IDENTIFYING AND POSITIONING CONSTRUCTION SUPPLY CHAIN PLANNING PROBLEMS

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The construction industry struggles with an ineffective supply chain. A literature review, in combination with an empirical study aims at identifying and positioning perceived supply chain planning problems. The empirical part is a series of semi-structured interviews with construction site managers, purchase coordinators, and a project leader. Most site managers are responsible for mid-sized turnkey contracts, which enable comparison. Findings show that most of the supply chain planning problems relate to lack of coordination between actors, and that many of the problems discovered on-site originate from the supply process or the design process. Through proactive coordination of the actors in the supply chain planning process and the actors in the construction process, the problems on-site causing "fire-fighting"-activities could be reduced.

Keywords: coordination, planning problems, productivity, supply chain management, supply chain planning.

INTRODUCTION

A major challenge in construction projects is the planning process and its problems. Examples of main problems are lack of information (Laufer and Tucker 1987) and challenges in communication between actors (Dainty *et al.* 2006). However, little research has been focused on what problems exist when it comes to the supply chain planning process in construction. One exception is Bankvall *et al.* (2010) who has showed that many problems lay in coordinating works and plans among members in the supply chain process.

A common problem in the intersection between the project planning process and the supply chain planning process is poor delivery reliability when it comes to delivering material to site (Agapiou *et al.* 1998) and it has for a long time been discussed that the construction industry would benefit from implementing supply chain management (SCM) principles (Latham 1994). Vrijhoef and Koskela (2000) could show that additional costs of about 50 % are added to the purchase price due to improper management of supply chains and logistics. They also argue that productivity is negatively impacted due to the lack of SCM in construction. A first step when developing SCM is to identify typical problems in the supply chain planning process and to analyse where in the process they appear and from where they originate.

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A challenge when it comes to studying supply chain planning problems is where to draw the borderline between the "supply chain" and the "project". In this study we will differentiate between the supply process and the construction process, according to the structure in Figure 5. The supply process encompasses all activities for refining raw materials to a final consumer end product. According to the definition of SCM made by CSCMP (2013), an equal important part of the supply process is the production of the end product. The construction process, however, concerns the activities for developing and erecting a building object, also including the production on-site. It is in inevitable that these two processes will unify on the construction site and cannot be treated solitarily, the construction project encompasses both these two processes. The supply chain planning process does therefore concerns the activities for planning the flow of material and construction on-site but not activities performed prior to construction (like design). Although, decisions made in this activity might have severe impact on the supply chain planning process. The purpose is to identify common problems related to the supply chain planning process and to position their origin in the supply and construction process respectively.

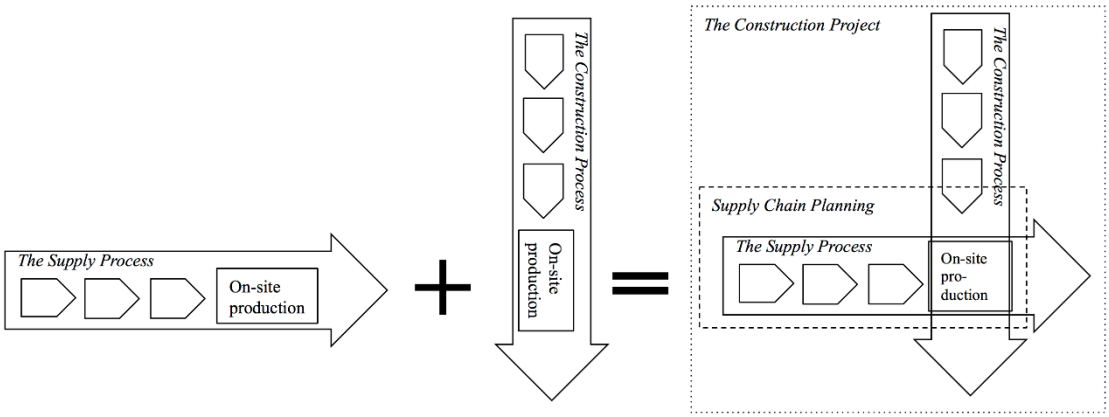

Figure 5 : A construction project as a construction and a supply process (Olsson (2000).

