CHALMERS

The Impact of Material Delivery Deviations on Costs and Performance in Construction Projects

Master's Thesis in the Design and Construction Project Management

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CHALMERS UNIVERSITY OF TECHNOLOGY
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ABSTRACT

Research shows that material delivery deviations such as delayed deliveries, quality defects and incorrect quantity are common within the construction industry. However, there are few studies investigating how suppliers' performance affects construction projects in terms of costs, quality and time. Therefore, this study aims to investigate how material delivery deviations impact on costs and performance in construction projects and how deviations are handled at construction sites. The study also examines what the shortcomings in the order-to-delivery process are and how the purchase department considers suppliers' performance. To fulfill the aim, measurements of delivery deviations in three residential projects at Skanska Sweden AB have been carried out as well as interviews with respondents from construction sites and the purchase department. The measurement, which is based on five material categories and 198 deliveries, shows that 44% of all deliveries result in at least one type of deviation. The result varies between the projects and material categories and for one of the material categories all of the measured deliveries were associated with at least one deviation. The most common reason for material delivery deviations was communication failure and poor communication between construction sites, the purchase department and suppliers was observed. Furthermore, delivery deviations in one of the projects caused additional costs corresponding to 10.1% of the invoiced sum for the measured material, but the figure is probably higher since 'hidden' costs were not considered. The study also shows that delivery deviations are seldom reported, there is no economical consequences for suppliers when not performing according to the contract, information from suppliers about delivery changes is often poor and total costs when procuring suppliers is seldom considered. Delivery deviations have for a long time been accepted by contractors, but the result of this study should address a changed attitude towards suppliers' performance. Conclusively, companies who start focusing on delivery deviations can gain many benefits, in terms of increased performance and decreased costs.

Key words: supply chain, material handling, purchasing, costs

Avvikelser i Materialleveranser och dess Inverkan på Kostnader i Byggprojekt
Examensarbete inom Design and Construction Project Management
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SAMMANFATTNING

Forskning visar att materialleveransavvikelser så som sena leveranser, kvalitets brister och kvantitets brister är vanliga inom byggprojekt. Det finns dock få studier som undersöker hur leverantörers prestationer påverkar kostnader, kvalitet och tid i projekt. Den här studien syftar därför till att utreda hur materialleveransavvikelser påverkar kostnader och prestationer i byggprojekt och hur avvikelser hanteras på byggarbetsplatser. Studien ämnar också visa vilka brister som finns i processen från order till leverans och hur inköpsavdelningen beaktar leverantörers prestationer. Mätningar av leverantörers prestationer har utförts i tre olika husprojekt inom Skanska Sverige och intervjuer har även genomförts med respondenter från projekten och personer inom inköpsavdelningen. Mätningarna är baserade på 198 leveranser och fem material kategorier och resultatet visar att 44% av alla leveranser resulterar i åtminstone en avvikelse. Resultatet varierar mellan projekten och mellan material kategorier och för ett av materialen så var alla leveranser förknippade med minst en avvikelse. Den vanligaste orsaken till leveransavvikelser var kommunikationsbrist och brist på kommunikation observerades mellan byggarbetsplatser, leverantörer och inköpsavdelningen. De flesta leveransavvikelserna medförde extra kostnader och i ett av projekten uppgick kostnaderna för leveransavvikelser till 10.1% av den fakturerade inköpssumman. Kostnaderna är förmodligen högre eftersom det finns många dolda kostnader som inte är inkluderade. Studien visar också att leveransavvikelser sällan rapporteras, att leverantörer inte drabbas av några ekonomiska konsekvenser om de inte levererar i enlighet med kontraktet, att information från leverantörer om order- och leveransändringar är bristfällig och att totalkostnaden sällan beaktas när leverantörer upphandlas. Leveransavvikelser har länge varit accepterat inom byggbranschen, men resultatet av vår studie borde leda till en förändrad attityd när det gäller leverantörers prestationer. Sammanfattningsvis kan nämnas att det finns en stor förbättringspotential inom materialleveransområdet och företag har mycket att vinna om de börjar fokusera på leveransavvikelser.

Nyckelord: materialleveranser, kostnader, inköp, leverantörer, byggbranschen.

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Göteborg, June 2010

Lisa Darvik & Julia Larsson

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1 Introduction

The construction industry is strongly dependent on subcontractors and material suppliers. Costs for purchasing material and services represent 75% of the turnover for Sweden's three largest construction companies (Dubois & Gadde, 2000), and purchases of material correspond to at least 40% of the contract sum in a construction project (Boverket, 2005). Although material suppliers have a great impact on costs, quality and time in construction projects, there are few studies investigating how suppliers performance affect these parameters. Hadikusumu et al. (2005) state that material delivery deviations, such as delayed deliveries, incorrect quantity and quality defects, are common in the construction industry, but measurement of material delivery deviations is a neglected area in construction, both by contractors and by construction management researchers.

Other industries, such as the automotive industry, have daily inspections and measurements of incoming goods and suppliers' performance (Bengtsson & Gustad, 2008). These manufacturing companies believe that their success in a great extent is dependent on suppliers' performances. Hence, by supporting suppliers to improve their processes, the manufacturing companies believe they will cut costs as well.

Effects on delivery performance after implementation of supplier development activities, such as continuous feedback of delivery performance to suppliers and formal evaluations of suppliers, have been studied by Krause (1997). Krause (1997) investigated the impact and benefits of supplier development in various types of organizations in the US and revealed that the suppliers' performance increased after supplier development activities had been implemented. Organizations with supplier development focus experienced fewer quality deviations, increased on-time deliveries, decreased quantity deviations and reduced cycle times.

Supplier development studies in construction are rare; however, supplier-contractor relations in the Swedish construction industry have recently been studied by Frödell (2009). Frödell found that many constraints have to be overcome before efficient supplier-contractor relations can be developed, implemented and maintained. Many of the constraints relate to the contractor's organizational structure and behaviour. Individual ways of working and project focus instead of focusing on the organization's best when making decisions are addressed as organizational constraints in Frödell's paper. Another identified constraint is the contractor's long-term/short-term perspective and Frödell (2009) questions the contractor's willingness to develop long-term relationships with suppliers, when measurements and incentives systems encourage reduction of prices each year. Frödell states that the organization's measures- and incentives systems rather drive the organization to a short-term perspective regarding supplier relations.

Contractor's short-term perspective was also brought up by many of the discoursers during an industry seminar at Chalmers University of Technology, hosted by CMB (Center for management of the built environment) in February 2010. The discourses argued that a total cost perspective instead of lowest prices should be in focus when contractors procure suppliers. Bertilsen and Nilsen (1997) also address this issue and state that the purchasing department within construction companies far too often only considers the cheapest price when procuring materials. Contradictory, Stock and Lambert (2001) point out that some of the most important aspects to consider when procuring suppliers are delivery precision, material quality and lead-time.

Moreover, the Swedish construction industry has during the latest decade been highly criticized, by both government and construction researchers, for being inefficient, associated with low quality and high costs (Josephson & Saukkoriipi, 2005; Byggkommissionen, 2002). The criticisms towards the industry in combination with the increasing competition on the market have made Swedish construction companies realize that productivity improvements and decreased costs are needed. Focus on purchases has been one of the strategies to cut costs and many of the major construction companies have today a centralized purchase department (Gunnerbeck & Hassel, 2004). A centralized purchasing department gives opportunity of purchasing greater order quantities and the companies can thereby cut costs when signing framework agreements with material suppliers. Another consequence of a centralized purchasing organization is that supplier relationships are moved from the construction site to the central department. Van Weele (2005) argues that purchases affects all business areas in a company and it is therefore important that all business areas can influence the purchases, so the outcome becomes optimal for the whole company. To reach the best effects of a centralized purchasing organization the company needs a way of working that supports feedback between the construction site, the purchasing department and the suppliers (Gadde & Håkansson, 1998). In order to know if the outcome is optimal, suppliers' performance has to be measured. As the old axiom says, "you cannot improve what you do not measure".

1.1 Purpose and scope

The purpose of this study is to investigate how material delivery deviations affect costs and performance in construction projects. The study examines how delivery deviations are handled at the construction site as well as at the purchase department.

To fulfil the purpose, the following research questions have been formulated:

RQ1) How common are material delivery deviations and which consequences and costs can be related to deviations at the construction site?

RQ2) What are the shortcomings in the order-to-delivery-process and in the way of handling material delivery deviations at the construction site?

RQ3) How is suppliers' performance considered by the purchase department?

In order to fulfil the purpose, a case study at Skanska Sweden has been conducted. The case study is based on three residential projects within the department Building Construction, Gothenburg Region. The process from order registration to material assembling is the main focus of the study. However, in order to investigate how suppliers' performance is considered when contracts are renegotiated, the evaluation process is also taken into account. Furthermore, when analyzing actions related to material delivery deviations, the actors taken into consideration are the purchasing department, the production department, the supplier and logistic firms. Finally, the study is limited to material deliveries from suppliers with framework agreements and does not include service deliveries from suppliers.

2 Presentation of Skanska

Skanska is one of the major companies that dominate the Swedish construction and civil engineering market. Skanska Sweden (hereafter referred to as Skanska) is part of the global company Skanska AB, which had a turnover of SEK 143.7 billion in 2008 and is employing approximately 60 000 people. Skanska's contribution to the turnover was SEK 30.3 billion and had in 2009 approximately 10 000 employees. Skanska is each year involved in approximately 3500 projects and purchases of material and services for the projects represent 70-80% of the turnover. Of total purchases approximately 45% represent purchases of material, where half are made from suppliers with framework agreements.

Skanska's vision is to become a role model in Swedish industry and has as a goal to become the most professional construction company. To make progresses towards the vision Skanska has as strategy to improve performance in existing business areas and to actively develop an efficient construction process. Decrease costs by increased industrialization and more efficient purchases is also part of the strategy.

Furthermore, Skanska Sweden is divided into support functions and the three units; Civil Construction, Asphalt & Concrete and Building Construction, see Figure 1. The support function includes economy, HR and project support, where procurement and purchasing is one part. In this study the main focus is on the unit for Building Construction, but the Purchase organization will be considered as well.

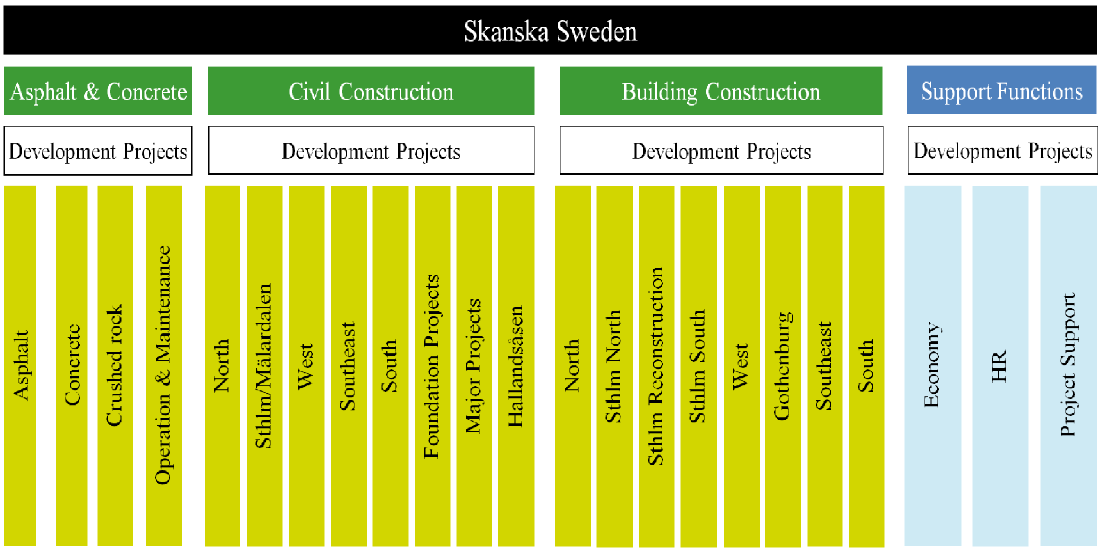


Figure 1. *Organization Chart for Skanska Sweden.*

2.1 Building Construction in the Gothenburg Region

Building Construction Gothenburg Region is one of eight regions in the business unit Building Construction. In Figure 2, the department's organization chart is presented. The department is divided into four districts, all with different types of projects in focus and each district is governed by a district manager. The districts managers have in turn two to four project managers that are responsible for a couple of projects. In 2009 the region had 282 employees. Purchases of goods and services contributed in

2008 with 760 MSEK to the turnover and approximately 65% of all purchases were made from suppliers with framework agreements.

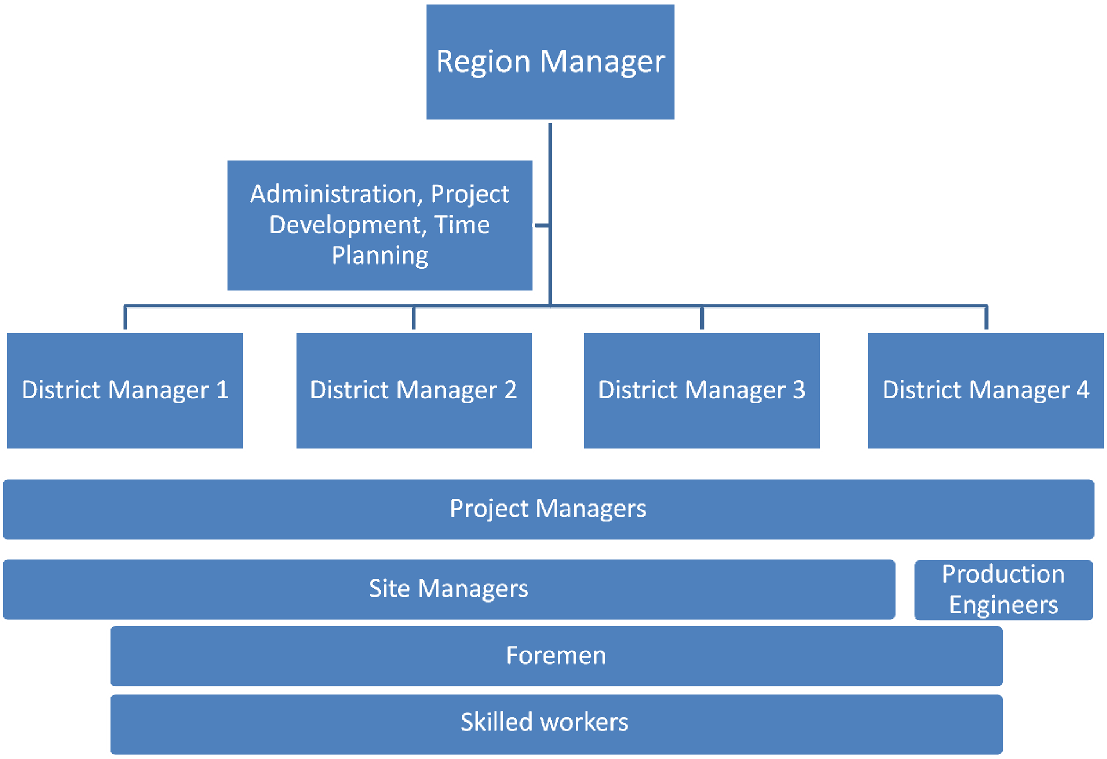


Figure 2. *Organization chart for Building Construction Gothenburg Region.*

2.2 Nordic Procurement Unit

The purchasing organization has during the latest year been going through a transformation and Skanska has since 2009 a centralized purchasing department, Nordic Procurement Unit (NPU). NPU is a service function that provides support and a wide range of other procurement related services to the line organization in Sweden, Finland and Norway. The organization has today approximately 210 employees working in the five main functions: Project Support, Framework Agreement, Logistics, Support Staff and Communication. Until 2012, the Nordic Procurement Unit will focus on:

• Improving current framework agreements (FWAs)

• Increasing the number of FWAs by extending existing ones into other regions, business units (BU) and other selected areas

• Improving procurement support in bidding & estimating phases

• Improving project procurement

In the longer run, NPU will also focus on establishing closer subcontractor relationships as well as support BU initiatives around improving site logistics.

3 Theoretical Framework

This chapter gives a brief overview of previous research related to buyer-supplier relationship, how delivery deviations are handled, costs of material delivery deviation and measurement as well as evaluation of suppliers' performance. The theoretical framework provides information from research within both construction and other industries.

3.1 Supply chain management

The supply chain consists of a set of activities that are linked to each other and involve material-, information- and financial flow between two or more companies. The traditional approach for organizations is to view themselves as a solid entity independent of other actors and that they need to compete with them to survive (Christopher, 1998). Christopher (1998) argues that units' solely attempt to reduce costs will only transfer the costs upstream or downstream the chain and will not increase their competitiveness.

The idea of supply chain management (SCM) is to go beyond the traditional view and instead focus on creating value for all parties in the supply chain and make the whole chain more competitive (Akintoye, McIntosh, & Fitzgerald, 2000). Christopher (1998) states that competition then occurs between supply chains rather than between companies.

A win-win situation is fundamental for developing an effective supply chain built on trust (Stadtler & Kilger, 2008). Supply chain management is based on integration and coordination and the concept has been widely applied in a range of industries that have experienced many advantages (Akintoye et al., 2000; Stadtler & Kilger, 2008). Reduced lead times, better quality and reduced costs are some of the advantages that has been identified after implementation of SCM. The external integration of SCM in relation to material supply typically includes supplier rationalization and implementation of a supplier evaluation system. With fewer suppliers long-term relationships can be developed and many benefits can be gained.

Integration and coordination is the foundation for an effective supply chain. Christopher (1998) suggests that a traditional chain with business units acting independent in isolation from the other business units can be developed to an integrated supply chain in three steps. In the first step, functional integration, the barriers between the functions purchasing, material control and production are merged to create a more integrated work process between functions. The second step put internal integration in the spotlight and includes establishment and implementation of an "end-to-end" planning framework. External integration is the focus in the third stage, where the linkage and co-operation that is implemented in step two is extended upstream and downstream the supply chain to suppliers and customers.

