Without a goods receiver to plan the logistics on-site, it is difficult to plan the use of construction elevators. However, if the site manager does not perceive logistics to be important, he/she will be unlikely to hire a goods receiver.

Project purchaser

The project purchaser raises the question of whether project purchasers are necessary at all. He believes that the strategic purchasers should do much of the work performed by the project purchaser today, and that the project purchaser should only call-off orders as needed. Currently, this extra node makes the cultural issues of procurement procedures even worse, as the project purchaser buys from whichever suppliers he chooses, rather than from the suppliers with which there are agreements. This hinders both standardization and improvement in communication. He also mentions the problematic cultural issue of people finding a problem exciting. This has led to a lack of integration of the design and construction processes; work disposition plans could therefore be several years old instead of thought through from the beginning and continuously updated.

Strategic purchaser

Cultural issues (such as arms-length relationship and attitude) are recognized by the strategic purchaser, who believes that these might lead to a lack of information sharing with suppliers, for example, how materials should be

packed. It is also important to establish communication with architects and suppliers as early as the design phase; for example, about how materials should be labelled. When labelling is standardized, it can be used in the drawings to ease information sharing with suppliers, who then can label their packages accordingly, making it easier for all parties in the information sharing process. According to him, this also ensures integration between the design and construction processes, as suppliers are involved early on and allowed to review drawings. He feels it is important to develop standards to improve knowledge in logistics.

Gypsum board supplier

The gypsum board supplier mentions that problems arise because time and resources are not spent on developing proper plans. The suppliers should be involved early in the planning phase, so that they can revise the plans, for example. Without this involvement, delivery plans could be inaccurate and additional express deliveries to the site could be necessary. Instead of calculating the need for gypsum boards in advance, many contractors often order materials as the need arises. He also argues that the culture regarding supply chain planning must change. The suppliers are not informed when projects start, resulting in late involvement, which affects communication, as agreements on how to communicate and plan are not developed early.

Kitchen supplier

The kitchen supplier also wants early involvement, as it is crucial to have high production capacity utilization, which early involvement in projects would help to improve. The contractors do not recognize that poor materials planning results in problems for the suppliers when scheduling production and deliveries. Instead, contractors think that they can just receive materials when needed. This lack of knowledge can lead to things being overlooked, e.g. if the suppliers' perspectives are not considered, the result could be an express delivery. Express deliveries are expensive for the suppliers; however, they pass the cost on to the contractor. Furthermore, information sharing is often difficult because they have to communicate with several purchasers. Better information sharing and better planning of the supply processes would reduce the need for express deliveries.

Within-case analysis case 3

It can be argued that the respondents in Case 3 have an on-site and project focus. It is discussed that it is up to managers in each project to plan the project as well as manage any problems that arise. This can be due to the size and the history of Case Company 3 with several types of projects that are geographically dispersed within Scandinavia. Case Company 3 has a history of autonomous projects, and this is also reflected in the strategic purchaser's perspective on planning. This is interesting as several of the problems identified by the respondents can be linked to a lack of standardization and lack of knowledge (illustrated in Figure 7). This signals the necessity of a mid-term to long-term supply chain planning process to share knowledge on planning the supply chain and sourcing materials in Case Company 3.

Cross case analysis

This section aims at answering the research questions posed in the synthesis section:

> RQ1: How can the linkages between common supply chain problems at different planning levels be illustrated?
>
> RQ2: What role does supply chain planning play in resolving common supply chain related problems in construction?

Table 2 presents the supply chain problems identified by the respondents following the structure of the conceptual model. Due to space and clarity constraints, Table 2 lists more problems than could be included in Figures 5–7.

Application of the conceptual model in Figure 2 to the three case studies (Figure 5–7) shows that the model can be used to answer research question 1. Applying the conceptual model to the three cases, a clear link can be demonstrated between on-site issues and a lack of supply chain planning on a long-term basis. Figures 5–7 show that short-term on-site supply chain-related problems occur as a result of a cascade of problems starting with the long-term supply chain-related problems occurring prior to construction on-site. The long-term problems were mentioned in one form or another by respondents from all the case companies (see Table 2), and often concerned lack of knowledge, lack of trust and lack of collaboration. However, the problems at an executional level differed. This means that at company/pre-construction supply chain planning level, the same problems are seen by all respondents, but their effect differs. This implies that the linkages that are created are specific for each company; nevertheless, the conceptual model can be used to structure the problems experienced.

