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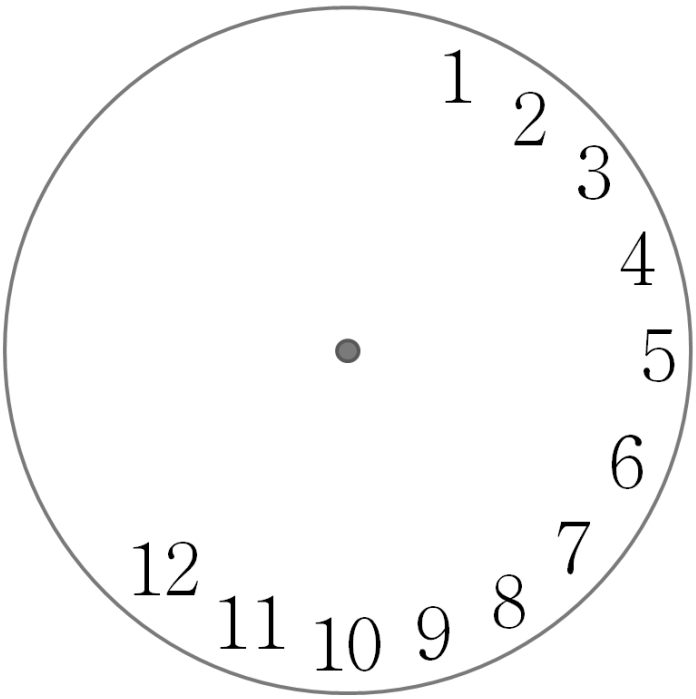

A framework for decreasing lead times by supplier collaboration

- A study performed at Mölnlycke Health Care

Master of Science thesis in Supply Chain Management

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Goteborg, Sweden, 2012
Report No. E2012:044

Abstract

It is widely acknowledged that responsiveness to customer demand is an important property to develop in order to be competitive. Responsiveness is with regards to price, product differentiation and delivery time, and is partly affected by the lead time of replenished material. Hence, decreasing lead time provides increased competitiveness. This thesis presents a framework for conducting quality improvement efforts across company borders, aiming at lead time reduction for replenished material. The thesis is based on relationship and quality management literature as well as empirical data gathered from interviews with supply chain professionals within Mölnlycke Health Care as well as from other companies. The findings show that assessing the relational fit prior to engaging in inter-firm efforts is beneficial, since it increases the likelihood of successful such efforts. They also show that a structured way of working is of great importance when working with quality improvements. For these reasons the framework clarifies what relational aspects to consider in inter-firm efforts, as well as comprises a process for conducting quality improvements.

The framework consists of three stages, the first one being choosing a supplier to conduct a joint quality improvement project with. This decision is mainly affected by the financial potential for the principal of the project, i.e. the customer, and the potential for attaining a cooperative way of working the companies in between. The second stage deals with initiating the project and revolves around retrieving the top management commitment of the chosen supplier, which is important for performing the project as well as for implementing the solutions resulting thereof. The third and final stage of the framework describes a process for how the project itself should be conducted. It comprises a set of tools retrieved from the field of quality management; these tools are combined in a way that provides an easy to use, yet effective process for quality improvement with the aim of decreasing lead time.

Acknowledgement

This Master of Science thesis was conducted during the spring of 2012 within the Master Degree Program Supply Chain Management at Chalmers University of Technology in Goteborg, Sweden. The thesis was carried out at Mölnlycke Health Care's (MHC) headquarters in Goteborg.

First, we would like to thank Ann-Christine Strigén and Staffan Bröte at MHC for initiating this project and giving us the opportunity to conduct the thesis at the company. We would further like to give a special thanks to Katerina Tomaskova who has served as our supervisor at MHC. The continuous feedback received regarding the expectations and usefulness of the thesis from a MHC perspective has been very helpful. Furthermore, we want to thank our supervisor at Chalmers, Pehr-Ola Pahlén, whose support and feedback on our ideas have been very helpful for the success of this thesis.

During the process of writing the thesis we have done numerous interviews and would like to issue a special thank you to the people interviewed who gave us much needed information. We would like to thank all people interviewed at MHC and their suppliers. Your information has formed the basis for findings and results. In addition, we would also like to thank the group put together by Andres Laas at Autoliv, Peter Lindkvist and Per Siesing at Flexlink and Jenny Lilliehöök at Volvo Powertrain for the valuable information provided from your perspectives on supplier interactions and lead time.

This project has given us valuable insights regarding lead time reduction and company interactions and we are very grateful for having gotten this experience.