Based on the purpose, the following research questions are addressed:

- RQ1: What are the most common problems related to the construction supply chain planning process identified (a) in the literature and (b) empirically?
- RQ2: Where in the supply/construction process do these problems originate?

METHOD

This study employs a combination of a literature review, a series of semi-structured interviews, and deductive reasoning. The literature review, addressing RQ1a, takes a starting point in the (Latham 1994) report and strives at identifying supply chain related problems. The interviews, addressing RQ1b, are conducted with respondents from five construction companies, all having Sweden as their main market. Finally, RQ2 is addressed via deductive reasoning (based on the outcome from the first two questions).

The interview study included identifying suitable respondents. Contact was made with Sweden's two largest construction companies and one mid-sized construction company who all accepted to participate. Eleven respondents were selected to participate in the study, including eight site managers, two purchase coordinators, and one project leader. All respondents have several years of experience in construction, are mainly concerned with residential construction projects, and are considered to be

actively involved in the construction projects, thereby being "close" to potential problems on a daily basis.

Interviews were in-depth and semi-structured, and a set of pre-defined topics was documented on beforehand. This document was e-mailed to the respondents about one week before the scheduled interview, to allow for respondents to prepare. The interviews were recorded and lasted between one and two hours. Transcriptions of the interviews were analysed in a quality research software[2] to identify if different respondents, and companies, experience the same type of problems or not.

Regarding the analysis process, the respondents are grouped based on gender, age, profession, years active, and company. As the respondents are asked to keep one project in mind they can also be grouped based on project type, project monetary size, project time, and type of building object. In this manner, comparisons between different project types can be made to see if certain project types are prone to certain problems.

Notes were taken during the interviews for classifying identified problems, with respect to the preceding literature review. This made it easier to code the interviews afterwards. However, before the interviews were coded, all transcriptions and notes were studied in order to identify new codes and to verify already identified codes.

SUPPLY CHAIN PLANNING PROBLEMS

Problems in the Literature

Planning problems in construction is a common topic discussed in the literature. Already in 1987, Laufer and Tucker (1987) identified a number of problems corresponding to planning and they concluded that most of the literature concerned technical aspects of creating schedules. Searching for literature concerning supply chain planning problems yields few results. Those who do talk about supply chain planning problems (Bankvall *et al.* 2010) often mention more “traditional” project planning problems (lack of communication, coordination, etc.). However, many of the traditional project planning problems are also a sub-set of supply chain planning problems (see Figure 5). For example, scheduling errors might be seen as a project planning problem, but as the on-site production also is a supply “activity”, scheduling error thus also become a supply chain planning problem.

Those authors who focus on identifying problems both in the construction process and in the supply process have reported on many different problems. One problem is the interaction with subcontractors. Gidado (2004) reports that neglecting input from subcontractors in the planning process might lead to an increase in the amount of reworks plus a lack of a mutual agreement between the contractors on what the aim with the project is and how to plan. Gidado (2004) also discusses that plans are developed in short time, with limited resources, and without an understanding of planning difficulties and the project. Johansen and Wilson (2006) also identified that a lack of mutual perspectives on planning between participants might increase the amount of reworks. Menches *et al.* (2008) agree and report that both internal and external staff members are unfamiliar with the project.

One of the most common problems cited in the current literature regards information sharing. One example is a lack of information sharing when planning among project members (suppliers, subcontractors, etc.) (Bankvall *et al.* 2010, Fellows 2009). Kelsey

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et al. (2001) report that solutions to identified problems in one project are not shared to other projects, which is vital to achieve continuous improvements. Another information aspect concerns technical information. Soekov and Lill (2011) argue that key personnel in a construction project do not have the same understanding of the project. This is apparent if one profession does the planning, but another profession is supposed to execute the plan. Ballard and Howell (2003) argue that interdependencies between activities are often forgotten or not recognised. This is supported by Arditi *et al.* (2002), who also argue that greater emphasis on production rate should be given when developing plans. They also argue that workflow and the handover process between two activities of different trades are neglected when plans are developed.