During the initial phase of the study, the respondents saw SCM and logistics problems as equivalent to material flow problems. However, as can be seen in Figures 5–7, the root causes of the problems observed in the material flow on-site are associated with communication at company/pre-construction level, for example. Furthermore, all three cases experienced problems due to lack of cooperation, coordination, and long-term relationships. A consequence of this was lack of information sharing. Regarding coordination, the respondents in Case Company 1 experienced that goals were not shared between supply chain members,

Table 2. Categorization of problems. Superscript numbers indicate the case companies in which the problem was found.

	Material flow	Project communication	Company communication	Complexity
Company/Pre-construction supply chain planning	Lack of logistics measurement[2] Different perspectives on measurement[2 3] Use of external conveyors[1 2 3] Lack of understanding of supplier production[1 2 3] Lack of a logistics function[1 2 3] Lack of logistics improvement[1 3] Lack of total cost thinking[1]	Lack of collaboration[1 2 3] Lack of trust[1 2 3] Do not improve subcontractors[2] Many actors[1 2 3] Lack of knowledge[1 2 3] Too much collaboration[1] Lack of shared goals[1]	Lack of design integration[1 2 3] Not knowing what we want[2 3]	Lack of standard processes[1 2 3] Lack of time and resources[1 2 3] Procurement form design[1 2] Piecework design[2] Inexperienced client[1 2 3] Attitude[1 2 3] Culture[1 2 3] Autonomous projects[1 2 3] Too many standard processes[3] Construction contract form design[1]
On-site supply chain planning	Short notice[1 2] Buying materials from other suppliers[2] Lack of goods receiver[1 2 3] Lack of control[1 2 3] Unrealistic delivery plans[1 2 3] Lack of forecast[3] Lack of understanding of lead times[3] Late material orders[1 3]	Lack of start-up meetings[1 2 3] Not following agreements[2] Bad information to suppliers[2 3] Not incorporating time plans in supplier production[2] Difficulty in sharing information[1 2 3] Conveyors not involved in project[2] Not demanding that suppliers improve[1 2 3] Suppliers not involved in SCP[2 3] Lack of follow-up meetings[2 3] Becoming too locked up to one subcontractor[1] Inadequate subcontractor management[1]Subcontractors not involved early[1] Lack of team work[1] Bad subcontractors[1] Bad material flow[1]	Inadequate drawings and documents[1 2 3] Inadequate work disposition plan[1 2 3] Different perspectives on logistics and purchase[1 2 3] Unrealistic time plans[2 3] Many purchasers[1 2 3] Difficulty in purchasing[3] Inexperienced design leaders[3] Design leaders do not visit site[1] Site managers not included in selecting subcontractors[1]	Things missed[1 2 3] Inadequate workflow planning[1 2 3] Lack of IT systems [2] Dynamic sites and organizations[1 2] Reinventing the wheel[2 3] Internal competition[3] Pushing prices[3] Sub-optimization[1] Clients demanding time plan too early[1]
On-site supply chain execution	No construction elevator[2] Increased costs[1 2 3] Increased material price[2] Many express deliveries[1 2 3] Too much inventory[2] Buffering materials[2 3] Difficulty in planning supplier inventory and logistics[2 3] Production stop[1 2 3] Lack of space[1 2 3] Low delivery reliability[1 2 3] Conveyors leaving site[2] Multiple deliveries[2] Difficulty unloading[2 3] Wrong type of trucks[2] Not knowing where to place materials[3] Lack of goods receiving area[3] Low supplier inventory[3] Not knowing who ordered what[3] Faulty packaging[3] Inability to plan supplier purchases[1] Not knowing if materials have been correctly delivered[1] Materials not correctly labelled[1]	Inability to reach goods receiver[1 2] Delivery reliability not shared[1 3] Faulty information, or information provided to wrong person[1 3] Not knowing when projects start[3] Work disposition plan not shared[3] Suppliers do not demand information[1] Bad meeting attendance[1]		Schedule clashes[1 2 3] Same mistake[2] Re-work[1 2 3] Changes in time plans[1 2 3] Firefighting[2] Bad working environment[2] Changes from clients[1 2 3] Lack of creativity[3]

and all interviewees in Case Company 1 described a low level of information sharing among project members. An important part of supply chain planning is the sharing of information, knowledge and plans. These cases showed that several of the material flow-related problems such as late deliveries were due to information not being shared.