Goteborg, 2012

David Magnusson Paul Simonsson

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1. Introduction

This chapter briefly presents Mölnlycke Health Care and the problems that the company experience with long lead times. In addition, a theoretical introduction presents the effects of long lead times that are put forward in literature. Lead time is here defined as the time in between an order is submitted to a supplier to when that order arrives at the customer's facility.

1.1 Background

Mölnlycke Health Care (MHC) was originally a textile company, founded in the mid 19th century, which started to develop textile products for health care applications as a response to the Swedish textile crisis in the 1950s. Today MHC provides various health care solutions and is a world leading manufacturer of single-use surgical and wound care products. The company has two separate business units, Surgical and Wound Care; the former provides products that are used during surgery, such as drapes and surgical gloves (see Figure 1), while the latter provides products to be used post surgery, such as wound dressings and wound treatment (see Figure 2).

Drapes / Gowns | Surgical gloves | Antiseptics | All-in-one surgical kit

Figure 1. Example of products offered by the Surgical division.

Wound dressings | Skin care | Negative pressure wound treatment | Biological wound treatment | Retention & Compression

Figure 2. Example of products offered by the Wound Care division.

MHC has manufacturing facilities located in Europe, Asia and North America, which are served by a supplier base that is spread worldwide, one reason being a limited number of possible suppliers for some materials. This can for instance be due to few manufacturers of a specific material as well as a restricted number of suppliers being able to adhere to the quality requirements that MHC and market regulations demand. The location of suppliers in relation to manufacturing facilities creates long lead times, which is a problem for a number of reasons, for instance planning of what quantities to order and manufacture becomes harder. This in turn leads to large safety stocks of material to

mitigate the risk of stock outs, resulting in tied-up capital and occupied warehouse space. A high safety stock level will also lead to obsolete material and won't fully prevent the necessity for rush orders. Long lead times decrease the company's ability to respond to market demand swiftly, which makes it more expensive to provide a certain service level than if the lead times were shorter.

As of now, MHC has not calculated the actual cost for long lead times, but the company is aware that they probably are costly. According to a health care industry benchmark, MHC is a midrange performer when it comes to number of days of sales in inventory, which relates to the safety stock level, but the company still perceives long times to drive inventory levels and reduce flexibility to unsatisfactory levels.

As a result of the drawbacks of long lead times, a procurement strategy within the Surgical division states that lead times should be optimised and that no suppliers should have a lead time that exceeds a certain number of weeks[1] by the year of 2014. For this reason a number of projects will be launched in collaboration with suppliers to decrease lead times. The company has identified that a structured way of working will be necessary in order for these projects to succeed. There is presently no structured way of decreasing lead times nor any structured way to conduct joint improvement projects; hence such a way of working needs to be developed.

1.1.1 Lead time effects

A challenge facing most companies in today's customer focused business environment is to create processes that facilitate responsiveness to customers' demands (Christopher, 2011). This can for instance be demands regarding product differentiation and pricing, which need to be considered in order to be competitive (Gunasekaran, Patel, & Tirtiroglu, 2001). Also short delivery time is widely recognised to be of great importance to customers, wanting to receive the ordered products as soon as possible (Ouyang, Wu, & Ho, 2007; Ray & Jewkes, 2004; Da Cunha, Agard, & Kusiak, 2007). The possibility to provide satisfactory levels of these three competitive dimensions, i.e. price, product differentiation and delivery time, is dependent on the lead time for fulfilling a customer order, and by that also the replenishment lead time for material from suppliers.

Product differentiation makes it possible to customise products, creating value for the customer and therefore also creating a competitive advantage for the offering company (Christopher, 2011). A manufacturer should not keep stock of all possible product variants, due to that the costs related to holding inventory of all such variants are substantial; customised products are therefore not suitable to produce prior to customer order (ibid.). This leads to that demand for customised products is hampered by a long lead time (Daaboul, Da Cunha, & Bernard, 2011). The inability to keep a full stock close to all customers is also valid for non-customised items for the same cost related reasons as just mentioned, which is a limiting factor for the availability of products. This means that a long lead time makes it harder to follow demand fluctuations in volume and product configuration, which limits the availability and therefore is a cause for stock outs and discontent customers (Ben-Daya & Raouf, 1994; Ouyang, Wu, & Ho, 2007; De Treville, Shapiro, & Hameri, 2004).