Creation of external integration includes choice of co-operators and identification of each actor's core competence. By letting each actor perform their key area waste can be reduced and a competitive supply chain achieved (Stadtler & Kilger, 2008). Procurement of new actors to the supply chain should according to Stadtler and Kilger (2008) be based on criteria that strengthen the chain's competitiveness rather than lowest price. Furthermore, another aspect that has to be considered is the company's ambition and culture, which should go hand in hand with the supply chain's ambition and culture. Successful implementation of SCM requires understanding and acceptance of the concept within the entire organization and Akintoye et al. (2000, p. 160) point out that "*there is nothing worse than trying to train for a technology when employees do not really understand or fear the concept that it supports*".

Coordination of the supply chain is supported by today's information- and communication technology, which make it easy to share up-to-date information with all actors (Stadtler & Kilger, 2008). An effective supply chain requires coordination of processes, which is reached by reduction of bottlenecks and weaknesses. Usage of advanced planning systems will according to Stadtler and Kilger (2008) facilitate coordination of the supply chain.

3.1.1 Support of suppliers

Collaboration and co-operation with suppliers is one of the keys to improve efficiency in production and it is impossible to cut costs unless suppliers cut costs (Liker, 2004). Pinch (2005) states that if one actor fails to take on the responsibility that has been allocated, a domino effect often occurs through the production chain that affects the overall project performance. To address this problem, the car manufacturing company Toyota uses according to Liker (2004) a supportive approach towards their suppliers instead of being punitive. They have developed divisions with experts in order to support operations and suppliers. One of these divisions is the Toyota Supplier Support Center (TSSC), which is operating in US and has the function to educate suppliers through projects. After completing 31 projects in 1997, TSSC contributed to 124% productivity increase, 75% inventory reduction, along with space reduction, quality improvements and reduced number of emergency deliveries. Krause (1997) also studied the impact and benefits of supplier development in various types of organizations in the US and revealed that the suppliers' performance increased after supplier development activities had been implemented. Organizations with supplier development focus experienced 50% fewer quality deviations on incoming deliveries and percent on-time delivery increased from 80% to 91%. Moreover, quantity deviations decreased with 50% and cycle times were reduced after implementation of supplier development activities.

Moreover, Liker (2004) states that the method "learning by doing" is widely used within Toyota to improve supplier performance. Instead of focusing on training, learning takes place close to the production and feedback to achieve constant improvement is encouraged. To obtain constantly improved performance, Toyota has developed long-term relationship with their supplier and does seldom source suppliers through open bidding. Pheng and Tan (1998) also underline the importance of having good relations with suppliers and state that suppliers should be treated as long-term business partners.

3.1.2 The supply chain in the construction industry

Akintoye et al. (2000) stresses that no studies have defined what supply chain in the construction industry is, but argue that the general definition by Christopher (1992) can be applied. Christopher (1992) defines the supply chain as:

"the network of organizations that are involved, through upstream and downstream linkages, in the different processes and activities that produce value in the form of products and services in the hands of the ultimate consumers".

The upstream chain involves construction clients and design team that performs activities which leads to preparation of the construction site. The downstream chain, on the other hand, contains activities and tasks in the delivery of construction products and involves material suppliers and subcontractors (Akintoye et al., 2000).

The material supply chain in the construction industry differs from the one in traditional manufacturing industries. In traditional manufacturing, materials are sent to one factory while the construction industry "build their factory" around each object. Further, the construction industry traditionally organizes around projects and different actors are chosen for each project, which decrease the level of continuity (Wegelius-Lehtonen, 2001). Construction projects normally include client, general contractor and subcontractors, which all have its own suppliers of material. Therefore, the material supply chain, which is illustrated in Figure 3, is more complex than for other manufacturing industries.

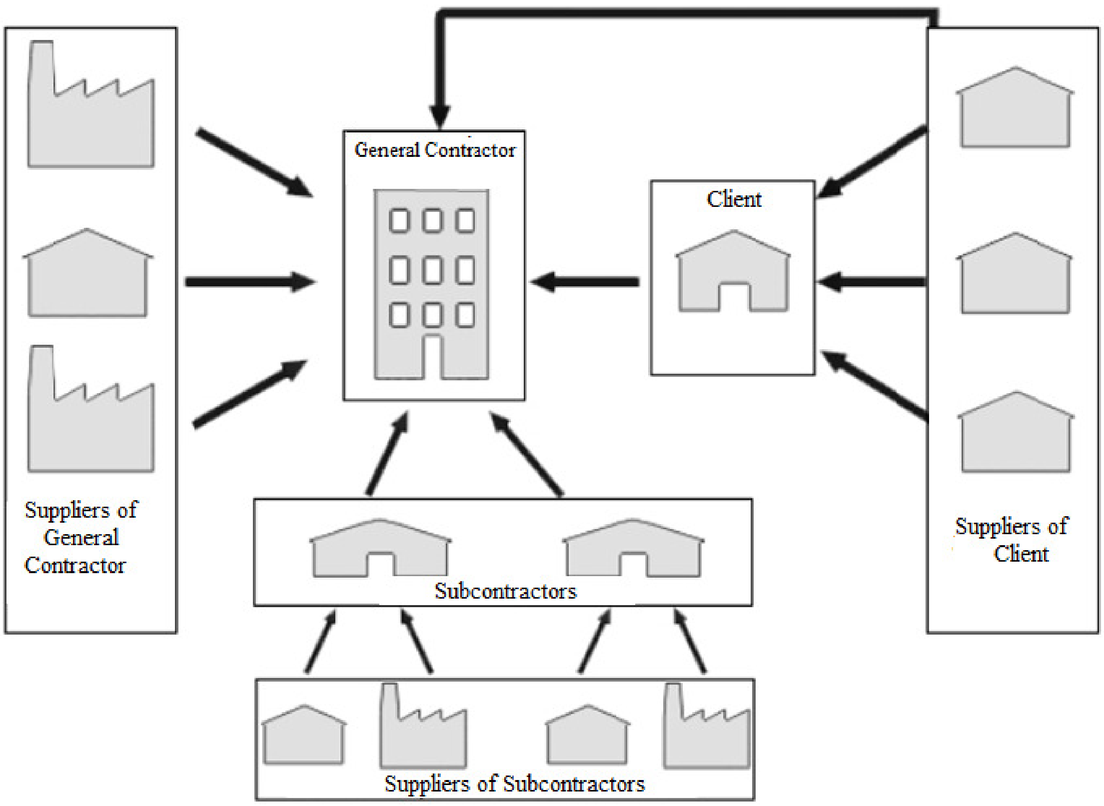


Figure 3. *The material supply chain in the construction industry* (Bengtsson & Gustad, 2008).

Akintoye et al. (2000) found in their study that implementation of SCM in the construction industry is a key element to reduce costs and to stay competitive. However, they found that there are many barriers to overcome before SCM can be implemented. The traditional culture, the organizational structure and the lack of appropriate support structures in the construction industry are components that hamper a successful implementation of SCM (Akintoye et al., 2000). Moreover, suppliers' performance is also dependent on contractors' internal processes and ways of working, which have been criticized by some authors. Bertelsen and Nielsen (1997) state that material deliveries are not scheduled properly, unforeseen events are common and managers have little control over the process. A study by Frödell and Josephson (2008) revealed that out of 181 investigated orders, 107 were required to be delivered in a short notice, which underlines construction projects poor planning of material deliveries. According to Bertelsen & Nielsen (1997), material deliveries are rarely delivered 'Just in time' and Andersson et al. (1983) state that 10% of the material costs correspond to extra costs due to unforeseen events.

3.2 The order to delivery process

Stock and Lambert (2001) describe the typical order cycle as a set of activities linked to each other, which all consume time and costs. An example of the path of a customer order is illustrated in Figure 4. Simplified, the order cycle involve the following six steps: 1) order preparation and transmittal, 2) order receipt and order entry, 3) order processing, 4) warehouse picking and packing, 5) order transportation and 6) customer delivery and unloading. Furthermore, the activities correspond to costs for customer service, transportation, warehousing, order processing and information, lot quantity and inventory carrying. The time from the point when the order is placed until the time when the order is received is referred to as order cycle time or order lead-time (Christopher, 1998).

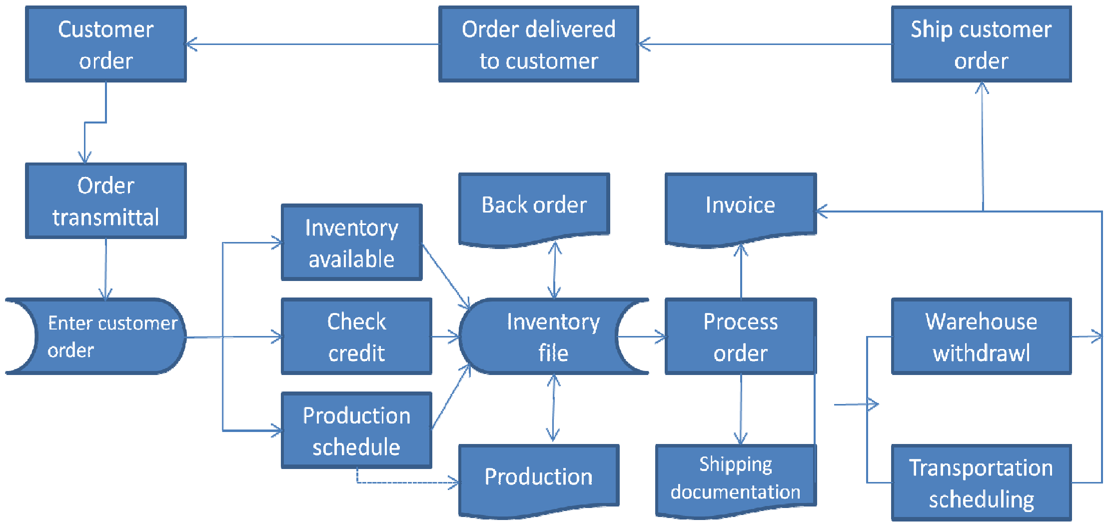


Figure 4. *The path of a customer's order* (Stock & Lambert, 2001).

Christopher (1998) further argues that reliability of deliveries is even more important than the duration of the order cycle. If the order cycle time is not consequent and reliable each actor will compensate for it by for example order earlier than the actual need, which can result in storage of material (Christopher, 1998). A strategy to reduce production cycle times, inventory and flow variation is usage of just-in-time (JIT) deliveries, which has been widely applied in the manufacturing industry. The JIT method is built on the inventory *pull* system where materials are delivered on demand and inventory levels are minimized or even zero (Liker, 2004). Contradictory, the inventory *push* system, which is widely used in the construction industry, means that large material inventories are stored at site.

When orders are received a quality and quantity inspection should according to Lumsden (1998) be performed and the information should be registered in the company's order system. Jonsson (2008), on the other hand, states that quality inspection is only necessary if the supplier has low reliability, since quality inspections are expensive, time consuming and there is a risk of damaging material during inspection. Quantity can be verified against order documents, while quality inspection can be performed in several ways. Quality inspection can be made by the suppliers, by random samples by the buyer or by inspection of all received products at the production site (Lumsden, 1998).

Reyniers and Tapiero (1995) state that quality inspection policies depend on the contract between the supplier and the buyer. Due to high costs for quality inspection both supplier and buyer wants the other part to perform quality inspection of goods (Reyniers & Tapiero, 1995). However, whether the buyer wants the supplier to perform quality inspection or not depend on the reliability of the supplier (Jonsson, 2008).

3.3 Costs of delivery deviations

Delivery deviations result in many consequences, which cause additional costs. Some costs can direct be measured and priced, while others are "invisible" and can have a greater impact on a company's performance in the longer run. In the forthcoming text, the costs of time-, quantity- and quality deviations will be described.

A late delivery or delivery of incorrect quantity often affects the time plan in a project and Ala-Risku and Kärkkäinen (2006) state that 8-25% of non-complete activities are due to delivery deviations. It is both costly and time consuming to go back and complete work activities later on and many construction sites take actions in advance to avoid situations like this. Material is for example ordered earlier and with greater quantity than the actual need. Early deliveries and large order quantities contribute to disorder at site, extra handling, breakage and loss of material, which is costly and unnecessary waste (Bertelsen & Nielsen, 1997). Storage of material also increases the risk of theft, which in turn results in extra costs for new material and administration. In addition, extra handling of material might negatively affect health and safety conditions (Formoso, Soibelman, De Cesare, & Isatto, 2002). Furthermore, late deliveries, which cause delays in the project, will impact on customer satisfaction.

Heskett, Sasser and Schlesinger (1997) address the importance of satisfied customers when they state that a satisfied customer tend to tell one other person about the company while a dissatisfied customer tend to tell ten other people about its "bad" experience of the company. Furthermore, satisfied customers are in general willing to pay a higher price and buy more products in the future (Sörqvist, 2001). The importance of satisfied customers is often given low priority or is even neglected by companies, but is a notation that all companies should keep in mind if they want to succeed (Heskett et al., 1997).

Inaccurate quality sometimes also affects customer satisfaction, which might result in additional costs. This is referred to as external failure cost and arises when customers identify errors. Costs of processing complaints from customers, costs for resolving customer claims and disputes and loss of "goodwill" are all examples of external failure costs (Van Weele, 2005). The cost of lost "goodwill" or reputation is an indirect cost that is extremely hard to price and grasp, but it is a cost that can be devastating for a company. Furthermore, quality errors noticed before the product is delivered to the customer are referred to as internal failure cost. These quality errors result in costs for corrections and reduced speed or standstill of the production.

Beside external and internal failure costs, Juran and Gryna (1993) also mentions two other quality cost categories namely, prevention- and assessment costs. Prevention costs are costs that arise in the attempt to minimize quality defects and include expenses for development, implementation and control of the system for total quality control. Development and implementation of procedures for quality inspection, performing systematic product inspections, investigations to find causes for quality errors and education and motivation of personnel on quality management are all examples of activities that generate prevention costs (Van Weele, 2005). Assessment costs are according to Van Weele (2005) a result of activities that are performed with the aim to minimize consequences of errors, for example inspection of purchased goods, handling of damaged products and registration and reporting of quality defects.

Moreover, quality costs can also be divided into tangible and intangible quality costs (Campanella, 1999). According to Sörqvist (2001), tangible quality costs are costs that can be priced and measured as for example rework, warranty costs, reclamations and costs for control personnel. Measuring tangible quality costs gives a basis for making quality improvements, however, if the quality improvement only is based on these costs there is a great risk that many hidden costs are neglected. Van Weele (2005) states that quality costs are mainly invisible and many companies do not know the extent of quality costs.

Hidden- or intangible quality costs are, according to Campanella (1999), for example engineering time, management time, increased inventory, decreased capacity and increased project time. These costs are hard or sometimes even impossible to measure but have nevertheless great impact on the profitability of an organization. Campanella (1999) states that some organizations consider intangible costs as three to four times greater than tangible costs. Sörqvist (2001) further argue that one problem with measuring intangible costs are that personnel handle problems without accounting for them. This way, an illusion of effective quality management is preserved.

Furthermore, responsibilities for quality costs are often unclear, nevertheless, it is an issue that has to be clearly stated in business relationships. Quality defects are mostly discovered in the production phase, however, defects often originate from earlier operations within the supply chain. By breaking down the reasons for quality costs in several steps, the cost sources can be identified (Sörqvist, 2001).

3.4 Performance measurements

Performance measures are used to control and improve efficiency and quality of the business processes, as well as for identification of opportunities for progressive improvements in process performance (Wegelius-Lehtonen, 2001). Performance measurements should answer if functions and departments are doing the right things and if they are doing them well (Lynch & Cross, 1995).

Wegelius-Lehtonen (2001) divides measures into two dimensions, the use of measures and its focus. Measures can either be used for improvments or monitoring and focus can either be on company level, project level or sub-contractor/material supplier level.

Improvements measures are imperative when starting new development and cooperation projects. On the other hand, monitoring measures is used for screening and controlling daily activities (Wegelius-Lehtonen, 2001). Furthermore, Wegelius-Lehtonen (2001) argues that continious measuerements should be simple and the data collection should be standardized. It is not to be forgotten that the measurement should be used in dicision making, *"What is done with the measure is even more important than what the measures are"* (Wegelius-Lehtonen, 2001, p. 115)

A performance measurement system that is applied effectively may result in better communication between functions and departments, better decision-making, higher motivation of personnel and a greater insight into the company‘s dealings with suppliers (Van Weele, 2005). Van Weele (2005, p. 264) suggests the following six stages when developing a performance measurement system: 1) After a careful analysis, determine which targets and objectives, as well as activities, that is most important and justify the effort of evaluation. 2) Determine the frequency and format for data reporting, as well as which personnel that will assume these responsibilities. 3) Develop a systematic procedure for collecting a great deal of historical and statistical data that may be used in the evaluation program. 4) Analysis of data and identification of interrelationships between various types of data. Furthermore, establish a relationship between means and ends and do not forget to differentiate between purchasing effectiveness and efficiency. 6) Develop and implement measures. A danger that has to be avoided is that the measure becomes too complex or numerous. Simplicity is the key. 7) The final stage in the operating process is timely reporting of results to those who should use them, along with appropriate follow-up.

Further, Christopher (1998) states that if suppliers performance should be controlled it must be against predetermined standards. The following standards were identified by Christopher (1998, p. 62) as essential key areas:

- Order cycle time: How long is the time from order to delivery?
- Stock availability: The percentage of demand for a given item that can be met from available inventory.
- Order size constraints: Do the supplier have the flexibility to cope with just-in-time deliveries of small quantities?
- Ordering convenience: Is it easy to do business with the supplier? Does our system talk to their system?
- Frequency of delivery: Can the supplier perform frequent deliveries that just-in-time concepts require?
- Delivery reliability: How many orders are delivered on time?
- Documentation quality: What is the error rate on invoices, delivery notes and communication?
- Claims procedure: What is the trend in claims? How quickly does the supplier deal with complaints?
- Order completeness: What proportion of orders is delivered complete?
- Technical support: What support does the supplier provide?

- Order status information: Can the supplier at any time inform about the status of the order? Do the supplier inform about potential problems on stock availability or delivery?