The company/pre-construction supply chain planning level problems are common to the cases because there is a lack of standardized processes for supply chain planning. For example, the respondents from Case Companies 1 and 3 saw low levels of logistic improvements as a reason for the common supply chain-related problems persisting between projects. It is interesting to observe that Case Company 2, a construction company with a clear focus on standardizing processes, is able to identify that some of the problems they experience are due to a lack of standardized processes. At the same time, Case Company 3 does not see the benefits of standardizing the planning process. One reason for this difference is that Case Company 2 has already discovered the link between lack of standardized planning processes and supply chain-related problems, and has started to deal with this issue by increasing the level of standardization, while Case Company 3 has not made this discovery. However, the suppliers in Case 3 all promote better standardization and raise problems in Case Company 3 that are due to lack of standardization. Thus, standardized supply chain planning processes have the potential to decrease the number of common supply chain problems occurring at site because they provides structures for dealing with these problems at an early stage in the construction process. The conceptual model can help illustrate how common supply chain-related problems experienced on-site are linked to the lack of a standardized supply chain planning process. This will help site managers and other decision-makers to realize the importance of supply chain planning, and to know what should be included in the supply chain planning processes to help them improve their situation.

Discussion

Earlier research in planning in construction has revealed different planning processes at strategic and portfolio levels as well as at project level (Gidado 2004, Winch and Kelsey 2005). However, in line with the argumentation by Engwall (2003), projects are affected by and affect the company in which they exist. Resources such as supplier capacity are taken from a common pool, and strategic decisions on market positioning etc. affect which projects will be tendered. In order to know whether resources are available already in the tendering phase of a project, it is important to link strategic and portfolio planning with resource plans and project plans for all projects within the company. Gidado (2004), Winch and Kelsey (2005) and (Wysocki 2012) all touch on this issues in their papers, and Dubois and Gadde (2002) and Vrijhoef and Koskela (2000) describe the chain of problems arising from the lack of connection between planning levels. However, none of them make a connection between decisions made prior to the project and their effects when executing the plan on-site. Thus, the contribution of this study is that it expands the existing body of knowledge on supply chain planning in construction.

Gupta and Maranas (2003) declare that supply chain planning can be used in improving coordination. Integrating the different actors of the supply chain would allow improved coordination as clients, subcontractors and suppliers could start to share information and plan at different levels. This would enable several of the root causes of the common supply chain-related problems occurring on-site to be resolved. According to Laureano Paiva *et al*. (2014) supply chain planning can be a facilitator for improving trust between the actors in the supply chain. Trust can be improved, as suppliers and subcontractors are engaged early in the planning process. They are thereby able to share their knowledge on planning, and to gain a broader understanding of the construction project as such.

The initial hypothesis of the study was that there should be logical links between different common supply chain-related problems, in accordance with the discussion by Dubois and Gadde (2002), and Vrijhoef and Koskela (2000), and that supply chain planning could be one way to address these problems. As such, it can be a facilitator for adopting SCM in construction. The proposed conceptual model in Figure 2 proved able to analyse and illustrate the linkages between problems in construction from long-term company/pre-construction to short-term executional. Thus, the model aids in understanding the origin of the problems. Understanding how problems are linked clarifies where to focus improvements. It also helps to understand why plans at different levels need to be connected. The results of this paper thus demonstrate the importance of research that connects the different planning levels in construction. Contractors often focus on improvements at the executional level, but fail to see the connections between planning levels and the reason the executional problems arise. Starting firefighting and implementing ad hoc solutions to solve executional problems in the different projects is not efficient if they are likely to reoccur in the next project due to lack of long-term planning. The conceptual model presented in this paper aids in illustrating which long-term problems must be dealt with at a company level in order to decrease the number of problems on-site. To summarize, the conceptual model developed can help to illustrate the linkages between supply chain problems in the Cases and the

planning levels, and thereby illuminate the root causes of the problems on-site. Given the discussion above, a proposition for further research is developed.