Cost and lead time are intimately connected to each other, both on the supplier side and on the purchasing side (Ray & Jewkes, 2004). On the purchasing side, lead time has a positive correlation with the required size of inventory and safety stock levels, that is needed to prevent stock outs (Pahl,

[1] The exact number of weeks is known but confidential

Voss, & Woodruff, 2005; Vernimmen et al., 2008). A longer lead time thus increases the safety stock costs, which are a result of tied-up capital, obsolescence, damaged goods and warehousing operations and facilities (Christopher, 2011). Increased safety stock levels also reduce the inventory turnover rate, incurring costs for bound capital as well as procrastinating product updates and by that inhibiting them from reaching the market. In addition, a long lead time magnifies the bullwhip effect; leading to over- or under-production and inaccurate inventory levels (Chen, Drezner, Ryan, & Simchi-Levi, 2000; Lee, Padmanabhan, & Whang, 2004). A longer lead time also makes it harder to plan operational activities (Stalk, 1988) and impacts the cash flow in a negative way, by tying up capital in physical resources (Christopher, 2011). Furthermore, the amount of rush orders from suppliers will also increase with increased lead time, because a larger share of orders will fall outside of the time frame required for standard expediting, inflicting costs by performing express expediting. In conjunction to this, a long lead time causes difficulties in creating a responsive supply chain, obstructing the possibilities of rapidly responding to customers' demand (ibid.). To conclude, the difficulty of forecasting the demanded quantities is positively related to lead time, as illustrated in Figure 3.

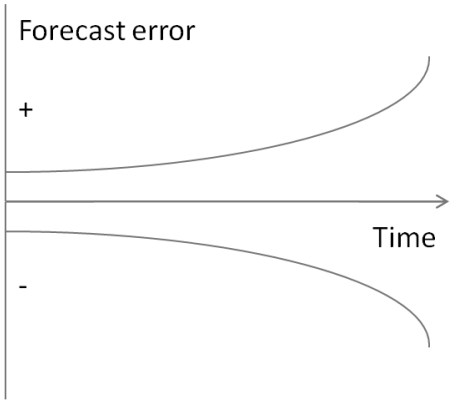

Figure 3. Relation between lead time and forecast error (Christopher, 2011).

In order to limit the total cost for the supplier's business, the supplier needs to consider the economies of, among other things, batch sizes, order quantities and storage of both raw material and finished goods. All these considerations affect the lead time since economies of scale usually is at hand; producing large batches due to set up times, ordering large quantities to attain less administration and to get better possibilities for efficient utilisation of the chosen transport mode (Christopher, 2011). In addition, the suppliers have other customer to prioritise between, which can result in various implications in the event of being a not so important customer to a supplier that is experiencing problems. This can be with regards to not solving quality issues and other kinds of issues in a timely manner; resulting in a prolonged lead time, causing uncertainty and even higher levels of safety stock.

Altogether, a long lead time causes increased costs and delivery time, in the end affecting the customers' value benefit of a company's offerings. The flexibility to react to changes in customer demands is also affected. In addition, measures to encounter long lead times benefit from inter-firm cooperation across the supply chain, if performed effectively (Gadde, Håkansson, & Persson, 2010).

1.2 Problem analysis

The current problem is that MHC lacks an established way of working for reducing lead times in collaboration with the company's suppliers. The company does not know the actual financial savings that are generated by decreased lead times.

1.3 Purpose

The purpose of this thesis is to provide MHC with a process to be used for shortening lead times in collaboration with the company's suppliers and to provide a basis for calculating the financial benefits of decreased lead times.

1.4 Research questions

How can lead times be improved by cooperating with suppliers?

How should MHC work with suppliers in order to improve lead times?

How can MHC visualise the financial benefits gained from lead time reduction?

1.5 Scope

This thesis is performed at the Surgical division and is thus delimited to this business unit. Furthermore, the focus is to identify and generate improvement measures that require cooperation with suppliers in order to be fully utilised.

2. Theoretical Framework

This section contains the relevant theory for the thesis. It is divided into two sections; managing process changes and business relations. It aims to provide a basis for the framework and also provide means on how to manage the relationship with the supplier.

2.1 Process changes and improvements

It is important to have a structured way of working when conducting quality improvement efforts; by working according to a defined process one can conduct similar improvement efforts without the need for reinventing the process each time it is needed (Bergman & Klefsjö, 2010).

2.1.1 Total cost approach in make or buy decisions

When making a decision whether one should make or buy a specific item, the company need to evaluate what is more advantageous. Taking a total cost approach enables one to take in all costs involved in the manufacturing or purchase of a product in order to find the most beneficial for the firm. Both qualitative aspects, such as quality control, and quantitative aspects, such as relative costs, need to be involved when making the decision (Business Dictionary, 2012).

Jennings (1997) presents five factors that need to be emphasized when making a make or buy decision. These factors can be seen in Figure 4.