Moreover, supplier performance is highly correlated with production performance, hence, organizations need to strengthen their relationships with suppliers to stay competitive (Vonderembse & Tracey, 1999). Vonderembse and Tracey (1999) further found in their study that the two most important factors of supplier performance were percent of on-time deliveries and high quality of incoming products.

In accordance, Lynch and Cross (1995) divide external measurements into quality and delivery. Quality corresponds to features, performance, durability, reliability, aesthetics and perceived quality (Lynch & Cross, 1995). Furthermore, quality can for example be measured in parts per volume accepted, percentage of good components in final assembly, percentage of problem-free installs, cycle count accuracy and invoice accuracy (Lynch & Cross, 1995). Delivery involves quantity and timeliness, where percentage delivered according to schedule to the right location and quantity accuracy are aspects that can be measured. Measurements of orders delivered on time require data of ordering date, promised delivery date and shipping date (Wegelius-Lehtonen, 2001). With the data available, lead-time of orders and lead-time of deliveries can also be measured. Further, Lynch and Cross (1995) point out that it is important to make sure that measures are reported by the right people; measures of delivery and quality should be reported to suppliers by the purchasing department.

3.5 Procurement and evaluation of suppliers

Two different strategies can be applied when companies want to procure suppliers (Gadde & Håkansson, 1998). The first strategy focus on reducing prices through competition among a number of suppliers and the purchasing department chose the supplier with the lowest bid (Gadde & Håkansson, 1998). The second strategy focus on indirect costs, such as logistics, administration, warehousing and reclamations, and a fewer number of suppliers are selected for development of long-term relationships (Gadde & Håkansson, 1998). Furthermore, Dubois and Gadde (2000) stress that long-term relationships create better conditions for product development and innovation in the construction industry.

Gadde and Håkansson (1998) illustrate the total purchasing price as an iceberg, where the price represent the visible part and other costs are indirect costs that are hidden under the surface. The purchasing price is the only cost that is visible on the invoice, which makes it tempting to just focus on this component. However, hidden costs represent more than twice the direct price that is presented on the invoice (Gadde & Håkansson, 1998).

One example of a concept where a holistic cost perspective was considered is the Danish *Bygglogistik* (Bertelsen & Nielsen, 1997). The concept was, according to Bertelsen and Nielsen (1997), applied on six housing projects in Denmark and the main aim was to look at both direct material delivery costs (the price) and indirect material delivery costs. This means that packing, temporary storage, on site transportation, losses and breakages, also were considered. Logistical planning was in focus in the projects and overall logistics planning were consider as well as JIT planning for daily deliveries.

This type of logistical planning approach requires good co-operation and communication between production and suppliers and delivery deviations should be communicated to suppliers immediately (Bertelsen & Nielsen, 1997). According to Bertelsen and Nielsen (1997) it is important that suppliers pack and mark material correctly so that deliveries easily can be transported to the accurate work area at the construction site. The result from the housing projects, where *Bygglogistik* was applied, was overall positive. The Danish Building Research Institute estimated savings to 9% of the net building cost and all housing projects resulted in increased productivity, increased quality and a higher morale among workers (Bertelsen & Nielsen, 1997).

Moreover, Wegelius-Lehtonen (2001) argues that purchase price is a parameter that neglects quality and delivery aspects. In accordance, Vonderembse and Tracy (1999) state that focus should be on a set of supplier selection criteria that evaluates suppliers across multiple dimensions including product quality, product performance and delivery reliability. Stock and Lambert (2001) agree and argue that the buying firm should develop a list of important attributes, rank the importance of each attribute and then evaluate suppliers for each attribute. By having a holistic approach when procuring suppliers, costs for delays and claims can be reduced and the company's profit will increase (Hadikusumu et al., 2005). Vonderembse and Tracey (1999) state that a purchasing approach that goes beyond the lowest bid and instead focus on a set of supplier selection criteria is common in the manufacturing industry. In contrast, competitive bidding, where the lowest bidder gets the contract, is a tradition that is deep-rooted in the construction industry (Wegelius-Lehtonen, 2001). Other performance measures are in best case considered secondly and in worst case totally neglected.

Hadikusumu et al. (2005) suggest a transparent selection system to facilitate supplier evaluation, where suppliers past performance score are one of the included factors in the system. Vonderembse and Tracey (1999) found in their study that firms with established supplier selection criteria and greater supplier involvement had created a relationship with suppliers that were based on trust and communication. These relationships improved performance by eliminating material stock-outs, increasing on time delivery, reducing in-transit damage and improving incoming product quality (Vonderembse & Tracey, 1999).

The past performance evaluation process is one of the most vital processes for any business transaction (Hadikusumu et al., 2005). Vonderembse and Tracey (1999) state that evaluation of suppliers' performance creates an atmosphere among suppliers that increase their efforts, which can lead to improved performance. The following three aspects were identified by Monczka, Trent and Handfield (2005) as the most important to consider when evaluating suppliers' performance:

Price – for each article or for the total turnover

Delivery precision – Do the deliveries arrive at the right time and in correct quantity?

Quality – How many defect products have been delivered?

Hadikusumu et al. (2005) include attitude, capability and service as additional aspects in the evaluation of suppliers' performance.

4 Methodology

Since the purpose of this study is to investigate how material delivery deviations affect costs and performance in construction projects and how delivery deviations are handled, this study draws on both a quantitative and a qualitative research method. According to Backman (1998) a quantitative study is based on measurements that result in numerical observations. A qualitative research, on the other hand, draws upon human beings perceptions and its general aim is to *"achieve an understanding of how people make sense out of their lives, delineate their process of meaning-making and describe how people interpret what they experience"* (Merriam, 2009, p. 14). The quantitative study will answer research question one, while the qualitative study will answer research question two and three.

Furthermore, if a study aims at answer "how" or "why" questions, which this thesis does, a case study is according to Yin (2003) the preferred research method. A weakness of case studies as research method is that the result cannot be generalized (Yin, 2003). However, this kind of study could give an increased understanding and guidance in similar cases (Kvale, 2006). Moreover, Yin (2003) defines the scope of a case study as:

> *"A case study is an empirical inquiry that investigates a contemporary phenomenon within some real-life context, especially when the boundaries between phenomenon and context are not clearly evident."* (Yin, 2003, p. 13)

The research was carried out as a case study investigating three projects at Skanska, which in accordance with Yin (2003) corresponds to a multiple-case design. A multiple case study is seen as more credible than a single one since the result is based on more than one object (Yin, 2003). The three case projects were chosen by Skanska as research objects. The first project (Project A) had frequently experienced problems with kitchen deliveries and was therefore chosen as case object in this study. The second project (Project C) was a large construction site with a complicated logistic location which demanded timely deliveries. The last project (Project B) had not experienced any severe problems with material deliveries and was therefore chosen to obtain an objective view of material delivery deviations.

The data collection from the case projects have been carried out in different phases during three months. Data can according to DePoy and Gitlin (1999) be divided into primary and secondary data where the latter corresponds to data that already exists and the other to data that is observed. This study is mainly based on primary data that has been collected through interviews, observations and measurements. Interviews and direct observations are the foundation for the description of the present situation at Skanska. Measurements of delivery deviations correspond to statistics of delivery deviations and costs associated with deviations. Furthermore, secondary data has been collected from Internet, Skanska intranet, annual reports and invoices.

4.1 Quantitative data

Statistics of delivery deviations are based on measurements at the three case projects. The materials for measurement were chosen in accordance with the project team and with respect to the project time plan. The investigated material groups are: kitchen cabinets, sliding doors, kitchen appliances, consumer expendables and concrete. Table 1 shows the number of deliveries for different product categories in the three projects.

Table 1. *Number of measured material deliveries for each project distributed on product categories.*

	Project A	Project B	Project C
Kitchen appliance deliveries	14	-	-
Kitchen cabinet deliveries	14	9	-
Sliding door deliveries	10	-	-
Consumer expendable deliveries	-	30	-
Concrete deliveries	-	-	28
Concrete trucks	-	-	121
Total	38	39	28/121

In Project A and B the management teams at the construction sites have logged all deliveries of the chosen materials. We prepared a Microsoft Excel document with drop-down lists where the projects could specify material group, type of delivery deviation, reason for the deviation, consequences of the deviation, extra work time due to the deviation and there were also a field for comments. Figure 5 illustrates the log file with examples of the alternatives to choose in the drop-down lists. The alternatives in the drop-down lists were identified by means of the theory and the project teams. The two projects have logged time-, product-, quantity-, quality-, documentation- and package/marking deviations. In Project C, on the other hand, we performed the deviation measurement by analysing advice notes and invoices.

	Deviation						Reason			Consequence						
Material	Time	Quality	Quantity	Doc.	Package and marking	Product	1	2	3	1	2	3	Extra time M (h)	Extra time SW (h)	Extra time or waiting time SC(h)	Comments
Kitchen cabinets	In time	Quality defect	Correct	Correct	Correct	Correct	Production failure at Supplier			Rescheduling						
Kitchen appliances	Late	Without deviation	Too Few	Missing	Incorrect marked	Incorrect	Supplier has packed in-correct quantity			Storage of material						
Sliding doors	Early	Damaged during transport	Too many		Incorrect packed		Communication failure			Extra time skilled worker (SW)						
							Supplier lacks product			Extra time manager (M)						
							Damaged during transport			Extra time sub-contractor(SC)						
							Other reason			Extra time for several groups						
										Unfinished house at moving in						
										Extra cost for hired machine						

Figure 5. *An example of the log file for delivery deviation measurement.*

The deviation statistics in Project A are based on both measurements during the study and documentation of previous kitchen deliveries performed by the site manager. In total, 38 deliveries of kitchen cabinets, kitchen appliances and sliding doors have been analyzed. The documentation that existed when the study started included information about quantity-, quality- and product deviations of 11 kitchen deliveries; hence time- and package/marking deviations were not logged. Furthermore, the additional time for skilled workers and subcontractors due to the delivery deviations were documented as well. The collected data during the time for the study was performed by the foreman at the project who logged time, quantity, quality, product and package and marking for 27 deliveries. For kitchen appliances, documentation was included as a sixth parameter, since this was the only measured material category that included instruction manuals for the final customer. Of the 38 deliveries, kitchen cabinets contributed with 14 deliveries, kitchen appliances with 14 deliveries and sliding doors with 10 deliveries. Moreover, we had weekly contact by phone or e-mail with the foreman to get up-dated information about the deliveries.

In Project B, 39 deliveries of consumer expendables and kitchen cabinets are the basis for the delivery deviation statistics, where kitchen cabinets contributed with 9 deliveries and consumer expendables with 30 deliveries. The data collection in this project was not performed as intended, which probably have affected the result. We made site visits four times during the measurement period to get an update of the situation and to remind the management to perform the measurement. In Project B, however, this reminder had little effect since the management team lacked time for the data collection. When the data collections in the two projects were completed we analyzed the data and performed statistics for each project as well as for each material group.

In Project C, we have investigated and analyzed time and quality of 121 concrete deliveries, occurring at 28 different dates. Measurements of time deviations for concrete deliveries are based on information from invoices and advice notes. Moreover, quality deviations for concrete are based on the production team's observations and experiences. We analyzed arriving time for the first truck, unloading time for each truck, time in-between two trucks and if concrete quality was in accordance with the ordered. When each delivery had been investigated, the result was discussed with the site manager and the responsible foreman. During the discussion, questions concerning ordered delivery time, time in-between trucks and reasons for long unloading times were clarified. The investigation approach used in this project, with analysis of invoices, gave good conditions for realistic cost calculations of delivery deviations.

4.2 Qualitative data

During this master thesis totally five interviews have been carried out with personnel at construction sites as well as at the purchasing department. Each interview lasted for approximately one hour and four of the interviews have been conducted at the interviewee's workplace and one by phone. An interview guide, with questions divided into focus areas had been prepared before the interviews.

The semi-structured approach (Gillham, 2000) that was used gave an opportunity to capture issues raised by the respondent as well as get answers to predefined questions. The interview guide consisted of open-ended questions to avoid leading the respondents and they were encouraged to speak freely and to elaborate and exemplify answers. Yin (2003, p. 90) states that case study interviews require the interviewer to operate on two levels at the same time: satisfying the needs of the researcher's line of inquiry while simultaneously putting forth "friendly" and "nonthreatening" questions in open-ended interviews.

We selected the respondents in assent with the supervisor at Skanska. Respondents from different occupational groups were chosen in order to obtain a holistic view of the purchase- and material delivery process. To get insight in how suppliers today are procured and evaluated two respondents were selected from the purchase department. One of the respondents at the purchasing department works with operational purchases and is responsible for the process from order until invoice, which also includes reclamations. The respondent will in the forthcoming text be referred to as 'the project leader'. The second respondent from the purchase department is category manager for three out of six suppliers that deliver material that have been measured in this study. The department Building Construction was represented by four respondents, two foremen and two site managers, which contributed to the understanding of how material orders and delivery deviations are handled today and what consequences it result in. Two respondents for each function were in accordance with Kvale (2006) selected to verify information. One interview was held with both a site manager and a foreman at the same time. During the interviews with the production department the order to delivery process were mapped together with the respondents. The process was mapped with post-it notes and the actions were connected with lines during the interview. The process map performed during the interviews is the basis for Figure 7.

The interviews were in accordance with Kvale (2006) recorded, which gave an opportunity to go back and clarify indistinctness. Recording also gave us a chance to actively listen, notice body language and reactions and to ask follow-up questions. Furthermore, field notes were taken by one of us during the interview, which afterwards were coded in order to systemize the data to facilitate further analysis. After each interview the outcome was discussed and reflected upon and the recorded interviews were as soon as possible transcribed to be analyzed.

4.3 Documents

In addition to the previous described data collection, documents have been collected to provide a proper background for the study. The documents have especially been collected from Skanska's intranet and include framework agreements, guidelines for how to work in different processes, reports and purchase statistics. Furthermore, the framework agreements that Skanska has with suppliers have been studied to receive background information before the interviews as well as for verification of qualitative data. Invoices and advice notes have been used to verify ordering dates, promised delivery days and to compare them with the actual situation in Project C.

5 The process from procurement of suppliers to material deliveries at Skanska

This chapter will describe the purchasing process and the order to delivery process within Skanska. The chapter is based on interviews and discussions with employees at Skanska as well as information from the intranet.

5.1 Purchasing and evaluation of suppliers

In 2005 Skanska set a goal to yearly decrease the purchasing costs with at least 2 MSEK for the 3-5 coming years. The strategy involves reduction of costs by improving existing supplier contracts through increased cooperation and follow-up of suppliers' performance. The strategy is utilized in the process of coordinated purchases, which involve negotiation and design of framework agreements. The process is divided into four steps; category planning, procurement, implementation and supplier evaluation, see Figure 6. During category planning, purchases are categorized and which material groups/suppliers that should be prioritized for procurement is decided. In the second step, a future strategy for how to proceed with procurement is determined and suppliers are procured in line with Skanska's policies. In the third step, framework agreements are implemented in the organization and the implementation step includes both new and renegotiated agreements. Finally, suppliers are evaluated in order to improve and develop framework agreements.

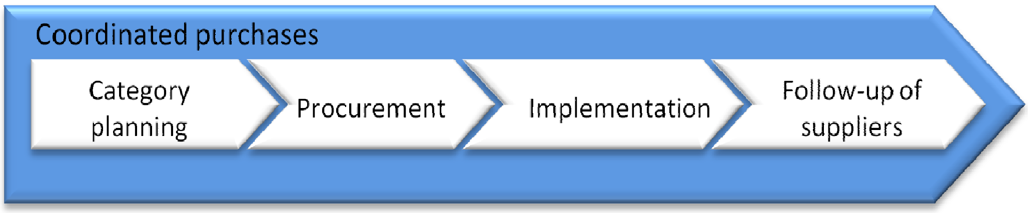


Figure 6. *The process of coordinated purchases.*

5.1.1 Procurement of suppliers

NPU has according to the category manager recently developed and introduced a manual for the procurement process, which shall be followed by the Nordic countries when suppliers are procured. The category manager stresses that a reference team is involved to state important requirements for purchases. The reference team consists of representatives from the residential development organization, RDN, and from the production department, which usually is a site manager or a project engineer.

The category manager argues that price has been the main focus when suppliers are procured. When the recession started in the autumn of 2008, the purchase department was instructed to renegotiate agreements with suppliers in order to reduce prices. The category manager argues that Skanska has pressed its suppliers to the greatest extent and that there is no room for further price reductions. The site manager in Project C agrees and states that the purchase department far too often only focuses on prices and forgets to have a holistic approach. Further, the site manager states that the lowest-price approach in many times only transfers the costs from the purchase department to other departments within Skanska. However, the attitude is according to the category manager taken a new direction and focus is now on creating value for the whole chain. The interviewed category manager states that his main focus when procuring suppliers is to reach a solution that facilitate for the projects.

5.1.2 Supplier relationships

Skanska has according to the category manager not prioritized and valued long-term relations with suppliers. The attitude has rather been to keep a distance to the suppliers and not get to friendly than take advantage of their knowledge. However, the category manager states that Skanska now has changed strategy and aims at developing long-term relations with their suppliers. By taking advantage of the suppliers' knowledge of products and delivery processes they believe many of the problems that today arise in the production phase can be reduced.

Follow-up meetings with suppliers are according to the category manager held two to four times a year, where the supplier's performance is discussed. The suppliers measure delivery precision in terms of quantity accuracy, which the category managers sometimes take part of and use at follow-up meetings. However, the level of control of supplier's performance depends on the supplier's past performance. The kitchen supplier, which according to the category manager has great problems to fulfil their obligations, sends weekly reports of their delivery precision to the category manager. A region manager at the building construction department informed the category manager about the kitchen supplier's poor delivery performance. The projects in the region were then contacted and offered support, but only one project was interested in the help the category manager offered. The category manager called to a meeting where they sat down together with the supplier and discussed the situation. The supplier was aware of the situation and the project got economic compensation. The category manager stresses that it is unusual to have meetings like this one, but that he gladly help the projects if they have problems with suppliers. Further, the category manager stresses that the information from projects is poor, which the project respondents agree with. The project respondents state that the purchase department is only contacted if they have severe and long-lasting problems with material deliveries from suppliers.