González *et al.* (2009) describe the dynamic nature as one important factor that often is neglected in planning. They argue that most plans are developed based on the idea that the project will not be exposed to any "dynamic" circumstances. This is also highlighted by Laufer and Tucker (1987) that describe project uncertainty and local site variations in projects as problematic when planning. Finally, Kelsey *et al.* (2001) report that necessary inventory holding areas are not properly planned in advance, and Gidado (2004) argues that other types of intricacies are forgotten. If these kinds of plans are developed they are seldom updated properly (Kelsey *et al.* 2001). Table 6 below summarises the identified problems in the literature. For a full list of references, please refer to (Thunberg 2013).

Table 6 : Identified problems in the literature.

Problems	References	Problems cont.	References cont.
Different meanings	(Johansen and Wilson 2006)	Local variations	(Laufer and Tucker 1987)
Exclusion of subcontractors when planning	(Gidado 2004)	Planning difficulties and project specifics forgotten	(Gidado 2004)
Unfamiliarity of the project	(Menches *et al.* 2008)	Lack of time and resources	(Gidado 2004)
Information shortage	(Bankvall *et al.* 2010)	Dynamic projects	(González *et al.* 2009)
Not understanding the construction process	(Soekov and Lill 2011)	Not considering production rate and repetitiveness	(Arditi *et al.* 2002)
Interdependency	(Ballard and Howell 2003)	Workflow planning	(Arditi *et al.* 2002)
Project uncertainty	(Laufer and Tucker 1987)	Flows and inventories	(Kelsey *et al.* 2001)

Perceived Problems from the Interviews

Table 7 below depicts those empirically identified problems that were most often cited by the respondents. If compared with Table 6 above it can be seen that some problems are similar and some not (e.g. delivery reliability and transporter issues). The most common problems cited by the informants regard some kind of lack of knowledge, information shortage, and attitudes, etc. The respondents argue that important information (about e.g. work planning, incoming deliveries, etc.) is often lost. This together with faulty information was reported as common issues among the respondents, and cases where extensive re-works had to be made due to faulty information were exemplified by the respondents. Other effects might be that different contractors schedule work on the same location at the same time, as they do not share this information.

Table 7 : Empirically identified problems.

Problems	**Problems cont.**	**Problems cont.**
Attitude towards team-works etc. C1, C2, P1, S1, S3, S4, S5, S6, S7, S8	Flows and inventories C1, C2, S2, S3, S4, S7, S8	Knowledge transfer C1, C2, P1, S1, S2, S3, S4, S5, S6, S7, S8
Lack of long term agreements C1, C2, S2, S3, S6, S8	Lack of time and resources S1, C1, C2, S2, S3, S4, S5, S6, S7, S8	Changing site layout C1, C2, S1, S2, S3, S4, S7, S8
Unfamiliarity of the project C1, C2, P1, S1, S2, S3, S4, S5, S6, S7, S8	Unpredictable delivery reliability C1, C2, S2, S3, S4, S5, S6, S8	Goods reception issues C1, C2, S1, S2, S3, S4, S6
Information shortage S1, S2, S3, S4, S5, S6, S8	Dynamic projects C1, C2, S1, S2, S3, S4, S5, S6, S7, S8	
Workflow planning C1, C2, S1, S2, S3, S4, S5, S7, S8	Transporter issues C1, C2, S1, S2, S3	

Ci: Purchase coordinators (i=2), Pi: Project leaders (i=1), Sn. Site managers (i=8)