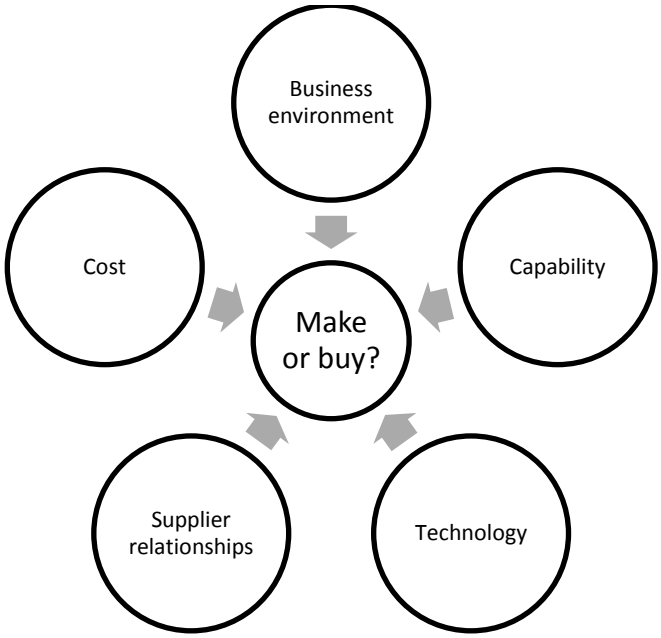

Figure 4. Guidelines to make or buy decisions, adapted from Jennings (1997).

The first factor, business environment contains aspects such as the firm's competitive advantage, flexibility and consonance with changes in the overall organizations environment (Jennings, 1997). The implications from choosing strategy need to be considered on a long-term basis since it might be hard to reverse the decision.

The second factor is capability and basically states that the one with the best capability to make the specific task should conduct it (Jennings, 1997). The challenge here lies in defining and knowing which of the firm's capabilities that is within the company's core and which that are peripheral. It is more likely that a core activity is kept in house, both based on that the company probably has better

capabilities for making it and that it is important for the company's competitive advantage. It is also important to consider whether an outsource decision has the potential of creating competitors (ibid.).

Technology is also important to consider when making these decisions. Jennings (1997) states that being able to access technology and maturity of these is a prerequisite of a company's competitive advantage. If a supplier can provide new or have a better maturity of its technology it can be a good reason to make a buy decision.

There are several important aspects to account for when managing the supplier relationship. The first step should be a careful evaluation of the supplier's capabilities and culture so that it complements one's own. It is also important to present clear expectations regarding performance and service (Jennings, 1997). Furthermore, one should aim to develop trust and commitment to the relationship.

Cost aspects are probably those aspects that are most considered when making a make or buy decision (Jennings, 1997). Even though the direct costs of buying might be lower, especially when outsourcing to a low cost country, one must consider the indirect costs associated with this. Van (2010) states that it is important to address the transaction costs when making a make or buy decision. He furthermore categorize them as (1) costs associated with establishing, monitoring and enforcing the contract, (2) costs associated with managing the relationship with the external party, and (3) costs that are associated with the transaction itself. Gadde et al. (2010) exemplifies this with an iceberg picture, see Figure 5. These costs are not always easy to detect but should anyhow be handled as equally important (ibid.).

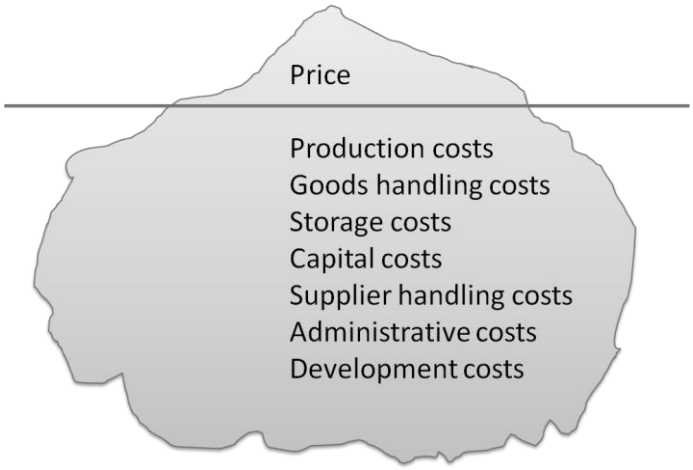

Figure 5. Costs affected by purchasing, adapted from Gadde and Håkansson (1993).

Choosing to outsource activities can provide great benefits for the firm due to it being able to focus on core competence but outsourcing activities may increase both the length and width of the supply chain as more suppliers get involved (Lambert & Cooper, 2000). However, at the same time the amount of relationships the company is involved increases which in turn increase the complexity of managing the supply base (Christopher, 2011).