5.1.3 Evaluation of suppliers

When the time for a contract expires the category manager evaluates the supplier and presents the result for a steering group who decides if Skanska shall continues to work with the supplier. The features that are considered for evaluation according to Skanska's guidelines are competitiveness, delivery of goods and services, technology, competence, environment, work environment, ethics, communication, cooperation and trust. The evaluation is according to the category manager based on information from the reference team and feedback from projects, which unfortunately is inadequate.

The projects can give feedback of a supplier's performance by phone, by e-mail and by an evaluation form. The site manager is asked to do a supplier evaluation ones an invoice exceeds a certain amount of money. Foremen are according to the project leader at the purchase department also allowed to do evaluations, but must actively seek an evaluation form on Skanska's intranet. It is possible to evaluate both project specific and framework agreement suppliers and the result of supplier's evaluations along with other supplier performance information is presented at Skanska's intranet.

The foreman in Project B rarely makes evaluations and the site manager in Project C has never made an evaluation. Although, many invoices exceeding the level for evaluation has been received, the site manager has never been asked to do a supplier evaluation. The site manager in Project A has approximately done four evaluations of service suppliers but none of material suppliers. Contradictory, the evaluation form is, according to the project leader at the purchase department, designed to suit material suppliers rather than service suppliers and further states that information about for whom the evaluation form is suited has not properly been communicated to the construction sites.

Beside the evaluation form, category managers can also absorb information about suppliers' performance through direct communication with the production team. In addition, the project leader and the site manager at Project A state that if severe problems with material supplier occur on construction sites, category mangers sometimes make a site visit. The site manager in Project A and the foreman in project B perceive that the purchasing department appreciates feedback from construction projects. However, the foreman in Project B argues that category managers should more often contact production teams to receive feedback, at least before each follow-up meeting. All respondents agree that exchange of experiences between the purchasing department and production teams is generally poor. The project leader at the purchase department further states that the purchase department should in a greater extent actively seeks feedback from construction projects concerning suppliers' performance. The respondent in Project B suggests that the purchase department should develop a digital system for delivery deviation reporting.

The category manager agrees and states that a system for delivery deviation reporting has to be easy, compulsory and not time consuming if it shall improve the feedback between the departments. Further, a first step could be to start focus on key suppliers and report their delivery performance. The category manager argues that information about suppliers' performance from projects is necessary to improve the purchase department's performance as well as the suppliers'.

5.2 Delivery agreements

Delivery agreements for different materials are specified in the framework agreements in order to clarify responsibilities for seller and buyer in the delivery process. The delivery agreements concern loading, transportation, unloading and carrying materials to the place of assembling on the construction site, which all are steps in the delivery process. The four delivery agreements that are considered in this study are: Collected Loaded Seller (CLS), Delivered Not Unloaded Buyer (DNUB), Delivered Unloaded Buyer (DUB) and Delivered Carried Buyer (DCB) and is presented in Table 2. The CLS agreement implies that the buyer is responsible for transportation and unloading of goods while the seller is responsible for loading. The DNUB agreement means that the seller is responsible for loading and transportation of goods while the buyer is responsible for unloading. The DUB agreement implies that the seller is responsible for the whole delivery process, which includes transportation, loading and unloading of goods. Finally, the DCB agreement is similar to the DUB agreement, but in excess of the seller being responsible for the whole delivery process, the seller is also responsible for carrying materials to the spot where it later will be assembled.

Table 2. *Responsibilities in delivery agreements.*

	CLS	DNUB	DUB	DCB
Loading	🟢	🟢	🟢	🟢
Transportation	🔴	🟢	🟢	🟢
Unloading	🔴	🔴	🟢	🟢
Carrying	🔴	🔴	🔴	🟢

🔴 = Buyer
🟢 = Seller

If a delivery is late the seller is entitled to pay a fine of 2 % of the contract price and at least 2000 SEK for each delayed week. Furthermore, the seller is permitted to provide documentation about assembling, instructions and maintenance. The buyer should, in connection with each delivery perform a goods inspection in two steps, first at the goods reception and secondly before the goods is assembled. Obvious quality or wrapping defects is checked at the first goods inspection and if defects are found the buyer should make a complaint within a week. If the buyer is responsible for transportation, the freight driver should also immediately be notified. Defects, which are discovered at the second goods inspection, should be communicated to the seller within reasonable time.

5.3 The order to delivery process

The order to delivery process was during the interviews mapped together with the project respondents. In Figure 7 the process from order registration to delivery is illustrated. The figure gives a view of the ideal process and all activities and actions that are presented are not always performed. The different activities and actions in the process will be described in the forthcoming text. In chapter 7 a flowchart of the delivery deviation handling will be illustrated.

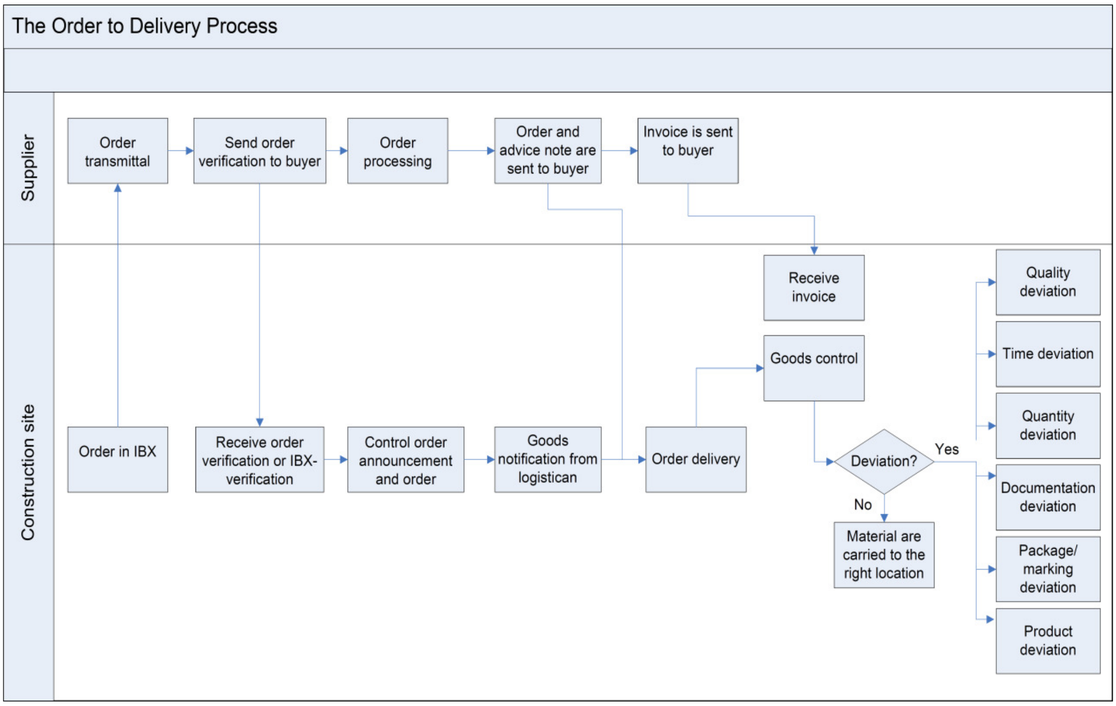


Figure 7. *The order to delivery process at Skanska.*

5.3.1 Ordering of material

The total quantity of material needed in a project is calculated in the initial project stage and a delivery plan is created based on these calculations. Material call-offs should according to Skanska's guidelines be based on the purchase- and material delivery schedule and employees that have been approved by the project manager are allowed to order material for the project. Further, materials from framework agreement suppliers should be called-off in IBX, which is an internet-based purchasing tool within Skanska.

The project respondents state that continuous call-offs are made according to the delivery plan and with respect to suppliers' delivery time. Material orders from suppliers with framework agreements are according to the respondents mainly performed in IBX. However, the foreman at Project A states that urgent material purchases, which might occur in the final stage of a project when a product is damaged or a spare part is missing, might be called-off by e-mail or phone. The reason for not using IBX in this case is that making call-offs by phone or e-mail reduces the risk of receiving wrong product as well as double invoices, according to the foreman at Project A.

Materials are mostly according to the respondents at Project A and B called-off for a couple of houses at a time. The foreman at Project B states that the number of houses for which materials are ordered each time depend on storage space at site and montage capacity. If the production team discovers that there is a lack of material or a redundancy in the end of the project, the order is adjusted to match the demand. Furthermore, respondents at Project A state that there is generally no need to call-off a certain amount of material units at a time in order to push prices, since prices are predetermined in the framework agreements.

The foremen at Project A and B state that materials are called-off so that long storage times are avoided, however, since materials seldom are delivered on time, the production management team often order materials earlier than needed. By doing so, they guard themselves against late deliveries which, according to respondents at the projects, have more serious economical consequences than storage of material on site. The foreman at Project A also states that materials, especially from suppliers that are known from past experience to have low delivery precision, are ordered with large time margins.

5.3.2 Order announcement from suppliers

Suppliers confirm orders by sending an IBX-verification or a more detailed order announcement and sometimes both, according to respondents at Project A and B. The foreman at Project A states that the order announcement is always compared with the order to ensure that the order quantity and desired delivery date is correct. However, the foreman at Project B stresses that comparison between the documents is only carried out if there is time. It is the responsibility of the production team and not the suppliers, to compare order announcement and order according to foreman at Project B. However, it lies within the production team's self-interest to do so, since a lot of faulty deliveries thereby can be eliminated.

According to the foreman at Project A, information about delivery date is either confirmed or changed by the supplier in the order announcement. However, the foreman at Project B mentions that some supplier uses the IBX-verification just to confirm that the order is received. Suppliers then fail to inform about possible delivery date changes. Furthermore, delivery time is mostly specified as date but some suppliers only specify which week the order is supposed to be delivered.

The foreman at Project B states that the detailed order announcement is considered as more accurate than the IBX-verification, since the supplier has processed the order announcements more thoroughly. The respondent further questions why Skanska is using two different systems for order announcements. Moreover, if a supplier is unable to deliver some of the products in a delivery, that information is only provided on the advice note and not on the order announcement according to the foreman at Project B. Most suppliers send the advice note at the same day as the delivery, according to interviewees at Project A and B. However, the kitchen supplier sends the advice note one day ahead.

5.3.3 Delivery notification from logistic firms

The site manager at Project A states that some logistic firms make delivery notification before delivering materials to the construction site in order to inform the production team that a delivery is on the way and to receive information about where to put the material. However, the foreman in Project B states that logistic firms who have daily deliveries rarely make delivery notifications. On the other hand, they know from past experience where to deliver materials or even have an unloading spot of their own.

Early delivery notifications from logistic firm are rare, some drivers notify one hour ahead, but most drivers does not do it at all. The foreman at Project B thinks that the reason for not making delivery notifications is due lack of communication between Skanska, suppliers and logistic firms. The respondent along with the category manager further argues that accurate delivery notifications are important to be able to prepare unloading of material and stresses that the information flows between the three actors need to be improved.

When foremen make a call-off in IBX they provide information about contact person, phone number, delivery address, e-mail etc. However, this information is sometimes not specified on the consignment note. According to the foreman at Project B, drivers can sometimes call and notify that they have a delivery for Skanska, but lack accurate delivery address. The foreman estimates that approximately 30 such calls are received per week and it takes a lot of extra unnecessary time to guide drivers.

Furthermore, the category manager states that the logistician is obligated to do delivery notification if the buyer demands it at call-off, according to the framework agreement. However, one problem with demanding delivery notification is that the logistician then only is allowed to deliver goods if a notification is made. Hence, deliveries might be delayed if the logistician is unable to reach the responsible person at the construction site.

5.3.4 Goods reception and inspection

A common situation when deliveries arrive to the construction site is explained by the foreman in Project B as follows; *"a confused driver arrive, states that he has a delivery for Skanska, when the foreman ask who the delivery is for the driver do not know and on the question what the delivery include the driver do not know"*.

Furthermore, some drivers who cannot find any foremen at the construction site, sometimes leaves the delivery on a random spot or inform that the goods can be collected at the nearest post office. The foreman at Project B states that there even have been deliveries, which have been sent back to suppliers' production destination if drivers were unable to contact the foremen. The respondent states that this causes confusion at the construction site as well as at the logistic firm and at the supplier firms. It also results in late deliveries and extra work for foremen.

When deliveries arrive to the construction site and when material is unpacked, goods inspection shall according to Skanska's guidelines be performed, but the level of control varies. The level of inspection performed at the construction site depends on material group and is based on the extent of inspection that is performed by the supplier. The following steps shall according to the guidelines be performed when material is delivered to construction sites:

1. Control the number of packages against the consignment note.
2. Visual inspection of the delivery to verify damage free package.
3. Control expected delivery against the advice note.
4. If goods are damaged when it is delivered, reclamation should be made to the driver. The advice note should be signed by the driver as a verification of the damage. Furthermore, Skanska's reclamation form should be filled in and sent to the supplier and the purchase department.

The production interviewees state that a delivery inspection is performed if the production team has time when goods arrive at the construction site. Interviewees in Project A and B estimate that delivery inspection is performed on approximately half of the deliveries. However, the respondents further state that if a supplier is known to have poor delivery performance, delivery inspection is always performed. On the opposite, delivery inspection is never performed on deliveries from suppliers with high delivery performance. Some products, such as kitchens, on the other hand, are hard to control in detail before assembling since they contain a great deal of components. The foreman in Project B underlines that kitchen deliveries are inspected with regards to quantity and obvious quality defects, since there have been many problems with these deliveries in the past.

The foreman at Project B underlines the importance of delivery inspection and suggests usage of bar-code scanners for delivery reception. By using a bar-code scanner, the time for inspecting deliveries would decrease and the number of delivery inspections would probably increase. The foreman at Project B also suggests a digital system for delivery inspection, which is tied to the bar-code scanner. Delivery inspection is today performed manually, which involve a lot of time consuming paper work. Skanska's purchasing department has according to the project leader developed a new system for delivery inspection, which probably will facilitate the goods inspection (see chapter 5.3.5).

Moreover, quantity and quality of package is checked during the delivery inspection and the driver's consignment note is signed if everything is acceptable. If the wrapping is defect and the goods have been damaged during transport, the consignment note is marked with a "damaged goods stamp" and a damaged goods number is also provided by the logistic firm. The foreman at Project A states that the damaged goods number is reported when a new product is ordered and by doing so the invoice for the new product is sent directly to the logistic firm. However, it is possible to make a complaint on damaged goods even if the consignment note lacks a "damaged goods stamp", but the complaint process is then more complex, according to the foreman at Project A.

The site manager at Project C states that quality inspection is always performed for deliveries of advanced types of concrete. Faulty or wrong deliveries of concrete will have severe effects on a project in terms of time and costs and inspection is therefore very important. The interviewee further states that if the foreman accepts faulty concrete deliveries and sign the consignment note, the concrete supplier has no liability to pay for extra costs due to quality deviations. Furthermore, it is also important to inspect that concrete deliveries contain correct quantity. Concrete suppliers who have long driving distances rather fill trucks with slightly too much concrete than too little, according to the site manager at Project C. As a result, leftover concrete has to be driven to a dumping station and the construction project has to pay for extra concrete and landfill costs, unless a quantity inspection is made.

5.3.5 A new system for delivery planning and inspection

Skanska is currently using a two-way matching of invoices and orders according to the project leader, which means that orders and invoice are matched with regards to price, order number and quantity. However, Skanska's purchasing department has recently initiated a project called LGT (Delivery, Goods inspection and Three-way-matching), which aims to facilitate material delivery planning and have been tried out in a couple of pilot projects. LGT include tree-way matching which denotes that, besides matching order and invoice, delivery reception is also considered. The project leader states that LGT is built upon a delivery calendar where expected material deliveries automatically are marked in the calendar when call-offs are made in IBX. If a supplier changes a delivery date in the delivery announcement or if a logistic firm notifies a delivery change, the delivery date in the calendar is also adjusted. Information about order numbers and suppliers is tied to each calendar activity and the production team can also add orders made by phone or e-mail.

The delivery calendar is also connected to a delivery reception system where the person responsible for inspecting a delivery can add information about quantity-, time- and transportation-damage deviations. Moreover, there is a link to a reclamation form where the user can fill out information about other deviations. However this form is yet not integrated with the rest of the system, which imply that a lot of information has to be filled out manually. According to the project leader, integration and development of a reclamation function in the system will be the next step after implementation of LGT within Skanska. The project leader believes that implementation of LGT will increase the number of call-offs in IBX as well as the number of delivery announcements from suppliers and the feedback from the pilot project has unanimously been positive.

6 Material delivery deviations in the case projects

This chapter presents the result from the delivery deviation measurements in the three residential case projects. The investigated material groups are: kitchen cabinets, sliding doors, kitchen appliances, consumer expendables and concrete. Project A contributed with delivery deviation measurements of kitchen cabinets, kitchen appliances and sliding doors and in Project B deliveries of consumer expendables and kitchen cabinets have been logged. The two projects have logged time-, product-, quantity-, quality-, documentation- and package- and marking deviations. In Project C time and quality of concrete deliveries have been investigated.

The following list presents the definition for each deviation:

- Time deviation: The delivery arrives to the construction site earlier or later than what is agreed up on. For kitchen cabinets, sliding doors and consumer expendables, delivery time is specified as date, which means that a delivery deviation occurs if it is delivered at least one day earlier or later. Kitchen appliances and concrete are ordered to be delivered just-in-time. Therefore, delivery deviations for kitchen appliances and concrete occur when deliveries are 20 and 10 minutes late, respectively.
- Quality deviation: The goods have been damaged during transport or the product has quality defects that originate from the supplier's production. All damages that creates extra time for any occupational group is considered as quality deviations.
- Quantity deviation: The delivery includes fewer or additional components than what is ordered.
- Product deviation: Incorrect product is delivered to the construction site.
- Package/marking deviation: The delivery is not marked or packed in accordance with what is agreed up-on.
- Documentation deviation: The material is not delivered with correct instruction manual.