> Proposition: The root causes of different supply chain executional problems on-site are often the same throughout the industry, and originate with a lack of supply chain planning at company/pre-construction level.

Conclusions

The purpose of this paper was to study how linkages between common supply chain-related problems in construction can be illustrated to demonstrate how they could be resolved using supply chain planning. Two research questions were formulated to realize this purpose. The first concerned how linkages between common problems can be illustrated. The second concerned the role that supply chain planning plays in resolving these problems. A conceptual model (Figure 2) was developed, which was shown to be useful to illustrate how common supply chain problems occurring at executional level on-site were related to problems originating with lack of planning at company/pre-construction level. The study also shows how supply chain planning can aid in resolving common supply chain-related problems, thus answering the second research question. It is apparent that supply chain planning can play an important role as many of the problems stem from a lack of trust, communication and standardization. These factors are all covered in supply chain planning. A proposition for further research is formulated in the discussion, showing that the root causes of the executional supply chain-related problems are similar throughout the industry and are to be found at a company/pre-construction level. The contribution of this paper is that it provides further evidence that the construction industry should proceed to adapt SCM through supply chain planning.

Future research is needed to expand the knowledge on how different activities in supply chain planning processes can be used to overcome the identified problems. This study is based on three case studies with a total of 14 respondents in a similar context: Sweden, housing, mid-size to large projects and design-build contracts. This confers a lack of generalizability. The respondents were encouraged to add experiences from other projects, and most of the respondents were also experienced in working in non-housing projects. Therefore, although the model is developed based on house-building in a Swedish context, it should be possible to apply the conceptual model in different contexts. Another problem is not knowing whether the respondents acted as they said. This has not been validated in the study as the respondents were asked to talk about problems and how the problems were linked, and not about how the problems should be resolved. Additional cases from other contexts are needed to validate the findings in this study and to see how procurement strategies can help to implement supply chain planning.

Acknowledgement

We would like to thank the editors and reviewers for taking the time to provide invaluable feedback and improving the paper greatly. We would also like to thank the Development Fund of the Swedish Construction Industry (SBUF) for funding this work.

Disclosure statement

No potential conflict of interest was reported by the authors.

Funding

This work was supported by Development Fund of the Swedish Construction Industry (SBUF).

References

Akintoye, A., McIntosh, G., and Fitzgerald, E., 2000. A survey of supply chain collaboration and management in the UK construction industry. *European journal of purchasing & supply management*, 6 (3–4), 159–168.

Al-Hussein, M., *et al.*, 2008. Application of lean thinking to improve the productivity of water and sewer service installations. *Canadian journal of civil engineering*, 35 (4), 418–430.

Aloini, D., *et al.*, 2012. Supply chain management: a review of implementation risks in the construction industry. *Business process management journal*, 18 (5), 735–761.

Alreshidi, E., Mourshed, M., and Rezgui, Y., 2016. Requirements for cloud-based BIM governance solutions to facilitate team collaboration in construction projects. *Requirements engineering*, 1–31.

Arditi, D., Nayak, S., and Damci, A., 2017. Effect of organizational culture on delay in construction. *International journal of project management*, 35 (2), 136–147.

Atkinson, R., 1999. Project management: cost, time and quality, two best guesses and a phenomenon, its time to accept other success criteria. *International journal of project management*, 17 (6), 337–342.

Ballard, G., 2000. *The last planner system of production control*. Thesis (Doctoral). School of Civil Engineering - Faculty of Engineering, University of Birmingham.

Bankvall, L., *et al.*, 2010. Interdependence in supply chains and projects in construction. *Supply chain management: an international journal*, 15 (5), 385–393.

BIS, 2013. *Supply chain analysis into the construction industry - a report for the construction industrial strategy 145*. London: Department for Business Innovation & Skills (BIS).

Briscoe, G., Dainty, A.R.J., and Millett, S., 2001. Construction supply chain partnerships: skills, knowledge and attitudinal requirements. *European journal of purchasing & supply management*, 7 (4), 243–255.