The interviewed project leader mentioned that there sometimes is an obsolete attitude towards teamwork mostly among the subcontractors. The site managers interviewed agreed, and some mentioned that some subcontractors do not want to attend coordination meetings, as they can "solve this by themselves". The site managers also reported that they perceive problems with the internal staff members off-site, typically mainly involved in early phases of the projects. One example mentioned was that purchase coordinators procure subcontractors and materials from a supplier that the site manager knows do not work well. This means that knowledge from the site managers is not shared among the internal staff. If knowledge from site managers regarding the supply process is not transferred to other functions (like architects etc.) it is a risk that the purchase coordinators procure materials that have a negative impact on the supply process. One example is that special materials with long lead times are procured instead of standard products with short lead times. The informants also mentioned that communication lacks due to limitations in time and resources. The purchase coordinators and site managers lack the time to sit down and talk-through the supply process. As can be seen, many of the problems identified concern some sort of *communication*. Attitude, information sharing, and knowledge transfer are all important parts of communication.

Another problem often mentioned by the interviewed site managers regards the flow and management of materials. The most frequently mentioned issue concerns that the contractors do not know when and where materials will arrive and in what condition, often termed delivery reliability in logistics literature. The site managers mentioned that it is difficult to plan and schedule resources for managing incoming deliveries. The site manager also observed another type of problem resulting from late deliveries; the contact with the transporter. First they need to contact the supplier to know who is transporting the materials. Then they have to contact the transporter to get information of when and where the materials will arrive. The site managers believe that the transporters and not the suppliers cause most of the delays. They also feel that too much time is devoted on contacting the transporter.

Other issues mentioned by the purchase coordinators are that the material flow of the subcontractors is not reconciled with the main contractor. They mentioned that schedules and plans are not properly developed based on the material flows. This can result in excessive materials on-site at certain times and that multiple (non-consolidated) deliveries are scheduled and not coordinated to the same date and time.

The goods reception is problematic as it is not coordinated among the contractors. These problems all concern *material flow issues.*

Other problems when it comes to planning regard *complexity* factors. One problem often mentioned is the site layout. Workflow plans and inventories are often not updated with the changing layout of the site. The site managers argued that a work-site plan needs to be developed and be kept up to date. This plan also needs to be communicated to other contractors. This work plan also affects where inventory-holding areas can be located to not interfere with the craftsmen's activities. Another complex factor is the set of new contractors in the supply chain for each project. The site managers often mentioned long term agreement as a positive factor for planning workflow, material flows, and to overcome communication barriers (such as attitude).

PROBLEM GROUPING AND POSITIONING

From the discussion made in previous section four major problems areas appears; material flow issues, internal communication, external communication, and complexity (see Table 8). Internal communication regards communication with internal staff-members off-site at the main contractor, while external in this case regards communication with subcontractors, suppliers, and clients. Problems identified in the interviews like attitude towards meetings and planning together with a lack of and faulty information and lack of time and resources all concerns means to deal with communication. In comparison with the literature it is also evident that unfamiliarity of the project, exclusion of subcontractors in the planning process, workflow planning, different meanings, lack of long term agreements, not understanding the construction process, interdependency between activities, and not considering production rate and repetitiveness also concerns communication.

Material flow issues include goods reception issues, flows and inventories, transporter issues, delivery information, and delivery reliability. Other problems that could be grouped are site layout and dynamic projects from the interviews with local variations, project uncertainty, intricacy forgotten, and long term agreements from the literature. They all concern some sort of complexity. For communication, some problems exist both for the internal and the external part. For attitude, it can both mean sub-contractors attitude towards teamwork but also attitude among internal staff-members to co-work when developing plans.

Olsson (2000) argued that many problems originate from a lack of reconciling the supply process with the construction process. This is depicted in Figure 6 where the two processes meet on the construction site, the left-hand part depicting where the problem areas is located. From the interviews it is identified that internal communication problems (P2) arise in the pre-construction/design phase and its interaction with the construction site. The external communication problems (P3) on the other-hand are more associated with the supply process as the respondents concerned it as the communication with suppliers and subcontractors. To achieve a smooth production process, subcontractors and suppliers must be involved in an early phase to safeguard that the material flow process is designed appropriately.