In total, 198 deliveries have been measured in this study. The study revealed that 87 out of the 198 deliveries included at least one deviation, which is illustrated in Figure 8. The frequency of delivery deviations differs between the three projects and deliveries without deviations vary from 7% in Project C to 82% in Project B. In Table 3 the delivery performance for each project is illustrated. The forthcoming text presents the delivery deviation measurement for each project.

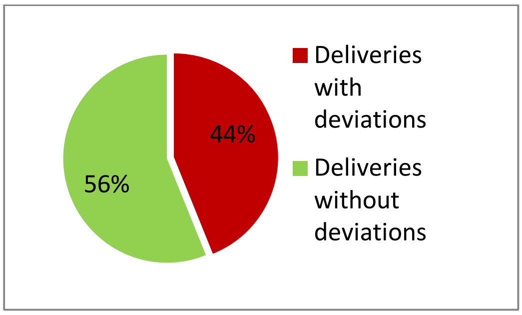


Figure 8. *The average frequency of delivery deviations.*

Table 3. *Suppliers delivery performance in the three case projects.*

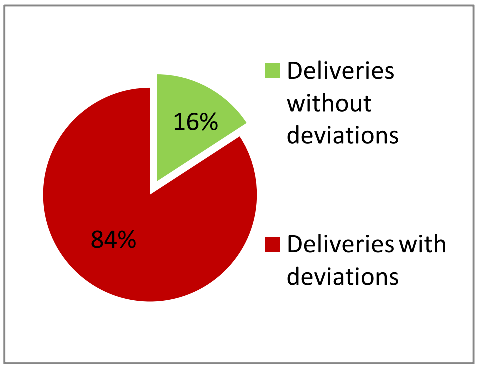
	Number of deliveries	In Time	Correct Quantity	Correct Quality	Correct Product	Correct Package and Marking
Project A	38	48%	63%	76%	68%	81%
Project B	39	100%	43%	71%	86%	100%
Project C	Delivery dates: 28 Trucks: 121	Delivery dates: 7% Trucks: 60%	-	93%	-	-

6.1 Material deliveries for Project A

Project A is a housing project including construction of 22 single-family houses, where Skanska is the general contractor. The project was under construction from May 2009 until April 2010 and had on average three production leaders, six skilled workers from Skanska and nine skilled workers from subcontractors employed. During the time of this study, the project was mainly working with the interior and the last finish before final inspections. The total contract sum was approximately 39 MSEK, where costs for material contributed with approximately 40%. The houses were manufactured and assembled by a subcontractor and all subcontractors sent invoices including costs for both work and material, which makes it difficult to get an exact sum of material costs. Subcontractors have during the project invoiced 23.6 MSEK for material and services. Skanska has during the construction time so far ordered material for 7.3 MSEK excluding consumer expendables such as nails, screws and safety clothes.

In this project, totally 38 deliveries of kitchen appliances, kitchen cabinets and sliding doors were measured. One of the foremen at the project has logged time, quantity, quality, product and package and marking for all deliveries. Kitchen appliances include instruction manuals for the final customer and documentation deviations were therefore included as a sixth parameter in the measurement. Delivery time are for kitchen cabinets and sliding doors specified as dates, hence a time deviation occur if the delivery do not arrive to the construction site at the promised delivery date specified in the order announcement. Kitchen appliances, on the other hand, has delivery time specified as hour.

The measurement in Project A shows that 84% of the deliveries included at least one deviation and only 16% were error free, see Figure 9. The analysis of the measurements revealed that it was more common that a delivery included two deviations than one deviation and 11% of the deliveries included three deviations, see Figure 10. The delivery deviations in the project resulted in extra work time for construction workers, subcontractors and manageement team. Totally, 80 extra work hours were the result of the measured delivery deviations.



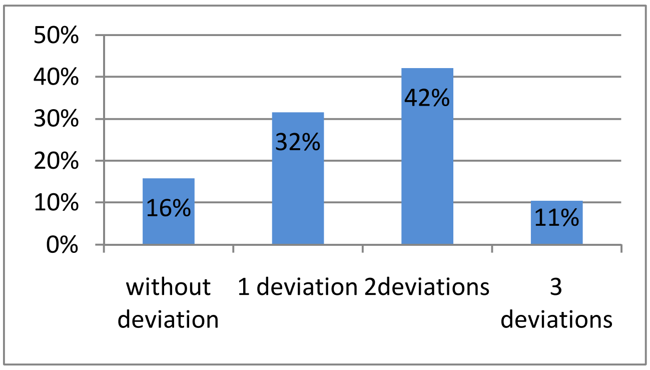


Figure 9. *Frequency of delivery deviations in Project A.*

Figure 10. *Distribution of the number of deviation for the deliveries in Project A.*

Furthermore, the frequency of each deviation is illustrated in Figure 11 and the analysis of the frequency showed that untimely deliveries are the most common deviation. More than half of the measured deliveries included a time deviation, which in all cases were caused by a late delivery and mainly occurred due to lack of communication. None of the deliveries arrived to the construction site earlier than ordered. Delivery of incorrect quantity occurred mainly because the supplier lacked products. Incorrect package or marking caused a deviation in 19% of the deliveries and all of them originated from inaccurate marking of packages. All the quality deviations originated from production defects, which were caused by the supplier. Moreover, documentation deviations were only measured on the kitchen appliances since those were the only product deliveries that included instruction manuals. Two out of 14 deliveries lacked instruction manuals, which was caused by lack of control by the supplier.

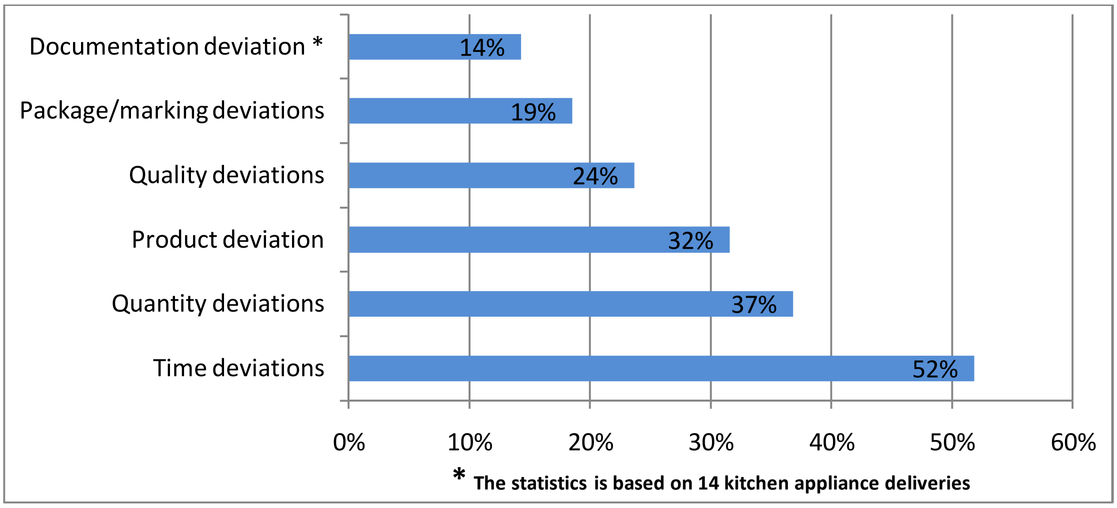


Figure 11. *Frequency for each type of category of delivery deviation in Project A.*

Moreover, consequences of the delivery deviations are showed in Figure 12. Most of the deviations caused extra working time for construction workers, foremen and subcontractors. In addition, almost half of the deliveries resulted in rescheduling of work activities, which means that construction workers had to go back and do additional work. Finally, a 25% of the deliveries resulted in unfinished houses when customers moved in. This consequence is relatively unusual compared to most of the other consequences. In addition, compared to extra time for foremen, construction workers and subcontractors, unfinished houses when customers move in does not contribute to extra direct costs.

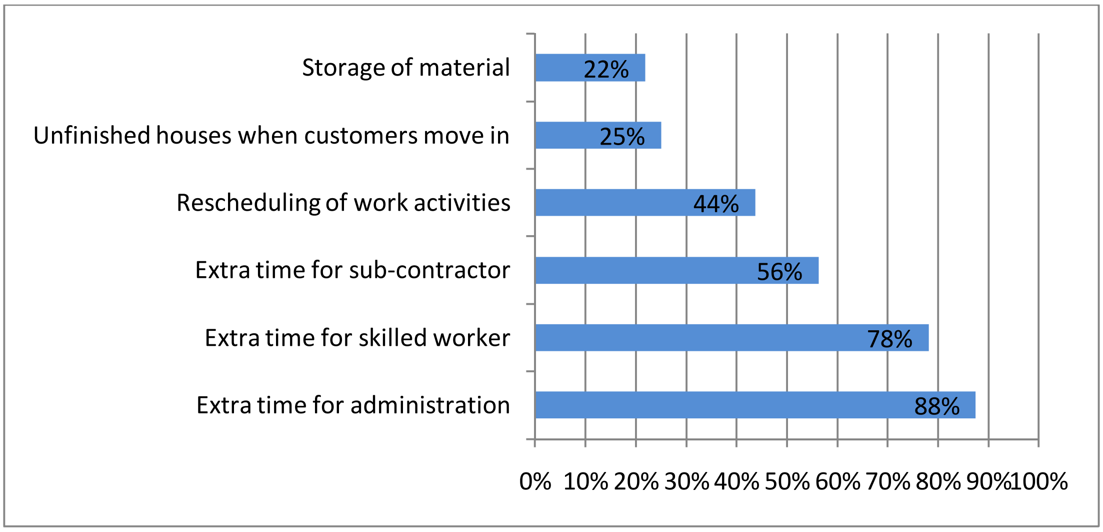


Figure 12. *Consequences of delivery deviations in Project A.*

6.1.1 Kitchen appliances

The kitchen appliance supplier was in this project responsible for the delivery as well as for installation, which address a DCB agreement. Examination of kitchen appliances for 14 houses, delivered at four occasions, is the basis for the statistics. Two of the deliveries included kitchen appliances for four houses, one included kitchen appliances for five houses and one delivery included only components for one house. Kitchen appliances are due to the high theft risk delivered the same week as the customers move in. Therefore, it is of great importance that the material is delivered in time, in full and without quality defects.

None of the deliveries from the kitchen appliance supplier were delivered without a deviation. 64% of the deliveries were late, which caused waiting time for the sub-contractor in charge of installation and extra time for the foreman who had to contact the supplier for information about the delivery. However, if the statistics is based on the four delivery occasions the figure is 50% untimely deliveries. The frequency of quantity deviations, quality deviations and product deviations were unanimous 36%. However, none of the deliveries included a package or marking deviation. The most common reason for quantity and product deviations was communication failure, while the quality deviations occurred due to production defects, which were caused by the supplier.

All deviations resulted in extra time for administration and 93% of the deviations caused extra time or waiting time for sub-contractors. Rescheduling of work activities were the consequences for 64% of the delivery deviations. Moreover, unfinished houses when customers moved in were the result in 57% of the deviations and in half of the cases the consequence was extra time for skilled workers. Furthermore, the commonness of deviations for kitchen appliances resulted in a controlling atmosphere at the construction site. All deliveries were carefully inspected, which consumed many work hours for the production team.

6.1.2 Kitchen cabinets

The kitchen cabinet supplier has a DNUB agreement with Skanska, which means that the supplier is responsible for loading and transportation of the material and Skanska is responsible for unloading and carrying material to the place of assembling.

The statistics of kitchen cabinet delivery deviations is based on measurements of deliveries occurring during the time for this study as well as on documentation of earlier kitchen deliveries. The production team had before we started this study logged quantity-, quality- and product deviations for 11 kitchen deliveries. Hence, statistics of time- and package and marking deviations are based on three deliveries. Further, frequencies of quantity-, quality- and product deviations are based on 14 material deliveries.

The study revealed that 7% of the deliveries from the kitchen cabinet supplier were delivered without a deviation, which indicates that 13 of 14 deliveries were associated with at least one deviation. 64% of the deliveries resulted in a quantity deviation, delivery of incorrect product was the case for 43% of the deliveries and quality defects occurred in 29% of the deliveries. None of the three deliveries included neither time deviation nor package and marking deviation.

Extra time for skilled workers was the result of all deviations and extra time for administration was the consequences in 69% of the delivery deviations. Delivery of incorrect product and quantity deviations resulted in unfinished activities, hence skilled workers had to go back to finish the work later, which in turn resulted in extra time. Seven of 13 deviations caused storage of material at the construction site and 38% of the deviations resulted in waiting or extra time for sub-contractors.

6.1.3 Sliding doors

Sliding doors were delivered for ten houses, totally at three occasions during the time of measurement. These ten deliveries are the basis for the deviation result. According to Skanska's framework agreement, sliding doors should be delivered according to the CLS agreement, which implies that the seller is responsible for loading, while the buyer is responsible for both transportation and unloading.

The production team had problems with late deliveries and package/marking deviations. However, no product-, quantity- or quality deviations were noticed. Out of the measured deliveries, five were delivered without a deviation and five included both time- and package/marking deviation.

The late deliveries resulted in rescheduling of work activities, extra time for administration as well as extra time for skilled workers who had to go back and do rework. The same deliveries were not marked with house number, which caused extra time for material handling and additional time for the foreman who had to localize which door belonged to which house.

6.2 Material deliveries for Project B

A design build contract is used in Project B and the contract sum is approximately 78 MSEK. The project includes construction of both single-family houses and multi-family houses and the project started during the spring 2009 and will be finished in the autumn 2010. Five production leaders, 30 skilled workers and 15 skilled workers from subcontractors have on average been employed at the project

In this project 39 deliveries have been measured, where consumer expendables contributed with 30 deliveries and kitchen cabinets with nine deliveries. Both the kitchen cabinet supplier and the consumer expendables supplier have as a DNUB agreement with Skanska. Delivery time are for the two measured material groups specified as dates, hence a time deviation occur if the delivery do not arrive to the construction site at the promised delivery date specified in the order announcement. The extent of delivery deviations is shown in Figure 13 and as can be seen, seven out of 39 deliveries were associated with a deviation. The measurement revealed that 56% of the deliveries from the kitchen cabinet supplier were delivered without any deviation and for the consumer expendable supplier the figure is 90%.

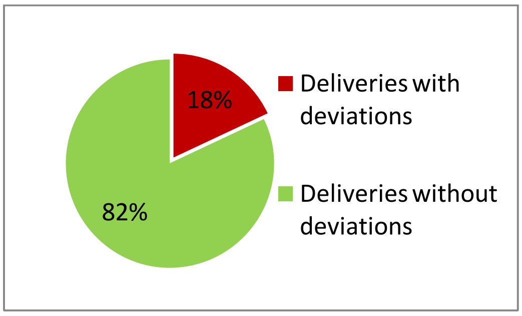


Figure 13. *Delivery deviation frequency in Project B.*

All deliveries arrived to the construction site in time, and none of them included a package/marking deviation. Product deviations occurred in 3% of all deliveries, which all were represented by kitchen cabinets. Accordingly, 11% of the kitchen cabinet deliveries were associated with a product deviation. The deviations were caused by the supplier who had sent wrong product and the consequences so far are extra work for skilled workers and sub-contractor, rescheduling of work activities as well as extra time for the foreman. The foreman estimated that the deviation caused four extra work hours for administration, eight extra work hours for skilled workers and four extra work hours for sub-contractors. According to the foreman it is uncertain if the correct product will be delivered before the customer move in due to long delivery time. Delivery of incorrect quantity because to the supplier lacked products was the most common deviation. Out of the 39 deliveries 10% were associated with a quantity deviation. Deliveries of kitchen cabinets included a quantity deviation in 11% of the cases. All delivery deviations that occurred for consumer expendables were quantity deviations, hence three of 30 deliveries were delivered with fewer components than ordered. However, quantity deviations for consumer expendables did not result in any time consuming consequences according to the foreman. Quality deviations were with 22% the most represented deviation for kitchen cabinet deliveries, which of total deliveries gives the figure 5% quality deviations. The consequences of the quality deviations were extra time for the foreman as well as extra time for skilled workers.

6.3 Material deliveries for Project C

Project C includes three multi-family houses, each with 59 apartments divided on eight floors. The houses are built on a parking deck, which obstructs the logistics in the project. The project time is 33 months and started in October 2009. During this time approximately 4 production leaders, 15 skilled workers and 25 skilled workers from subcontractors were employed. The contract sum is 229 MSEK and costs for material are expected to be 44 MSEK excluding subcontractors' material costs.

Deviations of 28 concrete deliveries, consisting of 121 trucks, were measured in the project, which is the basis for the result. Quality and time deviations have been measured in project B and time deviations include both late deliveries/trucks and long unloading times. The concrete deliveries took place during November to March, so the measurement is based on information from invoices, advice notes as well as observations and notes by the production team. The concrete deliveries for the project had been associated with quality and time deviations and were therefore chosen by the site manger as measurement object. Problems with concrete quality and delivery time are according to the site manager a well known issue in construction projects.

A DUB delivery agreement is used within Skanska for concrete deliveries, which means that the supplier is responsible for loading, transport and unloading of concrete. In addition, the concrete supplier was in this project responsible for delivery all the way to the end of the pump pipe, hence the concrete supplier were responsible for the pump. Furthermore, the concrete supplier charges for unloading and pump time per minute and for exact quantity, so problem free deliveries are of great importance to keep the costs down. Although the concrete supplier had a total responsibility for the delivery, additional costs for long unloading time due to problems with the pump and the concrete quality, were invoiced. Two types of concrete were used in the project, one with higher quality and more expensive than the other. The high quality concrete does not demand additional work afterwards and were therefore mainly ordered for the project. To maintain the benefits of the high quality concrete, deliveries of accurate quality is essential.

The examination revealed that only 2 of the 28 delivery occasions were without a time or quality deviation, hence 93% of the deliveries included at least one deviation, see Figure 14. Of total 121 trucks 49 included any time deviation, which is illustrated in Figure 15. A concrete delivery consists of between 1 to 8 concrete trucks and 54% of the deliveries had at least one truck that was late. In many cases, this caused a domino effect and all following trucks got long waiting and unloading times, which resulted in high costs. Furthermore, 82% of the deliveries had too long unloading time, given that a normal unloading time is maximally 60 minutes per 5 m^3 concrete. Of the 121 trucks 16% were late and 31% had too long unloading time.