2.1.2 Inter-firm connections

Most companies are utilising suppliers and are therefore part of a network of companies, although not directly linked, affecting each other (Gadde, Håkansson, & Persson, 2010). Gadde et al. (2010) describes these links between companies as composed of three layers; the actor, resource and activity layer. It is valuable to have notion about these three layers to understand how a company affects and is affected by other companies' businesses, and by that, providing a foundation for effective and efficient inter-organisational performance improvement efforts.

2.1.2.1 Actor layer

The actor layer is the network of actors, which is the entity that controls resources and performs activities, that make out the business landscape (Håkansson & Snehota, 1995). By studying the actor layer it is possible to put the focal company into a context, thus providing a greater understanding of the interests and behaviour of that company (Gadde, Håkansson, & Persson, 2010). A supplier can for instance be dealing with customers that have different preferences, some being more in line with the supplier's own preferences. This may cause the supplier to prioritise these customers' wishes over others', for instance in the event of considerations on what technology to invest in or how to set up logistics arrangements. The actors are linked together by actor bonds, which are a prerequisite to be able to utilise the resources actors in between (Håkansson & Snehota, 1995). The actor bonds constitute of among other things, commitments, obligations and social interaction; these dimensions make the actor bonds an important factor to manage, to bring about changes in the resource and activity layers (Gadde, Håkansson, & Persson, 2010). This is particularly important considering that a change to these layers in one business relation will affect those of another one (ibid.). This can for instance mean that a supplier, by making a decision to increase the service level for one customer, in fact at the same time decreases the possible service level for another one. Changes can however also provide strengthening positions for all the supplier's customers, by actors developing improvements to the resource and activity layers that are in line with all the customers' preferences.

2.1.2.2 Resource layer

The resource layer denotes how the actors' resources are connected to each other (Håkansson & Snehota, 1995). What is important is how well a resource connects to other resources, both intra- and inter-organisational wise; the value of a resource thus depends on how it is connected to other resources (Gadde, Håkansson, & Persson, 2010). The value of a resource such as a production system can for example increase, by altering a resource which it is connected to, such as the products built in the system. By achieving a better alignment between product design and the production system, the result is increased value in terms of greater operational efficiency (Pero et al., 2010). Resources are classified in accordance with the 4R model presented by Håkansson and Waluszewski (2002), i.e. the physical resources: products and facilities and the organisational resources: organisational units and business relationships. The products resource includes the products which are manufactured and distributed and the facilities resource includes the hardware for conducting manufacturing and distribution such as manufacturing and logistics equipment and the available infrastructure (Gadde, Håkansson, & Persson, 2010). The resource of organisational units comprehends the available knowledge and abilities of those, while the business relationships resource concerns how business units interact with each other to create value (ibid.). All four categories of resources interact with and affect each other, making it both important to understand how value is generated by the combining of resources. What is more, it is important and complex to understand what effects that changes to one resource will have on another one.

2.1.2.3 Activity layer

The activity layer comprises a company's entire set of activities, which in many ways affect each other, creating activity links (Håkansson & Snehota, 1995). Together, the activities and their links form an activity pattern, showing the relations between different activities, for instance product development and manufacturing (Gadde, Håkansson, & Persson, 2010). These relations contain a certain degree of interdependency between activities, signifying how dependent one activity is upon another one to be able to be performed (ibid.). In order to perform a specific task, for example the manufacturing of a product, the order of the concerned activities need to be structured, creating an activity configuration. In the case of manufacturing, this naturally comprehends activities related to the information and material flow. The activities supporting the material flow include for example materials handling, manufacturing, packaging and distribution, while the information flow involves everything from handling of customer orders to procurement. These activities can be broken down further into sub-activities, for instance the manufacturing activity can consist of the activities casting, cutting, honing, drilling, cleaning, welding, painting and assembly. In addition to the manufacturing related activities just mentioned, there are a number of activities that needs to be performed such as marketing, human resource management and financing (ibid.). The most important aspects of the activity layer are the interdependencies among activities that in conjunction with the design and configuration of activities have a great impact on a company's performance (Håkansson & Snehota, 1995).

2.1.3 Measuring inter-firm performance

In order to enhance the performance of an activity, one must first measure it (Neely, Gregory, & Platts, 2005). It is therefore important to track the performance of not only one's own activities but also activities of actors affecting one's own firm.

Performance measurements aim to measure the performance of pre-defined actions or occurrences in order to control and improve the performance of these activities (Neely, Gregory, & Platts, 2005). These measurements then form a system of measurements that should incorporate all important aspects that aims to be measured (ibid.).