Material flow issues (P1), however, concerns problems that is associated with the supply process. For example, the transporter issue is due to a flaw in the supply process and not in the construction process. Finally, complexity problems (P4) result from an inadequate interaction between the pre-construction processes and the

construction on-site. Even if the complexity is difficult to manage on beforehand, standard procedures can be developed in order to reduce its impact.

Table 8 : Grouping common problems from both the literature and the interviews.

Material Flow (P1)	**Internal Com. (P2)**	**External Com. (P3)**	**Complexity (P4)**
Goods reception issues	Knowledge transfer	Knowledge transfer	Project uncertainty
Flows and inventory	Attitude towards team-work, etc.	Attitude towards team-work, etc.	Local variations
Transporter issue	Information shortage	Information shortage	Dynamic projects
Delivery information	Unfamiliarity of the project	Unfamiliarity of the project	Planning difficulties and project specifics forgotten
Delivery reliability	Lack of time and resources	Meeting attendance	Changing site layout
	Not understanding the construction process	Lack of long term agreement	Lack of long term agreement
	Interdependency	Workflow planning	
	Not considering production rate and repetitiveness	Exclusion of subcontractors	
		Different meanings	

As discussed by Olsson (2000), it is important that both the construction and the material flow processes are considered when developing plans. Some of the problems discussed earlier can either be associated with the supply or the construction process. However, it is important to realise that these problems might exist because the two processes are not reconciled. Supply issues might arise due to a lack of transferring knowledge between design and construction teams. The design team might plan to use one sort of material that impacts the supply chain negatively (e.g. reduced delivery reliability or increased cost or lead time), which is acknowledged by some of the respondents. Decisions made in the design phase do have an effect on the supply process, but the design team does not know how the decisions on materials, solutions, etc. affect the material flow and thereby the project overall.

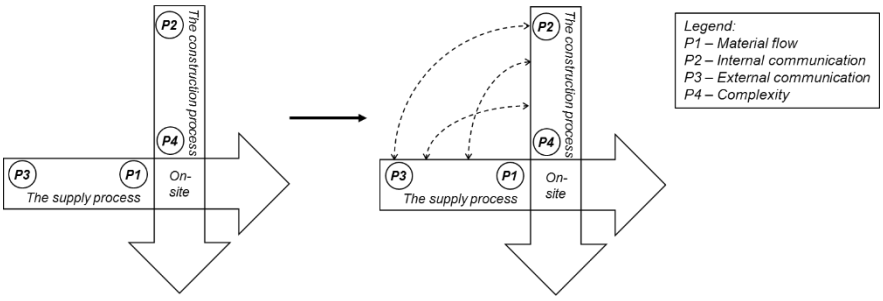

Figure 6 : Left: Mapping groups of problems to the construction and supply process. Right: Decisions made in the construction process affect the supply process.

To reconcile the construction and supply processes is vital, and key aspects of coordination concerns communication (both internal and external), collaboration, and knowledge transfer (Bankvall *et al.* 2010). It can then be argued that all four problem groups identified above actually to some extent concern coordination. Material flow issues stem from a lack of coordinating plans among contractors and suppliers.

Internal communication on the other-hand also regards a lack of coordinating the activities off-site in the preconstruction phase with activities on-site, including lack of sharing information and knowledge. External communication is a lack of coordinating work and information between contractors, sub-contractors and suppliers. Finally, complexity is mostly a result of not coordinating activities off-site. Plans developed off-site can often be revised if the construction team is advised early on in the process. They know much about complexity and can revise the plan based on their knowledge. A construction project is inherited with complexity due to many members and the separation of the supply and the construction processes. This implies that in order to cope with the complexity, coordination is important.