Bryman, A. and Bell, E., 2015. *Business research methods*. 4th ed. Oxford: Oxford University Press.

Council of Supply Chain Management Professionals. 2013. *Supply chain management terms and glossary* [online]. Available from: http://bit.ly/1sYBIlP.

Cox, A. and Ireland, P., 2002. Managing construction supply chains: the common sense approach. *Engineering construction & architectural management*, 9 (5–6), 409–418.

Dainty, A., Moore, D., and Murray, M., 2006. *Communication in construction - theory and practice*. 1st ed. Abingdon: Taylor and Francis.

Dainty, A.R.J., Millett, S.J., and Briscoe, G.H., 2001. New perspectives on construction supply chain integration. *Supply chain management: an international journal*, 6 (4), 163–173.

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.

Dubois, A. and Gadde, L.-E., 2002. The construction industry as a loosely coupled system: implications for productivity and innovation. *Construction management & economics*, 20 (7), 621–631.

Edelenbos, J. and Klijn, E.-H., 2007. Trust in complex decision-making networks - a theoretical and empirical exploration. *Administration & society*, 39 (1), 25–50.

Ellegaard, C. and Koch, C., 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.

Engwall, M., 2003. No project is an island: linking projects to history and context. *Research policy*, 32 (5), 789–808.

Engwall, M. and Jerbrant, A., 2003. The resource allocation syndrome: the prime challenge of multi-project management? *International journal of project management*, 21, 403–409.

Faniran, O.O., Oluwoye, J.O., and Lenard, D.J., 1998. Interactions between construction planning and influence factors. *Journal of construction engineering and management*, 124 (4), 245–256.

Fleischmann, B., Meyr, H., and Wagner, M., 2008. Advanced planning. *In*: H. Stadtler and C. Kilger, eds. *Supply chain management and advanced planning - concepts, models, software, and case studies*. Berlin: Springer, 4th ed, 81–106.

Flick, U., 2009. *An introduction to qualitative research*. 5th ed. London: Sage.

Friblick, F., 2000. *Supply chain management in the construction industry - opportunity or utopia?*. Department of Industrial Management and Logistics, Lund University.

Gadde, L.-E. and Dubois, A., 2010. Partnering in the construction industry – Problems and opportunities. *Journal of purchasing and supply management*, 16 (4), 254–263.

Gajendran, T., Brewer, G., and Marimuthu, M., 2013. Internationalisation of construction business and e-commerce: Innovation, integration and dynamic capabilities. *Australasian journal of construction economics and building*, 13 (2), 1–17.

Gidado, K., 2004. Enhancing the prime contractor's pre-construction planning. *Journal of construction research*, 5 (1), 87–106.

Gupta, A. and Maranas, C.D., 2003. Managing demand uncertainty in supply chain planning. *Computers & chemical engineering*, 27 (8–9), 1219–1227.

Hatmoko, J.U.D. and Scott, S., 2010. Simulating the impact of supply chain management practice on the performance of medium-sized building projects. *Construction management and economics*, 28 (1), 35–49.

Johansen, E. and Wilson, B., 2006. Investigating first planning in construction. *Construction management & economics*, 24 (12), 1305–1314.

Jonsson, P. and Holmström, J., 2016. Future of supply chain planning: closing the gaps between practice and promise. *International journal of physical distribution & logistics management*, 46 (1), 62–81.

Jonsson, P. and Mattsson, S.-A., 2009. *Manufacturing, planning and control*. Berkshire: McGraw-Hill.

Jonsson, P., Rudberg, M., and Holmberg, S., 2013. Centralised supply chain planning at IKEA. *Supply chain management: an international journal*, 18 (3), 337–350.

Kaipia, R., 2009. Coordinating material and information flows with supply chain planning. *The international journal of logistics management*, 20 (1), 144.

Khan, K.I.A., Flanagan, R., and Lu, S.-L., 2016. Managing information complexity using system dynamics on construction projects. *Construction management and economics*, 34 (3), 192–204.

Lambert, D.M. and Cooper, M.C., 2000. Issues in supply chain management. *Industrial marketing management*, 29 (1), 65–83.