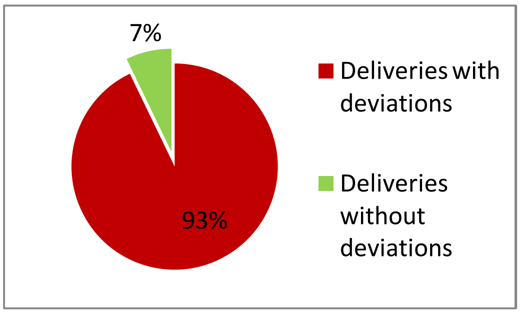


Figure 14. *Frequency of concrete delivery deviations for the 28 delivery dates in Project C.*

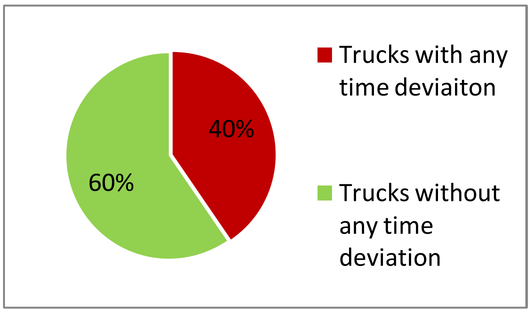


Figure 15. *Frequency of time deviations for the 121 trucks in Project C.*

Delayed deliveries and long unloading times caused, beside extra costs for unloading and pump time, also waiting time for construction workers and foremen. The total costs of delivery deviations, including costs for extra pump time, extra work time, quality defects and faulty invoices, correspond to 10.1% of the invoice sum for the measured concrete deliveries. Figure 16 illustrates how costs for long unloading time, long pump time, quality deviations and extra work time contribute to the total delivery deviation cost for concrete. Total costs of the measured 28 deliveries, excluding material costs, are illustrated in Figure 17. The figure illustrates normal cost for the concrete delivery without deviation in relation to additional costs due to long delivery time.

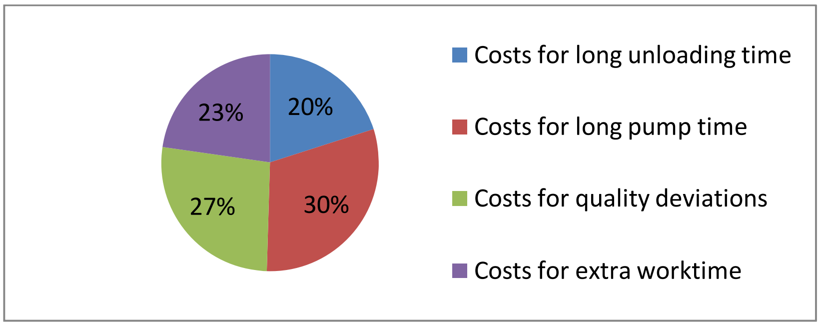


Figure 16. *Distribution of the delivery deviation costs in Project C.*

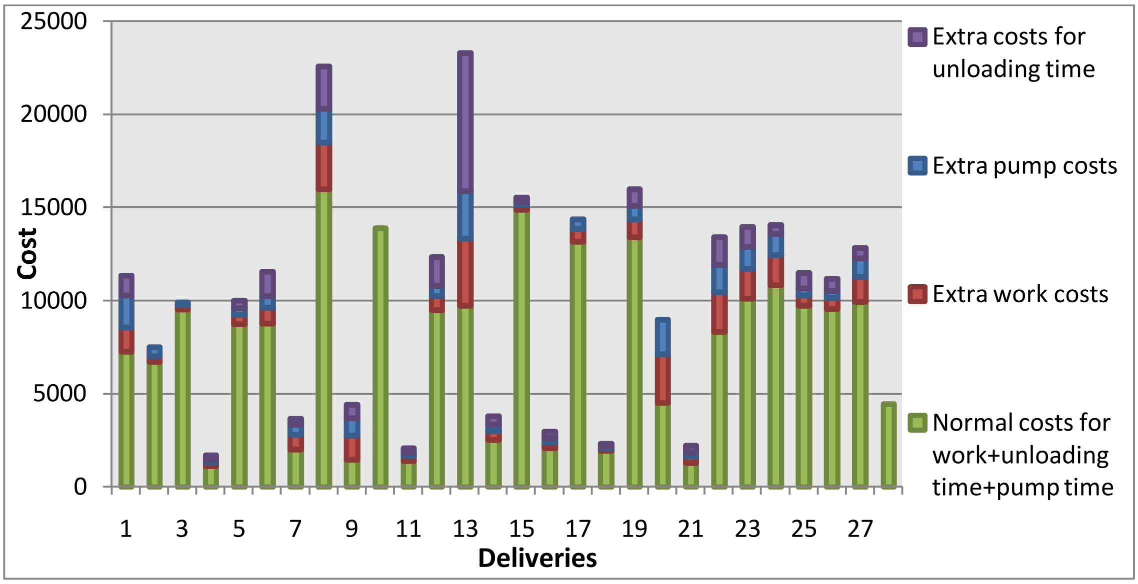


Figure 17. *Distribution of concrete delivery costs for the 28 delivery dates in Project C.*

7 Consequences of material delivery deviations

Delivery deviations result in consequences that cause additional work assignments for the production team. Consequences and ways of handling delivery deviations will be presented in this chapter. One consequence of delivery deviations is reclamations and reclamations of deviations shall according to Skanska's guidelines be performed by Skanska's reclamation form. The reclamation form shall be sent to the supplier or/and the logistician within a week after the delivery. The respondents from the purchase department stress that the reclamation form was introduced in the autumn of 2009, but has not yet been communicated to the construction sites. According to the category manager the suppliers have their own reclamation form, which currently shall be used by the production team.

The respondents at Project A and the project leader state that no common way of working with delivery deviations exists at Skanska. The project leader further states that each project team has their own way of communicating with suppliers and argue that Skanska do not have a good system to facilitate feedback of delivery deviations between construction sites and the purchasing department.

It is according to Skanska's guidelines the line organization's responsibility to drive the reclamation process. However, if the reclamation includes a supplier with framework agreement and if the deviation is crucial the project should contact the person at the purchase department that is responsible for the supplier. In accordance, all respondents argue that it is the production team's responsibility to drive the delivery deviation process, but that they can get help from the purchase department if they contact them. The foreman at Project B stresses that there has been quick response from the purchase department when they have been contacted for advice or notification of a problem with a supplier. Although, all project respondents state that they seldom contact the purchase department when delivery deviations occur. The respondents further argue that it takes a lot of time and energy to handle delivery deviations and therefore prioritize to solve the problem at site without contacting the purchase department. The project leader states that construction sites in the future will get better support from the purchasing department with delivery deviations handling, but underlines that it still will be the projects responsibility to drive the process.

The foreman at Project B describes the consequences of a delivery deviation as an administrative nightmare and a process that is avoided if possible. The respondent further argues that if you do not have a contact person at the supplier firm it results in long phone calls, where you have to wait in several queues and get transferred before you get contact with the right person.

The forthcoming text gives a description of how the production team handles untimely deliveries, quantity errors, quality defects, product deviations and incorrect marking of packages. In Figure 18the process of handling each delivery deviation is illustrated. The flow chart has been developed with the respondents during the interviews. Furthermore, the way of handling material delivery deviations is not consistent for production teams and material groups. Therefore, the flow chart should be considered as an example of the delivery deviation process.

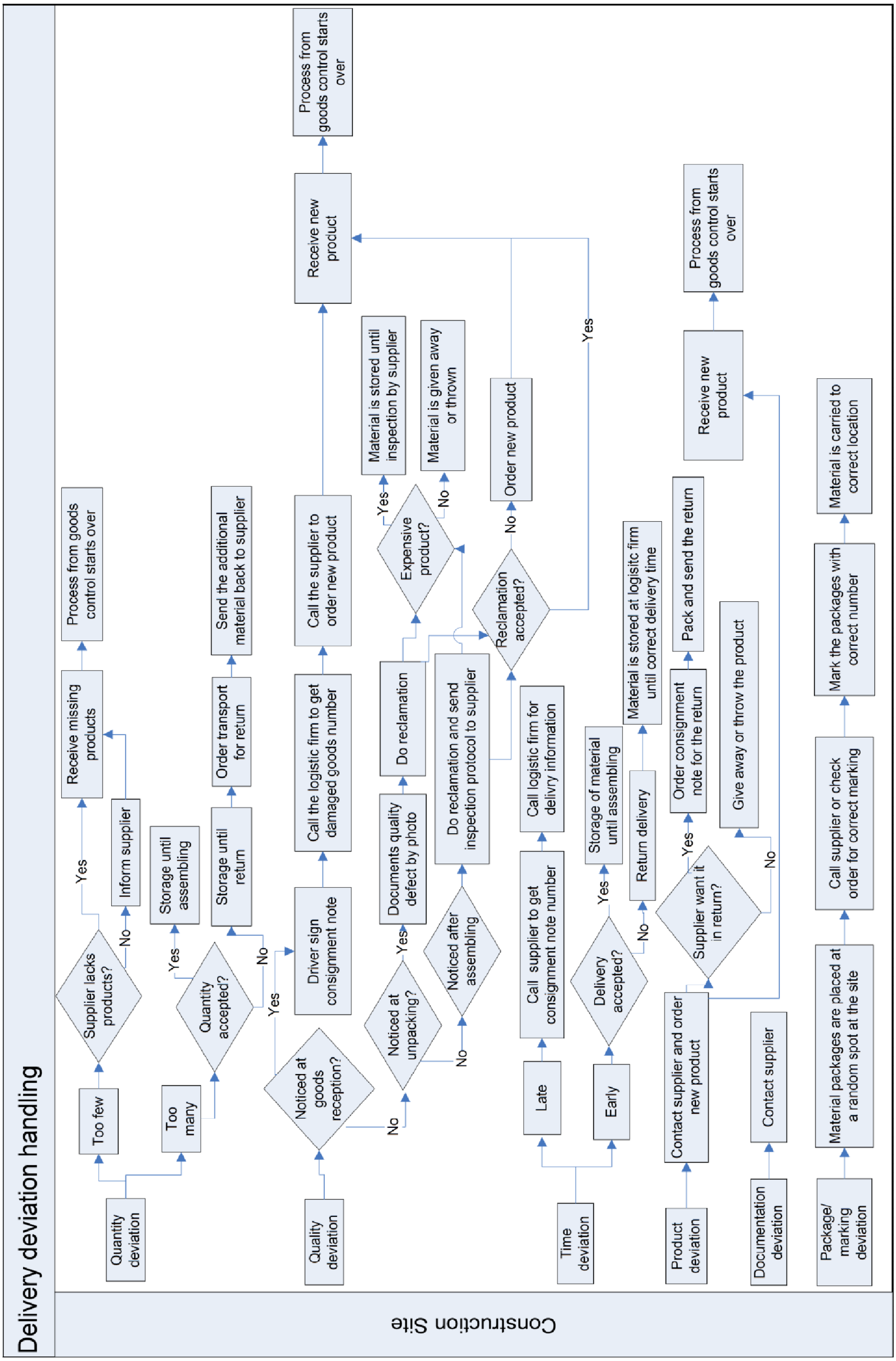


Figure 18. *A simplified example of delivery deviation handling at the construction sites.*

7.1 Time deviations

According to the foreman at Project A, materials are often delivered later than promised in the delivery announcement. Late deliveries causes delays and shifting of work assignments but above all forces construction workers to go back and do rework, which takes longer time than if all work could be performed as planned. The respondent states that it is mostly deliveries of interior products, which are delayed. Deliveries of consumer expendables, such as nails or gypsum boards, are on the other hand according to the respondents seldom late.

The respondents state that if a delivery is late the supplier is contacted to check if the goods have left the supplier's factory. If the goods have left the supplier they get the consignment note number and can thereafter call the logistic firm to track the goods. All project respondents state that material deliveries that arrive earlier than planned are in most cases accepted and therefore stored at site until time for assembling. The respondents stress that storage of ungraceful material, such as kitchens and parquetry flooring, causes logistical problems at site when delivered earlier than planned.

The foreman at Project A states that they at one occasion had repetitive problems with delayed inner doors. Although, the doors were ordered eight weeks ahead and the framework agreement claims delivery four weeks after call-off, the doors were still late. To avoid late deliveries, the foreman in accordance with a skilled worker decided to order doors without pre-drilled holes, which thus resulted in extra work for construction workers at site.

The foreman at Project B describes a situation with gypsum boards that caused additional work and extra costs because of late delivery. The gypsum boards were ordered to be delivered so they could be transported into the houses by crane when assembling the houses. At the day for assembling the gypsum boards had not been delivered and the foreman had not received any information from the supplier about the delay. To get the gypsum boards into the houses the foreman hired a logistic firm, which charged around 7000 SEK. In addition to the direct cost for the logistic firm, the late delivery caused extra time for the production team for hiring the logistic firm, instruct the logistic firm, document and inform about the deviation as well as administration of the invoice from the logistic firm. In this situation the foreman contacted the gypsum board supplier by e-mail and informed about the problem they had caused due to the late delivery and the cost for it. A copy of the e-mail was sent to the category manager at the purchase department. The supplier argued that they had done nothing wrong and made clear that they did not intend to pay the cost for the logistic firm. It is for now a process driven by the foreman with the intention to make the gypsum board supplier to pay for the costs. However, the foreman has low expectations that it will be the outcome. The respondent states that *"it is extremely time- and energy consuming to drive a process like this, which in most cases only ends in pittances"*. The interviewee thinks it is a contractual issue and that the suppliers' penalties for delays are too low in comparison to the costs caused at the construction site.

7.2 Quantity deviations

The most common quantity deviation at construction sites is according to the project respondents fewer delivered parts than ordered which mostly is due to shortage of products at the supplier. However, sometimes quantity deviations occur because the supplier has packed an incorrect number of products. If the supplier has missed to pack parts the foreman at Project A usually contacts the supplier and explains the situation. The respondent argues that the supplier mostly send missing parts without questioning. Quantity deviations due to lack of products at the supplier are according to the foreman at Project B sent to the site later on without need of a new call-off. Furthermore, the respondent states that the deviation results in two invoices, but transport are not paid for twice.

Deliveries that include greater quantity than ordered are according to the foreman at Project B either accepted or refused. If the delivery is accepted the material has to be stored until usage or until it can be sent back, which cause logistical problems at site. Moreover, the respondent states that deliveries occasionally have been refused due to lack of storage space, even though this is considered as an unallowable action.

All interviewees at the projects point out kitchen cabinet deliveries as the ones with most quantity deviations. Almost all kitchen deliveries have missing components, but the production team is according to the respondents informed about the situation through the advice note. The respondents believe that quantity deviations for kitchens occur due to long supply chains and because of the great deal of components included in the product. In addition, according to the category manager, kitchens are assembled late in the construction cycle, which means that there is no room for faults if high customer satisfaction shall be fulfilled. The category manager suggests closer cooperation with the kitchen supplier to decrease the quantity deviations.

The foreman at Project A describes a situation where customers had to move into their new houses with half of the cabinet doors missing due to inadequate kitchen deliveries. The order had according to the foreman been placed in accordance with the delivery time agreed upon in the contract and the problem with missing doors had been discussed with the kitchen supplier months before the customers moved in. The respondent experienced the situation as extremely humiliating and argues that situations like this give Skanska bad reputation. The interviewee states that "*it is like a practical joke to move into a Skanska house with missing kitchen cabinet doors, because a supplier cannot deliver on time*".

Respondents at Project A and B state that they once have logged kitchen cabinet deliveries due to repetitive deviations. Project A got the money they required from the kitchen supplier, but state that the required sum was low in relation to the actual costs for the deviations. The foreman at Project B, on the other hand, describes the outcome as a joke when the supplier only paid 1600 SEK for delayed kitchen cabinet doors of several months. The respondent stresses that "*it was like getting a hit in the face and a process you do not go into again*".

The foreman at Project B states that unfinished houses at the moving in date are if it is possible avoided by borrowing of components from houses later on in the production cycle. However, the interviewee stresses that an action like this result in a lot of extra work and states that the project today have one skilled worker on half time which go back and do additional work, caused by quantity deviations. The foreman argues that costs for extra work are preferred over finishing houses after customers have moved in. However, in cases when it is not possible to borrow material, the production team has to contact the customer and make an appointment, borrow the keys, clean up after the assembling and return the keys. In addition, there is also a risk to break interiors in the house during the assembling.

7.3 Quality deviations

Quality deviations that are visible at the delivery point, as for example if the package is damaged, shall according to the respondents be reported immediately to the supplier. After one week, it is the buyer's responsibility to prove that the damage was caused before the product was received, according to Skanska's guidelines. Furthermore, the time for reclamation of transport damage is out after two weeks. "Hidden" quality defects, on the other hand, should be reported within the number of days that is agreed upon in the contract with the supplier. The respondents at the projects state that reclamation of hidden quality defects is a very circumstantial process. The foreman at Project B states that the reporting of quality defects for most material groups is inferior and argues that there are high hidden costs related to quality deviations. For example the foreman states that they never report quality defects on timber, because of the supplier's requirement on storage until material is inspected.

All respondents state that they in most cases try to document damage goods by photos which they send to the supplier. The foreman at Project B states that most suppliers accept photos, but when there are quality deviations on expensive material the supplier often wants to come to the site and inspect the quality defect. Even if the goods have obvious quality defects at the goods inspection, it must be accepted and stored on the construction site until it is sent back, thrown or until an auditor from the supplier firm comes to inspect the goods.

When quality defects on goods are noticed the foreman calls the supplier and orders a new product. The delivery time for a new product are according to the foreman at Project B dependent on material group and can vary from two days to eight weeks. Respondents at Project A state that there is mostly not a problem to get a new product delivered when there are quality deviations, but it is unclear which actor that should pay for the extra transport.