At the midst of the problems arising from poor coordination is the on-site activities. Yet, none of the site managers mentioned coordination in itself as a problem. At an operational level "coordination meetings" are held on a weekly basis with subcontractors. Internal processes at a tactical level is however not coordinated, one example being lack of coordination between the purchasing function and the production team. However, the purchase coordinators interviewed were all consistent in that this is the overall issue to tackle in order to overcome many of other problems occurring on-site. Faulty plans, lack of information, faulty materials, etc., often stem from a lack of coordinating plans among internal functions and external partners in an early stage in the construction process, in the design phase. As it is now, plans are developed by the main contractor and handed over to the subcontractors allowing them to develop their plans separately. To develop robust plans it would be preferable if both the supply process and the construction process are reconciled/coordinated (see the right-hand part of Figure 6), illustrated with the dashed arrows in Figure 6. To get the full potential of the coordination this should be done both internally at the main contractor, but also externally with supply chain members.

Many construction companies (and researchers) argue for implementing SCM principles, yet successful implementation of SCM in construction seem to be lacking. Mentzer *et al.* (2001) argue that to implement SCM, one must first become supply chain *oriented*. This means that the company must first align all its processes and functions to strive at the same goal, i.e. to coordinate internal processes. Some of the aspects that have to be in place to achieve this are trust, commitment, top management support, etc. Many respondents reported on a mismatch between the internal functions and the production team when it comes to supply chain planning. They also reported on a belief that more focus should be placed on the design phase and how decisions regarding the production affect the supply chain and vice versa.

Olsson (2000) discuss that the lack of 'integrating' the construction/design phase with the supply chain is one of the reasons for why problems arise. One first step could be to integrate the plans among project members in an early stage. However, the interviewed site managers are afraid their workload will increase, if they will be responsible for this coordination. This is probably a natural reaction from their point of view, but having Mentzer *et al.* (2001) in mind, a more appropriate step would be to put this coordination process in the design phase with the design phase team (with the supervision of the project manager) as accountable. The site managers should of course be consulted to capture important knowledge about the production and supply chain.

CONCLUSIONS

This study sets out to investigate what problems there is when it comes to supply chain planning in construction. Results from a literature review and interviews with construction personal help in forming a list of common problems and reasoning about where in the construction process they originate. It is concluded that the overall problem is a lack of coordination. The identified problems can all be grouped into material flow issues, internal and external communication, and complexity. Addressing the coordination issues can have a positive impact on material flow issues, internal and external communication, and complexity. In order to coordinate the supply chain planning processes one must first cope with lack of coordinating internal processes.

Operational problems exist when it comes to the construction process and its planning/scheduling. The supply process in construction has just in recent time received attention from both construction management researchers and the operations management researchers. However, few authors connect the supply process with the construction process to see where problems (first discovered on the construction site) originate. Figure 6 shows that many "on-site problems" do actually originate from earlier on either in the construction process or in the supply process. This also suggests a greater attention to coordination. For example, if decisions made in the design process are not coordinated with the production team and the supply process it can have a negative impact on the overall performance. The design team might e.g. design a house with materials that just a few suppliers manage to produce. This will have consequences on costs and lead times.

An important insight is that many of the identified problems are not addressed on beforehand in the pre-construction phase; instead a "fire-fighter" mentality is common (fix the problems when they become a problem). Another insight is that at the beginning few respondents reckoned that they had problems. This is common as what they saw as a normal situation can be seen as problems by an external investigator. Finally, one way of overcoming the supply chain coordination issue is to design a planning process that does take knowledge and information from different contractors, suppliers, and internal staff into consideration. This might be done through an iterative mentality when developing plans in the design phase. Instead of "pushing" plans down to the subcontractors they should be developed more "co-jointly". This puts pressure on developing long term contractors with subcontractors plus devoting enough time and resources in the design phase. The idea is to develop a more robust plan that already on beforehand is scrutinised for any error and issues that could be solved.

For the industry this study contributes in addressing problems with supply chain planning which might not be recognised by all hierarchical levels in a construction company. It also contributes in an identification of where the problems originate in the construction process plus connects this process with the supply process. For academia, many problems are listed before but not connected to the supply process. This suggests that the borderline between a construction supply chain and the construction process is thin and that the industry needs to take the supply chain and its coordination into consideration when developing plans. This implies that the industry still has a long way left to implement SCM principles. Further research lies in identifying if different members of the supply chain share the view of what is a problem or not, and how they can be overcome.

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