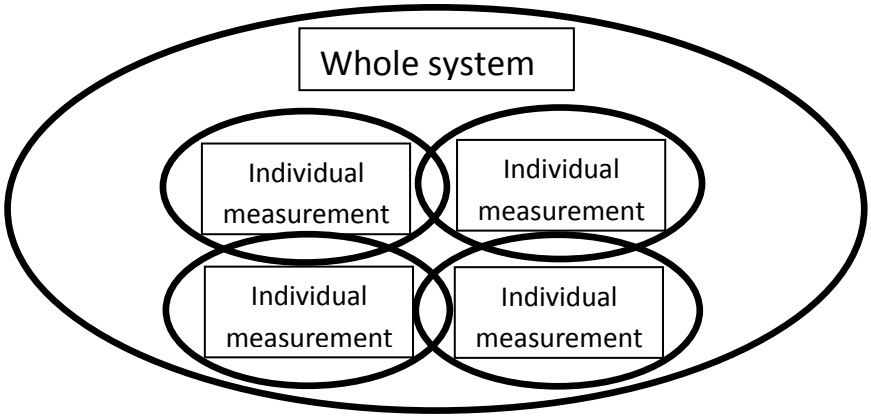

Figure 6. System of measurements, adapted from Neely et al. (2005).

Performance measurements can, according to Setijono and Dahlgaard (2007), be divided into two groups; proactive and reactive measurements. Reactive measurements are based on monitoring previous actions and its performance. Examples of such are on time deliveries and order fulfilment. Proactive performance measurements instead aim to track the eventual improvements of a process

such as yearly price cuts or lead time reductions. Setijono and Dahlgaard (2007) define the reactive measurements as Key Performance Indicators (KPIs) and the proactive as Key Improvement Indicators (KIIs). Furthermore, Setijono and Dahlgaard (2007) states that it is not always easy to define the difference between these two types of performance measurements and that they can overlap within different areas.

Performance measurements can hinder cooperation if they are chosen so that different business functions or different companies have conflicting ones (Jüttner, Christopher, & Baker, 2007). According to Jüttner et al. (2007), this is quite common to have between the marketing and sales areas and the operational areas such as manufacturing and purchasing. In order to have a total cost approach it is important that measurements benefit the overall business performance and not only the specific departments. Jüttner et al. (2007) furthermore recommends businesses to also reduce the number of performance measurements in order to more easily respond to market forces.

Commonly measured reactive performance measurements towards suppliers are for example service level and quality (Neely, Gregory, & Platts, 2005). The service level measures the percentage of deliveries made with the right quantity at the right time. In addition to the reactive measurements, commonly used proactive performance measurements are cost reduction and lead time reduction (Neely, Gregory, & Platts, 2005). These are often used on a more tactical or strategic level than the reactive performance measurements that are based on a more operational level.

2.1.4 Improving inter-firm performance

Performance needs not only to be measured but also improved; inter-firm performance can be improved by using the basis from the ARA-model in order to change and improve the different layers as presented by Gadde et al. (2010).

2.1.4.1 Re-configuring activities

By re-configuring activities or moving them in the activity layer, one can reap benefits in both cost and quality (Gadde, Håkansson, & Persson, 2010). Dubois (1998) provides an example from Swefork[2] where the company initially had a supplier for pre-machined plates and several suppliers of components delivered from several suppliers to a storage facility at Swefork. The next activity, the welding process, was triggered when all needed components together with the pre-machined plates became available. In order to have low costs, Swefork had relatively unsophisticated methods for the welding activity and in order to improve the efficiency of the process the activity was moved to the supplier supplying the pre machined plates, which resulted in lower total costs.

2.1.4.2 Resource re-combining

A supplier may have resource capabilities that are either complementary or superior to the buying company's resources. By re-combining the available resources within the supply network, one can gain improvements that are unable to attain by just using the own firm's resources. This can however be hard to evaluate due to that all resources provided by the network might not be known. It also requires the purchasing department at the buying firm to work strategically and long-term in order to make the necessary changes (Gadde, Håkansson, & Persson, 2010).

[2] Fictional name for a real company

2.1.4.3 Actor re-positioning

Actor interaction is required in order to re-combine resources and re-configure activities. The impact of interventions of actors is mostly decided by two factors; the interaction atmosphere and the identity of the actors (Gadde, Håkansson, & Persson, 2010).

2.1.4.4 Process quality

A company can increase its competitiveness by attending to the processes affecting a product's quality, which is defined as "a product's ability to satisfy, or preferably exceed, the needs and expectations of the customers" (Bergman & Klefsjö, 2010, pp. 23). In order to work with quality improvements there are a number of methods and tools developed and used within the field of quality management. For instance a method called the Plan-Do-Study-Act cycle can be utilised to structure the activities that need to be performed during an improvement effort (ibid). Furthermore there are a number of tools, such as Value stream mapping, the Pareto chart and the cause-and-effect diagram that can be used for identifying improvement areas and solutions. This can also be done by considering waste reduction, which is one of the principles of Lean production (Hines & Rich, 1997). In conclusion, the developed solutions will relate to and affect one or several of the layers of the ARA model and can for instance comprehend a restructuring of the actor layer. The following chapters provide a further elaboration on this and explain the presented methods and tools more in detail.