If a quality deviation is noticed when the time for reporting is over, the process becomes according to the respondents more complicated and it is now up to the foreman to prove that the damage has been caused by the supplier. The foreman at Project A states that if the inspection record is sent to the supplier it is usually not a problem to receive a new product after the reclamation period has passed.

7.4 Product deviations

If incorrect product is delivered, the foreman contacts the supplier and orders a new product. The site manager at Project A stresses that there are instructions in the contract for how returns should be handled. The product can according to the respondents in the projects be sent back if the product is in the original package, but then the foreman has to order a consignment note for the return. The site manager stresses that they get 75-80% back on the price if they send back a product in its original package. Furthermore, interviewees at Project A state that a product that cannot be returned is used in another house or thrown away.

The foreman at Project B argues that if wrong product has been ordered it is not worth to send it back, due to the high transportation cost. The respondent further states that incorrect products are usually thrown away or given to employees in the project. The foreman states that article numbers for kitchen appliances often are changed without an update in IBX, which is one of the reasons for ordering of incorrect product. During the time of this study Project A ordered a spare part for a cabinet and attached the old delivery announcement and a detailed description of the part to the order. However, when the part was delivered two weeks later it was the wrong product. The result of this incident were 30 minutes in a phone queue and two call transfers before the foreman got in contact with the right person at the supplier firm.

7.5 Package and marking deviations

Materials that are specific for each accommodation, as for example kitchens and stairs, is when ordered requested to be marked with accommodation number. Incorrect marking of products are, according to respondents at Project A, a common deviation. The foreman at Project B, on the other hand, states that unmarked packages are unusual. If a product is mismarked or not marked at all, the foreman has to compare the order number on the product with the order announcement or in worst case call the supplier to get information about marking. The foreman at Project B states that deliveries of missing components are never marked with accommodation number. According to the category manager this problem was common for missing kitchen components. However, the category manager recently notified that the kitchen supplier about the problem and perceive that the problem is solved.

During the time for this study Project A received unmarked sliding doors for four houses, which in addition were delivered one day late. The team at the construction site unloaded the truck and placed the doors at the house where they thought each door belonged. The foreman then spent half an hour to localize which door belonged to which house and found out that the placement of the doors was inaccurate. This delivery deviation caused 30 minutes extra time for the foreman, 30 minutes extra time for the skilled workers for material handling. In addition, the late delivery caused extra time for rescheduling of time plan and standstill of the skilled worker responsible for the assembling.

8 Analysis and Discussion

In this chapter, the result from the delivery deviation measurement and interviews are analyzed and compared with the frame of references. The chapter is divided into the three research questions that have been the core of this study.

How common are material delivery deviations and which consequences and costs can be related to deviations at the construction site?

Out of 198 measured deliveries for five different product categories, 44% had at least one delivery deviation. The result varies greatly between the projects and the frequency of deliveries without deviations was 16% in Project A, 86% in Project B and 7% in Project C. The high delivery performance in Project B was in a large extent due to high delivery performance for consumer expendables, which was represented by more deliveries than kitchen cabinets. However, the data collection in Project B has not been carried out with the same accuracy as in the other two projects, which probably has affected the result. The low delivery performance in Project A was mainly due to high delivery deviation frequency for kitchen appliances and kitchen cabinets. The low delivery performance in Project C, on the other hand, was only based on concrete deliveries, which was one of the three most problematic product categories along with kitchen cabinets and kitchen appliances.

The reasons for these three product categories being problematic can be questioned. According to the category manager, one factor that might affect the delivery performance for kitchen cabinets is the complexity of the product. Kitchen cabinets include many components and there is therefore a greater risk than for other products that the supplier miss to include some of the components in a delivery. Moreover, the category manager believes that another factor that affects the kitchen supplier's delivery performance is long supply chains. However, even if the product is complex and involves long supply chains, a delivery performance for the kitchen cabinet supplier of 7% in Project A is reprehensible. In Project B the figure is 56% and the reason for the better delivery performance for kitchen cabinets in Project B can be questioned. Either, the delivery performance in Project B was better or the higher figure is due to less accurate measurement in Project B. Regardless, a delivery performance of 56% can be considered as low.

Moreover, 7% of the concrete deliveries were without deviations and many of the deviations were caused by problems with the concrete pump, which resulted in long unloading times. However, there were also problems due to poor performance by the concrete supplier, as for example late deliveries and delivery of inaccurate concrete quality. A potential reason for the concrete supplier's low delivery performance is the strict requirements of timely deliveries. This requirement put more pressure on the concrete deliveries compared to most other material deliveries, where delivery time is specified as date. Time deviations for concrete deliveries caused extra costs for both pump and unloading as well as for construction workers.

Finally, the supplier of kitchen appliances had deviations in all deliveries! The result shows that quality defects were caused by production failure at the supplier, while quantity and product deviations mostly occurred due to communication failure. In accordance with concrete deliveries, the kitchen appliances also had just-in-time delivery requirement, which partly explains the result. However, beside strict delivery requirement, there is no clear reason that explains why the kitchen appliance supplier had such low delivery performance compared to other material suppliers. It can be questioned if such low delivery performance shall be accepted by Skanska.

Furthermore, the delivery performance for the sliding door supplier was 50%, which is better than the three most problematic material categories. Still, the delivery performance can be considered as low and many of the deliveries also included two deviations. Just like kitchen appliances there is no clear reason that distinguishes and explains the high frequency of deviations for sliding doors. However, sliding doors were delivered at fewer occasions compared to for example consumer expendables, which had deliveries almost every day. The consumer expendable supplier had a delivery performance of 90%, which might be explained by the high frequency of deliveries. A high frequency of deliveries creates a greater opportunity for making continues delivery improvements during the project time. Another factor that might have affected the high delivery performance for the consumer expendable supplier is the close distance between the construction site and the supplier's warehouse. However, as mentioned above, the measurement in Project B was performed with less accuracy than in the other projects.

The result further shows that the most common delivery deviation in Project A was time deviation. However, quantity and product deviations also had a high frequency. In addition, the most common reason for deviations was communication failure. In Project B, on the other hand, communication failure was not the main reason for delivery deviations. However, only quantity, quality and product delivery deviations occurred in Project B and quantity deviations were most common. Though, totally there were few delivery deviations in Project B and other deviations might have occurred if the measurement would have been carried out during a longer time period. The most common delivery deviation in Project C was time related deviations but the only deviations measured in this project were time and quality. All together, the most common deviation in the three case projects was time deviations. This indicates that Skanska's requirements on suppliers' delivery precision are low.

Consequences and costs of delivery deviations

The most common consequence of the delivery deviations in all projects was extra work time. In Project A and B the delivery deviations resulted in extra work time for all occupational groups and in Project C most of the extra work time consisted of waiting time for skilled workers. In Project A, the three consequences that had the highest frequency was extra time for administration, extra time for skilled workers and extra time for subcontractor. Totally the extra work time in Project A was at least 80 hours during the time of measurement in this study. Some of this extra work time originated from 'rescheduling of work activities' which had the fourth highest frequency in Project A. Rescheduling of work activities created extra administrational work, but also extra working hours for skilled workers, since they had to go back and do additional work. Extra work time (including waiting time) created extra costs in all three projects but the most severe costs were in Project C. In addition, the concrete supplier's poor delivery performance in Project C created additional costs for extra pump time, extra unloading time and poor quality. Totally the measured extra costs due to the delivery deviations in Project C corresponded to 10.1% of the invoiced sum (including material costs). The quality costs were costs for rework due to poor concrete quality and these costs are, according to Sörqvist (2001), referred to as tangible costs.

However, poor delivery performance also created a lot of intangible costs in all three projects. One example of intangible costs is 'storage of material', according to Campanella (1999), which was the consequence for 22% of the deviations in Project A. Storage of materials creates costs due to disorder at site, theft, extra handling and breakage and loss of material (Bertelsen & Nielsen, 1997). Other examples of intangible costs due to delivery deviations are costs for health and safety, decreased motivation and increased prices. Campanella (1999) states that some organizations consider intangible costs as three or four times greater than tangible costs. However, intangible costs are hard to measure and Sörqvist (2001) argues that personnel generally handle the problems from which the intangible costs originate without accounting for them.

In Project A there were also problems with unfinished houses when customers moved in, which originated from late kitchen appliance deliveries and have probably affected customer satisfaction. Unfinished houses when customers moved in, was the consequence for 25% of the deviations for all the measured materials in Project A. However, this percentage might become higher since some consequences become visible after the time of measurement in this study. Heskett et al. (1997) underline the importance of satisfied customers by stating that a satisfied customer tends to recommend the company to one other person while an unsatisfied customer tends to tell ten other people about the company's poor performance. According to Sörqvist (2001) customer who are statisfied are also generally willing to pay a higher price in future business.

Conclusively, the consequence 'unfinished houses when customers moved in' was not as frequent as 'extra working time for different occupational groups' or 'rescheduling of work activities', but the long-term effects of this consequence might have severe effects on Skanska's profitability. Furthermore, the measured delivery deviations resulted in many additional work hours in Project A that can be priced and measured and 10.1% additional costs in Project B. However, the highest costs caused by the delivery deviations were probably the intangible costs, which were not measured in this study.

What are the shortcomings in the order-to-delivery-process and in the way of handling material delivery deviations at the construction site?

During this study the order to delivery process has been mapped and investigated. The main constraints and weaknesses in the process, which hamper improvements of suppliers' delivery performance, are presented below.

Unreliable delivery time

Untimely deliveries were one of the most frequent deviations in the case projects and On-time deliveries are according to Vonderembse and Tracey (1999) one of the two most important factors of a supplier's performance. Further, Christopher (1998) argues that the reliability and consequentiality of deliveries are more important than the duration of the order cycle. If the buyer does not trust the supplier and the delivery time, the buyer will compensate for it by making call-offs earlier and of greater quantities than needed, which in many cases causes storage of material (Christopher, 1998; Alarcón, 1997). The project respondents confirm the theory by stating that they try to avoid long storage times, but if they know from past experience that a supplier has low delivery precision they compensate for it by ordering earlier than the actual need. This way of handling the problem creates additional costs and has an impact on the overall performance in projects. Storage of material also results in extra handling of material which can result in costs for health and there is also an increased safety risk with storage of material at site. The impact of unreliable delivery time on costs and performance was in focus in the Danish housing projects, where just-in-time deliveries were applied. Both direct and indirect material delivery costs were considered in the projects and the result was 9% decreased net building cost, increased productivity and quality and higher morale among workers (Bertelsen & Nielsen, 1997).

Moreover, one situation where short order cycle times are of high importance is when new products are ordered due to quality- or product deviations. Unfortunately, the order cycle time and the reliability of delivery time are in these cases often unsatisfactory according to the respondents. The long order cycle time affects the time plan in the project and work assignments has to be rescheduled, which creates additional time for going back and to re-work. In addition, long order times for interior products do in many cases result in unfinished houses when customers move in. One of the case projects has one full time construction worker that only perform work assignment that is due to that suppliers cannot deliver the order in full and in time.

Delivery information from suppliers

The supplier confirms an order by sending an IBX-verification or a more detailed delivery announcement. The respondents question why two systems for order confirmation are used within Skanska and further state that they would like to have a consistency in the delivery information sent from suppliers. Moreover, the handling and usage of delivery information varies in construction projects; one foreman states that the documents always is controlled in order to minimize unexpected events, but another foreman states that the information only is controlled if there is time. By controlling the information from suppliers, potential delivery deviations can be revealed and consequences minimized. However, if the projects could trust that the supplier would deliver what is ordered and in time this action would not be needed and the time could instead been used for value creating actives.

Furthermore, delivery time, specified as date or week, is either confirmed or changed by the supplier on the delivery announcement. It can be questioned why suppliers have the right to change delivery date if the required time for delivery is in accordance with the contracts and why suppliers are allowed to specify order time as week. Some suppliers also fail to inform about delivery changes, as for example the gypsum supplier mentioned in chapter 7.1, which caused additional costs for handling of material as well as lost motivation among workers. The imprecise information from suppliers gives the projects inadequate conditions for planning work activities, which affect the overall performance. Another constraint for efficient production planning is information about components and products that the supplier cannot deliver with the rest of the order. This information is only notified on the advice note, which is sent the day before the delivery or the same day as the delivery. It can be questioned if the suppliers do not have information about quantity deviations earlier than one day ahead and why Skanska does not requires information about order changes earlier in advance. Order status information, which includes information about delivery changes and potential problems, is one of the most essential aspects of a supplier's performance identified by Christopher (1998), however, many of Skanska's suppliers do today not fulfil this requirement.

Conclusively, today's situation where suppliers' have the right to change order date and often fail to inform about delivery changes reflects a relationship governed by the supplier. One way of improving the information from suppliers and making the governance equally divided between the parties would be to include clear requirements of when delivery information should be provided as well as penalties for not fulfilling the requirements.

Delivery notification from logistician

Delivery notifications from logistic firms are important for the projects, but are in many cases deficient. Early delivery notifications from logistic firm are rare, some drivers notify short in advance, but most drivers do not do it at all. The project respondents along with the category manager argue that accurate delivery notifications are important to be able to prepare unloading of material. However, the category manager states that one problem with demanding delivery notification at call-off is that the logistician is only allowed to deliver goods if a notification is made. Hence, deliveries might be delayed if the logistician is unable to get in contact with the responsible person at the construction site. This situation puts the production team in a "Catch 22"; they want to have delivery notifications to be able to prepare unloading, but if they require notification there is a risk the delivery becomes late if they do not have the possibility to answer the phone when the driver calls. However, if delivery precision would increase and time for deliveries could be trusted, delivery notifications might not be needed. In addition, the logistic firm's information about what, where and whom to deliver are in many cases inaccurate, which indicates that information is lost on the way between the supplier and the logistician. One foreman estimates that he receives 30 calls a week from drivers who want guidance, because they lack information about delivery address. This situation implies unnecessary time for the foreman, which could have been used for value creating activities if the information flow had been accurate. The reason for the inaccurate information provided on consignment notes and to logistic firms is according to one of the respondents non compatible systems. The compatibleness of buyer's and supplier's systems are referred to as ordering convenience by Christopher (1998) and is one of the eleven key areas of suppliers' performance that he identified. That the supplier' order system are compatible with Skanska's are of great importance in order to reduce delivery deviations and should be a requirement suppliers' have to fulfil if doing business with Skanska.

Goods inspections

Goods inspection shall according to Skanska's guidelines always be performed when deliveries arrive to the construction site and when material is unpacked. The project respondents, on the other hand, stress that approximately half of the deliveries are inspected and many consignment notes are signed before the delivery is checked. However, if a supplier is known from past experience for having low delivery performance, the goods are always carefully inspected. Inspection of goods is according to Jonsson (2008) time consuming and in accordance the project respondents state that lack of time is the main reason for not doing goods inspections. However, it can be questioned if it does not take longer time to handle a delivery deviation later on than immediately. The respondents suggest bar-code scanners for goods receptions, which would decrease the time for inspection and increase the number of inspections. Moreover, if the bar-code scanner could be synchronized with the order system, suppliers' delivery performance could be measured and used when suppliers are evaluated.

Inspection of product quality shall according to Reyniers and Tapiero (1995) be stated in the contract. Skanska has according to the category manager not included inspection of quality in the contract but argue that it is obvious that the supplier shall perform quality inspections before material are sent. However, since quality inspection is both time-consuming and expensive Skanska cannot trust that the supplier performs quality inspection if it is not included in the contract. Furthermore, if it is obvious that the supplier shall ensure quality why should it always be inspected at the construction site as well? Jonsson (2008) stresses that responsibility for quality control is a question of reliability and trust.

Acceptance of delivery deviations and no consequent way of handling material delivery deviations

All projects and each production leader have their own way of handling material delivery deviations and the respondents' view of a reclamation process is divergent. One foreman describes a reclamation process as an administrative nightmare, which you seldom drive home, while another foreman describes it as time consuming but quite easy to drive home if you have the right contacts at the supplier. However, all respondents stress that delivery deviations seldom are reported. Previous experiences of long, time consuming and undesirable outcomes seem to be the reason for making few reclamations. The production department cannot see the benefits of reporting deviations and driving a reclamation process. As it is today, it is easier, cheaper and less time-consuming to throw or give away products with quality defects than to do reclamations and reporting the deviation. All project respondents argue that they seldom contact and report delivery deviations to the purchase department. The only time the purchase department is contacted is when there are severe and long-lasting problems, in other cases the employees in the projects prioritize to solve the problem at site. This indicates a short-term thinking at the construction sites and no improvements of delivery performance will be achieved as long as this attitude exists. Moreover, if material delivery deviations never are communicated to the purchase department, the purchase department believes that suppliers perform in accordance with the contracts. However, it can be questioned why the purchase department is not more actively seeking and requiring information about suppliers performance from projects.

The diverse ways of handling delivery deviations and different treatments from suppliers address that a clear and common way of handling reclamations is needed. If all delivery deviations were reported to the suppliers as well as reported in the same way, the effect would be more substantial. Lynch and Cross (1995) state that delivery deviations should be reported to suppliers by the purchase department, but today's way of working with delivery deviations and the lack of delivery performance measurement at Skanska do not make it possible. Compulsory goods inspections and reporting of delivery deviations would facilitate the feedback between the projects and the purchase department and it would create a situation where the purchase department can be responsible for the contacts with suppliers as well as follow-up of suppliers' performance. Moreover, as all of the respondents point out, a system for reporting delivery deviations has to be easy, not time-consuming and has to facilitate the work situation in the projects.

Furthermore, the non usage of contractual reimbursements is another constraint in the way of handling material deviations, which affects suppliers' attitude towards contractors. The supplier's delivery time is stated in the contract and there are penalties if a supplier cannot deliver according to the agreement, but these are according to the respondents seldom utilized in construction projects. If there are no costly consequences for suppliers when they do not deliver in accordance with the contract, Skanska cannot expect that the suppliers delivery performance will be improved.

Conclusively, the acceptance of suppliers' poor delivery performance might be the strongest reason for the situation. Every person we have spoken to in the construction industry are aware of the problems associated with material deliveries, but suppliers poor performance have for decades been ignored and accepted. As long as this acceptance exists, no improvements of delivery performance can be expected.