Laufer, A. and Tucker, R.L., 1987. Is construction project planning really doing its job? A critical examination of focus, role and process. *Construction management & economics*, 5 (3), 243–266.

Laureano Paiva, E., *et al.*, 2014. Supply chain planning and trust: two sides of the same coin. *Industrial management & data systems*, 114 (3), 405–420.

Love, P.E.D., Irani, Z., and Edwards, D.J., 2004. A seamless supply chain management model for construction. *Supply chain management: an international journal*, 9 (1), 43–56.

Lummus, R.R. and Vokurka, R.J., 1998. Strategic supply chain planning. *Production and inventory management journal*, 39 (3), 49–58.

Menches, C.L., *et al.*, 2008. Impact of pre-construction planning and project characteristics on performance in the US electrical construction industry. *Construction management & economics*, 26 (8), 855–869.

Meng, X., 2012. The effect of relationship management on project performance in construction. *International journal of project management*, 30 (2), 188–198.

Mentzer, J.T., *et al.*, 2001. Defining supply chain management. *Journal of business logistics*, 22 (2), 1–25.

Meredith, J., 1993. Theory building through conceptual methods. *International journal of operations & production management*, 13 (5), 3–11.

Mintzberg, H., 1979. *The structuring of organisations*. Upper Saddle River: Prentice-Hall.

Modig, N., 2007. *Material flows incurred by activities at project sites*. Thesis (Doctoral). Department of Technology Management and Economics, Chalmers University of Technology.

Pibernik, R. and Sucky, E., 2007. An approach to inter-domain master planning in supply chains. *International journal of production economics*, 108 (1–2), 200–212.

Platje, A., Seidel, H., and Wadman, S., 1994. Project and portfolio planning cycle. *International journal of project management*, 12 (2), 100–106.

Rudberg, M., Klingenberg, N., and Kronhamn, K., 2002. Collaborative supply chain planning using electronic marketplaces. *Integrated manufacturing systems*, 13 (8), 596–610.

Said, H. and El-Rayes, K., 2011. Optimal material logistics planning in congested construction sites. *In*: *Annual Conference of the Canadian Society for Civil Engineering 2011, CSCE 2011*. Ottawa, ON, 2505–2514.

Tennant, S. and Fernie, S., 2014. Theory to practice: a typology of supply chain management in construction. *International journal of construction management*, 14 (1), 56–66.

Thunberg, M., 2016. *Developing a framework for supply chain planning in construction* (Doctoral). Department of Science and Technology, Linköping University.

Thunberg, M., Rudberg, M., and Karrbom-Gustavsson, T., 2017. Categorising on-site problems: a supply chain management perspective on construction projects. *Construction innovation*, 17 (1), 90–111.

Tserng, H.P., Yin, S.Y.L., and Li, S., 2006. Developing a resource supply chain planning system for construction projects. *Journal of construction engineering and management*, 132 (4), 393–407.

Van Landeghem, H. and Vanmaele, H., 2002. Robust planning: a new paradigm for demand chain planning. *Journal of operations management*, 20 (6), 769–783.

Vidalakis, C., Tookey, J.E., and Sommerville, J., 2011. The logistics of construction supply chains: the builders' merchant perspective. *Engineering construction & architectural management*, 18 (1), 66–81.

Vrijhoef, R. and Koskela, L., 2000. The four roles of supply chain management in construction. *European journal of purchasing & supply management*, 6, 169–178.

Walker, A., 2015. *Project management in construction*. 6th ed. Chichester: John Wiley & Sons.

Wegelius-Lehtonen, T., 2001. Performance measurement in construction logistics. *International journal of production economics*, 69, 107–116.

Wickramatillake, C.D., *et al.*, 2007. Measuring performance within the supply chain of a large-scale project. *Supply chain management: an international journal*, 12 (1), 52–59.

Winch, G.M. and Kelsey, J., 2005. What do construction project planners do? *International journal of project management*, 23 (2), 141–149.

Wysocki, R.K., 2012. *Effective project management*. 6th ed. Indianapolis, IN: John Wiley & Sons.

Yin, K.R., 2009. *Case study research: design and methods*. 4th ed. London: Sage.