2.1.4.5 The Plan-Do-Study-Act cycle

It is important to perform quality improvement efforts systematically; the Plan-Do-Study-Act (PDSA) cycle is a problem solving method providing a structured way of working (Bergman & Klefsjö, 2010). The cycle is commonly illustrated as seen in Figure 7.

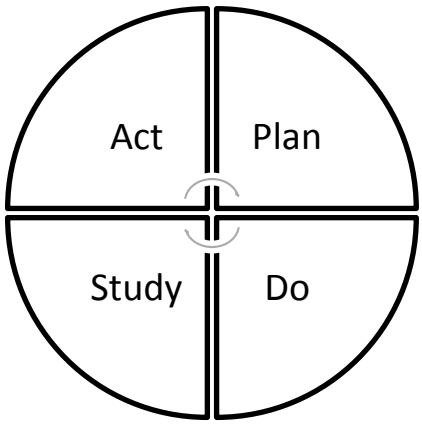

Figure 7. The PDSA cycle, adapted from (Bergman & Klefsjö, 2010).

The first step, *Plan*, starts with describing the problem affecting quality; large problems should be broken down into smaller ones to be manageable. In conjunction, one has to understand the needs and requirements that are present in order to clarify the performance gap that the problem causes, and by that also clarify the extent of the required quality improvements. After the problem has been specified one establishes potential root causes of the problem; a cause-and-effect diagram is often useful for this task. In order to verify the assumptions made about what causes the problem, data is collected and compiled in for instance a Pareto chart to illustrate the results. After causes have been verified, solutions to be developed and approved by management.

The second step, *Do*, comprehends implementing solutions to solve the chosen problem.

The third step, *Study*, comprehends following up the results of the implemented changes to make sure that these have had the wished for effect. Data is collected and evaluated by for instance a Pareto chart. Once improvements are convincingly attained, a control chart can be used to track the new and improved quality level to secure that it is retained.

The fourth step, *Act*, comprehends using the experience gained from the improvement process to avoid the same problem occurring again by establishing new routines supporting the new and improved quality level. An important part of this step is also to evaluate how the improvement process was performed in order to improve it as well.

2.1.4.6 Value stream mapping

The main reason for mapping a value stream is to discover waste in the production in order to eliminate it (Rother & Shook, 1999). The mapping includes all activities within the investigated part of the supply chain, including both value adding and non-value adding. A value stream perspective means that one does not only investigate single operations but instead takes the big picture under consideration and aims to improve the sum of the operations, not the single ones. The larger picture, the better since the risks of sub-optimization decreases. However, at the same time, the complexity increases with the increase of scope (Rother & Shook, 1999). Since mapping is complex, one should not choose to map all products but instead choose one product or product family to map at a time.

Both the production and information flows are important to map. The production flow is how products flow through the processes in the investigated area and the information flow are the activities that trigger each process in the physical flow.

When mapping the value stream it is important to use visual and graphical tools since these makes the map easier to interpret. According to Rother and Shook (1999) it is not as important to use the figures defined in the literature as using consistent figures that is easy to understand in the current work situation. Figure 8 shows an example of how a mapped factory setting can be viewed and also provides an example on which figures one can use while doing a value stream map. The boxes are processes and a process is defined as when the goods are active at that place (ibid.). One could break down the processes even further and create a value stream map within each process if one needs to. The triangles are storage zones. It can be raw material, work in progress and finished goods stock. The lines are either physical flows (thick lines) or information flows (thin lines).