How is suppliers' performance considered by the purchase department?

According to the category manager, the purchasing department at Skanska has since the recession in 2008 been focusing on pushing prices. Price reduction is an important parameter when procuring suppliers, but if price is the only parameter that is considered, there is a risk that other costs within the company will increase and thereby reduce or even eliminate the costs savings (Gadde & Håkansson, 1998). Skanska is not the only company within the construction industry which has price reduction as main purchasing strategy and construction companies are too often only considering cheapest price when procuring materials (Bertelsen & Nielsen, 1997).

Accordingly, Wegelius-Lehtonen (2001) argues that choosing suppliers based on purchasing price and ignoring parameters such as product quality, product performance and delivery reliability will affect a company's profitability. In addition, by always choosing the supplier with the lowest bid, the continuity and the opportunity to develop long-term relations is lost. The site manager in Project C argues that the purchasing department at Skanska often lacks a holistic view of purchases. According to the site manager costs are only transfered from the purchasing department to other departments within the organization when having price reduction as main focus for supplier selection. The category manager states that Skanska has begun to realize the problems with having price reduction as main focus and new directives include value creation for the whole chain. Liker (2004) states that the level of collaboration and cooperation with suppliers is decisive for a company's production efficiency, since the company will not cut costs unless suppliers cut costs. The category manager further states that Skanska's purchasing department have pushed prices to the limit of what suppliers can afford and that there is no room for additional reductions. The question is how Skanska can motivate suppliers to improve quality and delivery performance, when prices have been reduced to the limit.

One incentive for suppliers to improve these parameters might be long-term relationships. By developing long-term relationships, routines and communication can be improved, which probably will reduce the number of delivery deviations as well as costs for both suppliers and contractors. However, Frödell (2009) argues that the willingness among contractors to develop long-term relationships can be questioned since incentives and measurement systems encourage price reductions. On the other hand, the category manager believes that cooperation and long-term relations with suppliers are essential in order to avoid problems that arise at the construction sites due to delivery deviations. Furthermore, the category manager states that suppliers possess valuable product knowledge, which earlier has not been taken advantage of. According to Stadtler and Kilger (2008) a supply chain will become more competitive by letting each actor perform their core competence and by having a holistic approach when procuring suppliers. Creation of a win-win situation between parties is also important for the effectiveness and trust in a supply chain (Stadtler & Kilger, 2008). There are many examples of positive effects such as reduced lead times, better quality and reduced costs, from implementation of SCM in other industries. However, the traditional way of organizing different actors for each new project hamper successful implementation of SCM in the construction industry (Wegelius-Lehtonen, 2001).

Another important aspect of supplier relations is support of suppliers. According to Liker (2004) Toyota have their own supplier support centre, which help suppliers to improve productivity. No such support centre exists within Skanska and the attitude at the purchasing department has according to the category manager been to keep a distance to suppliers. However, when severe problems with the kitchen supplier occurred, a meeting was held with the kitchen supplier and one of the site managers in order to solve the problems. The category manager states, on the other hand, that these types of meetings are unusual and Akintoye et al. (2000) argue that the construction industry generally lacks appropriate support structures. However, compared to the automotive industry, the construction industry involves a greater number of suppliers which often are spread all over the world. Therefore, supporting all suppliers is almost impossible and would cost more than what possible performance improvements would bring in return. Nevertheless, the category manager states that a first step towards improving suppliers' performance could be follow-up of the key suppliers' delivery performance.

Three suppliers that can be regarded as key suppliers that have been considered in this study are the suppliers of kitchen appliances, kitchen cabinets and concrete. The concrete supplier can be regarded as a key supplier since concrete deliveries can become very expensive if there are many deviations, such as quality defects or long unloading times. Kitchen delivery deviations do not cause as much direct cost as concrete delivery deviations, but the kitchen supplier can still be regarded as a key supplier since kitchen delivery deviations are interrelated with customer satisfaction. According to the category manager, kitchen delivery deviations can severely affect customer satisfaction, because kitchens are assembled late in the production chain. Therefore, there is a risk that customers move in without complete kitchens if delivery deviations occur. The foreman in Project B states that dissatisfied customers due to unfinished houses at moving in has been experienced several times. Furthermore, the result of this study clearly shows that the kitchen- and concrete suppliers were associated with most delivery deviations. For these reasons, Skanska might gain both reputation and cost reductions by initiating measurements of the concrete and kitchen suppliers' performance.

Many of Skanska's suppliers perform their own measurements of delivery precision, which the category managers at the purchase department sometimes take part of. If this situation gives an objective view can be questioned. Other industries, such as automotive companies, consider two measurements of delivery precision; one performed by the supplier and one by the company. This way, a more objective view can be achieved. Vonderembse and Tracey (1999) state that suppliers' performance is highly correlated with production performance. Further, Vonderembse and Tracey (1999) identified high quality of incoming products and on-time deliveries as the two most important factors of suppliers' performance. Other industries have realized the link between supplier performance and production performance and have according to Bengtsson and Gustad (2008) daily controls and measures of incoming goods and suppliers. Hence, the construction industry might have a lot to learn from other industries however Wegelius-Lehtonen (2001) states that measures of supplier performance should be simple and standardized. The category manager agrees with this and states that a system for delivery deviation reporting should be user-friendly, compulsory and not time consuming.

The result of this study further revealed that lack of communication is one of the outstanding reasons for deviations, and it is both between suppliers and projects as well as between the purchase department and the construction sites. Van Weele (2005) states that implementation of a performance measurement system can result in better communication between functions and departments, better decision making, higher motivation of personnel and a greater insight into the company's dealings with suppliers. Further, Wegelius-Lehtonen (2001) points out the importance of using the performance measurements in decision-making and states *"what is done with the measure is even more important than what the measures are"* (Wegelius-Lehtonen, 2001, p. 115).

One forum where the measurement can be used is when suppliers are evaluated. Hadikusumu et al. (2005) describe evaluation of performance as one of the most vital processes in any business transaction. Although, Skanska does not currently measure suppliers' performance, delivery of goods and services is one of the parameters that should be considered when evaluating suppliers according to Skanska's guidelines. It can be questioned what is included in "delivery" and how is it evaluated when it does not exist a systematic way for reporting delivery deviations. Skanska base their supplier evaluations on information from the reference team and feedback from projects. However, the information flow from projects is inadequate, hence evaluation is mainly based on the reference team's experience. In addition, the reference team consists of one or two representatives from the production department, which limit the information about the suppliers' "real" performances. Moreover, the almost nonexistent exchange of information between purchase department and construction sites creates a situation where suppliers' real performance never is considered. The study shows that almost none of the eleven key aspects of suppliers' performance that Christopher (1998) identified are fulfilled by Skanska's suppliers, which address that a changed evaluation process is needed.

The site manger in a project is asked to evaluate a supplier when an invoice exceeds a certain amount of money. However, the study revealed that the projects interest in doing evaluations is very low. One site manager perceived that four evaluations of service suppliers had been performed and none for material suppliers. The other site manager states that he did not know about this evaluation form and has therefore never performed one. The site manager at Project A point out "time" as the reason for not doing evaluation forms. Moreover, the evaluation is based on human beings perceptions and is not based on actual fact, which a continually performed delivery deviation measurement would give. Further, it is the site manager who is asked to do an evaluation, but it is the foremen at the site that have the main contact with suppliers and take care of deliveries. Therefore, it can be questioned if the evaluation form is distributed to the right people. However, foremen can do evaluations but must in that case actively seek the evaluation form on the intranet, and if it is not compulsory and you have many other tasks to perform you will not prioritize to do evaluations.

9 Conclusions and recommendations

Material delivery deviations are a well-known problem in the construction industry, but the area has for a long time been neglected. The result from this study indicates that approximately half of all material deliveries for construction projects include any delivery deviation in terms of quality, time, quantity, product, documentation and package/marking. For two of the measured material groups, kitchen cabinets and concrete, more than 90% of the deliveries were associated with at least one delivery deviation and for kitchen appliances none of the deliveries were delivered without deviation. Furthermore, in one of the case projects 53% of all deliveries included two or three types of delivery deviations. The result of this study indicates that the construction industry has a great potential to improve efficiency and to cut costs. The study revealed that almost all delivery deviations resulted in rescheduling of work activities and extra time or waiting time for construction workers as well as for the management team at site. Unfinished house at moving in date was not as frequent as extra time and rescheduling, but it is a consequence that can have great impact on the company's brand in a longer perspective. All consequences result in additional costs, and the study revealed that costs for delivery deviations represent at least 10% of the purchase volume for some material groups. However, there are many consequences and costs of delivery deviations that are hard to reveal and measure so the figure might be even higher.

Lack of communication was the most common reason for delivery deviations that could be identified in the study and many of the shortcomings inherent in the order-to-delivery process are related to lack of communication. The shortcomings in the order-to-delivery process that are most outstanding are: unreliable delivery time, inaccurate delivery information from suppliers, poor delivery notifications from logisticians, inadequate goods inspection and inconsistent ways of handling delivery deviations. There are many constraints in the way of handling delivery deviations that hamper delivery performance improvements. Today's, inadequate reporting of delivery deviations to suppliers and to the purchase department is one of the areas that is in need of change in order to improve delivery performance. Further, penalties included in delivery contracts are today seldom utilized. As long as suppliers' do not experience any consequences of not delivering in accordance with the contract, the suppliers will not see any reasons for improving delivery performance. The lack of communication and cooperation between the purchase department and the production department contributes to purchase decisions made on inadequate grounds. Price is still the aspect with strongest mandate when selecting suppliers, but a changed attitude towards a more holistic view can be observed. A performance measurement system would facilitate and increase the communication between the construction projects and the purchase department and would also give a foundation where choice of suppliers can be based on actual fact and not on perceptions of suppliers' delivery performance. The large supply base obstructs delivery performance measurement of all suppliers. Therefore, focus should be on measurement of key suppliers' delivery performance. Suppliers of interior products can be viewed as key suppliers since the deliveries are scheduled late in the production phase and delivery deviations of those products can have great impact on customer satisfaction. The study revealed that the concrete deliveries were associated with many delivery deviations, which resulted in high costs and can therefore also be regarded as a key supplier. Further, the concrete supplier is an in-house supplier and improvements of the internal supply chain might be easier than the external. By having an effective internal supply chain the attempts to improve the external supply chain will be more trustworthy.

Finally, the poor delivery performance seem to be accepted in the construction industry and many people have a short-term perceptive when handling delivery deviations instead of acting in a way that leads to improvements in the longer run. The deficient delivery performance among suppliers and the costs resulting from delivery deviations address the need of a changed attitude regarding delivery deviations in the construction industry. Many benefits, in terms of increased performance and decreased costs, can be gained by companies who start focusing on material delivery deviations.

Recommendations to Skanska

- **Start measuring suppliers' performance and use the result when evaluating suppliers.** A performance measurement system will contribute to a holistic view when evaluating suppliers and supplier selection can be based on real facts instead of assumptions of suppliers' delivery performance. It is important to point out that the system should be easy to use for the projects and facilitate the reclamation process. The benefits of using a performance measurement system must be well communicated within the organization and responsibilities have to be clearly stated. Measurement of all suppliers' delivery performance will probably be too time-consuming, hence, a recommendation is to start measure key suppliers delivery performance. Further, it is also important to support suppliers to improve their delivery performance. The cost of supporting suppliers will be paid back when delivery deviations decrease.
- **Increase the feedback and the cooperation between the projects and the purchase department.** Today, the production department and the purchase department act in a large extent as solid entities independent of each other. The communication between the departments is poor and a changed attitude and ways of working is needed in order to improve delivery performance.
- **Require better information from suppliers in order to facilitate planning at the construction sites.** Information about changes of delivery time and if orders cannot be delivered in full should be communicated to the projects earlier in advance.
- **Start utilizing the penalties in the contracts.** If there are no economical consequences for suppliers when not delivering in accordance with the contract, there will not be any improvements in delivery precision.
- **Consider the total costs when suppliers are procured and not just lowest price.** By having price reductions as main focus when procuring suppliers there is a risk of neglecting other important and costly aspects of deliveries. The result of price reductions is in many cases just transferring of costs from one department within the company to another.

10 References

Akintoye, A., McIntosh, G., & Fitzgerald, E. (2000). A survey of supply chain collaboration and management in the UK construction industry. *European Journal of Purchasiong & Supply Management , 6*, 159-168.

Ala-Risku, T., & Kärkkäinen, M. (2006). Material Delivery Problems in Construction Projects: A Possible Solution. *International Journal of Production Economics , 104* (1), 19-29.

Andersson, Å., Karlsson, H., Lindahl, L., & Ruben, T. (1983). *Samarbetsformer inom byggmaterialdistributionen.* R3:1983, Statens råd för byggforskning.

Backman, J. (1998). *Rapporter och uppsatser.* Lund: Studentlitteratur.

Bengtsson, J., & Gustad, Ö. (2008). *Kartläggning av materialflödet I Peabs försörjningskedja till byggarbetsplatsen, med SCOR.* Norrköping: Linköpings Universitet.

Bertelsen, S., & Nielsen, J. (1997). Just-In-Time Logistics in the Supply of Building Materials. *International Conference on Construction Industry Development: Building the future Together*, (pp. 9-11). Singapore.

Boverket. (2005). *Ny prisstruktur för byggmaterial i Sverige - Samlade erfarenheter av tre genomförda projekt.* Huskvarna: Boverkets Byggkostnadsforum.

Byggkommissionen. (2002). *Skärpning gubbar! Om konkurrensen, kvalitén, kostnaderna och kompetensen i byggsektorn.* SOU 2002:115, Stockholm.

Campanella, J. (1999). *Principles of Quality Costs: Principles, Implementation and Use.* Milwaukee, Wisconsin: ASQ Quality Press.

Christopher, M. (1998). *Logistics and supply chain management : strategies for reducing costs and improving service.* London: Financial Times/Prentice Hall.

Christopher, M. (1992). *Logistics and Supply Chain Management.* London: Pitman.

DePoy, E., & Gitlin, L. (1999). *Forskning -en introduktion.* (J. Hellberg, Trans.) Lund: Studentlitteratur.

Dubois, A., & Gadde, L.-E. (2000). Supply strategy and network effects – purchasing behaviour in the construction industry. *European Journal of Purchasing & Supply Management , 6*, 207-215.

Formoso, C., Soibelman, L., De Cesare, C., & Isatto, E. (2002). Material Waste in Building Industry: Main Causes and Prevention. *Journal of Construction Engineering and Management , 128* (4), 316-325.

Frödell, M. (2009). *Contractor-Supplier Relations in a Large Contractor Organisation.* Göteborg: Chalmers University of Technology.

Frödell, M., & Josephson, P.-E. (2008). Initiating Supplier Development through Value Stream Analysis: The Case of Skanska Sweden and its Largest Supplier. *Proceedings of CIB W65/55 Commissions: Transformation through Construction.* Dubai, UAE.

Gadde, L.-E., & Håkansson, H. (1998). *Professionellt inköp.* Lund: Studentlitteratur.

Gillham, B. (2000). *Case Study Research Methods.* London: Continuum.

Gunnerbeck, K., & Hassel, C. (2004). *Inköpsstrategier i stora svenska byggföretag.* Lund: Ekonomihögskolan vid lunds universitet.

Hadikusumu, B., Petchpong, S., & Charoenngam, C. (2005). Construction material procurement using Internet-based agent system. *Automation in Construction , 14*, 736-749.

Heskett, J., Sasser, E., & Schlesinger, L. (1997). *The service profit chain: how leading companies link profit and growth to loyalty, satisfaction, and value.* New York: Free.

Jonsson, P. (2008). *Logistics and supply chain management.* Berkshire: McGraw-Hill Education.

Josephson, P.-E., & Saukkoriipi, L. (2005). *Slöseri I byggprojekt. Behov av förändrat synsätt.* Göteborg: FOU-Väst.

Juran, J., & Gryna, F. M. (1993). *Quality Planning and Analysis.* New York: McGraw-Hill, Ink.

Krause, D. (1997). Supplier Development: Current Practices and Outcomes. *Journal of Purchasing and Materials Management , 33* (2), 205-224.

Kvale, S. (2006). *Den kvalitativa forskningsintervjun.* (S. Thorell, Trans.) Lund: Studentlitteratur.

Liker, J. (2004). *The Toyota Way.* New York: McGraw-Hill.

Lumsden, K. (1998). *Logistikens grunder.* Lund: Studentlitteratur.

Lynch, R., & Cross, K. (1995). *Measure Up! - Yardsticks for continuous Improvement.* Oxford: Blackwell.

Merriam, S. (2009). *Qualitative Research: A guide to Design and Implementation.* San Francisco: John Wiley and Sons.

Monczka, R., Trent, R., & Handfield, R. (2005). *Purchasing and Supply Chain Management* (third ed.). London: Thomson South-Western.

Pheng, L. S., & Tan, S. (1998). How "just-in-time" wastages can be quantified: case study of a private condominium project. *Construction Management and Economics* (16), 621-635.

Pinch, L. (2005, November). Lean Construction - Eliminating the Waste. *Construction Executive* , 34-37.

Reyniers, D., & Tapiero, C. (1995). The Delivery and Control of Quality in Supplier-Producer Contracts. *Management Science , 41* (10), 1581-1589.

Stadtler, H., & Kilger, C. (2008). *Supply Chain Management and Advanced Planning.* Berlin: Springer Berlin Heidelberg.

Stock, J., & Lambert, D. (2001). *Strategic logistics management* . Boston: McGraw-Hill/Irwin.

Sörqvist, L. (2001). *Kvalitetsbristkostnader.* Lund: Studentlitteratur.

Van Weele, A. (2005). *Purchasing & Supply Chain Management.* London: Thomson Learning.

Wegelius-Lehtonen, T. (2001). Performance measurement in construction logistics. *International Journal of Production Economics , 69*, 107-116.

Vonderembse, M., & Tracey, M. (1999). The Impact of Supplier Selection Criteria and Supplier Involvement on Manufacturing Performance. *The Journal of Supply Chain Management* (August), 33-39.

Yin, R. (2003). *Case Study Research: design and methods.* Thousand Oaks: Sage Publications.