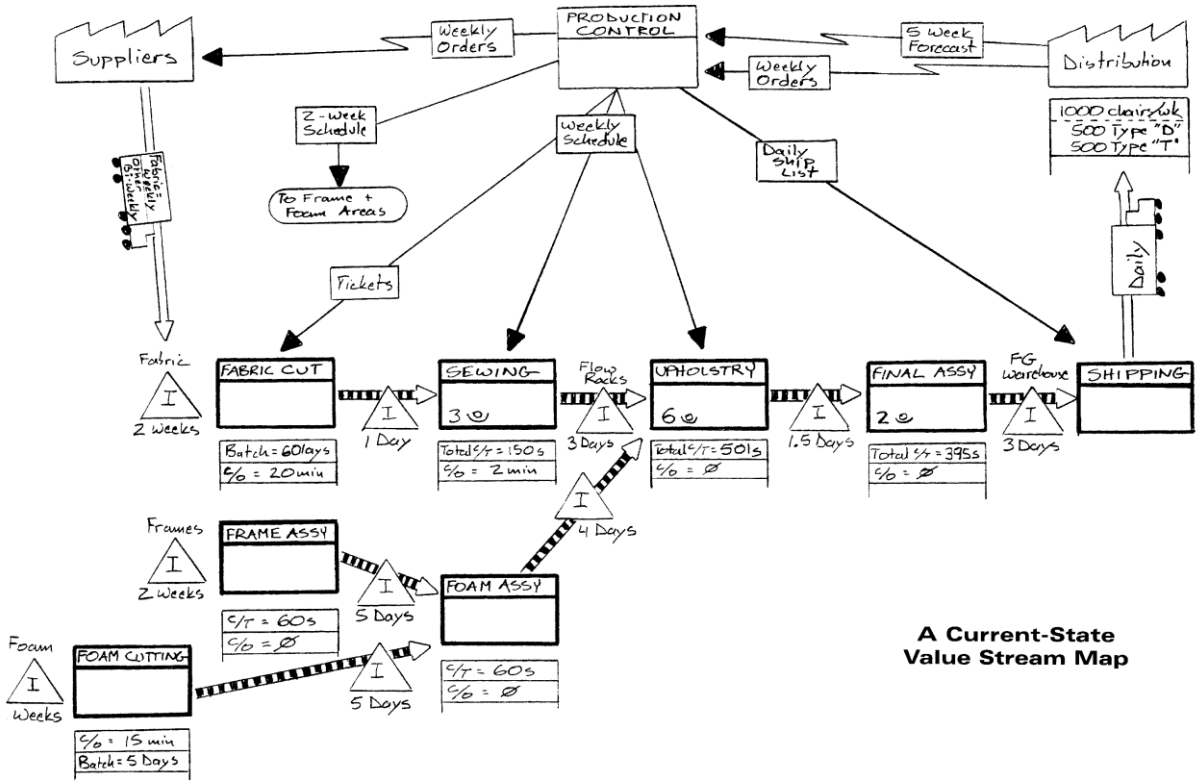

Figure 8. An example of a value stream map (Rother & Shook, 1999).

Rother and Shook (1999) present eight reasons for why one should utilise value stream mapping:

1. It helps you visualize the whole flow and not only the single processes such as welding or manufacturing.
2. It reveals more than waste. Mapping can help you see the sources of waste within your value stream.
3. It is commonly used and therefore easily used and presented to other people that is affected or affects the value stream.
4. It brings up issues about the flow so that decisions are not taken by default.
5. It ties together different concepts which decrease the risks of sub optimization.
6. It helps you form the basis for making necessary changes in order to decrease waste.
7. It also shows the linkage between the information and physical flows.
8. It creates a sense of urgency by presenting values on the waste in the organization.

Hines and Rich (1997) states that even though creating a value stream map creates several benefits it is important to take its shortages into account, which is that it might not identify overproduction and defects. This is worth taking into account when constructing a map.

2.1.4.7 Cause-and-effect diagram

In order to find the root causes, a cause-and-effect diagram (CED) can be used. Doggett (2005) states that a CED, also known as fishbone or Ishikawa diagram, is an easy to grasp tool which is able to both highlight lack of information and identify direct process problems.

The first tool was developed in 1943 in order to solve quality related problems in manufacturing but is nowadays used in other functions as well (Ishikawa, 1991). The main function of the CED is to

illustrate the possible causes of a particular problem by sorting and relating the causes in a classification scheme (Doggett, 2005). The activities of constructing and studying the diagram intend to promote discussion and stimulate knowledge acquisition (ibid.). According to Fredendall et al. (2002) the CED process can be seen as an exercise in structured brainstorming. The reasoning behind CED is that one cannot or should not act until the cause and effect relationship of a problem is known, the CED thus attempts to present related actions in order for action to be taken (Doggett, 2005).

Ishikawa (1991) presents five steps that one should take when constructing a CED:

- Step 1: Decide upon the problem to improve.
- Step 2: Draw an arrow and write the problem on the arrow's right side, according to Figure 9. Steps in building a cause-and-effect diagram, adapted from Doggett
- Step 3: Write the main factors that might be causing the problem as branches connected to the arrow.
- Step 4: Write down minor causes as twigs attached to the major branch causes. Even smaller twigs can be attached to these twigs if one intends to go deeper with a cause.
- Step 5: Ensure that all possible causes are included in the CED.

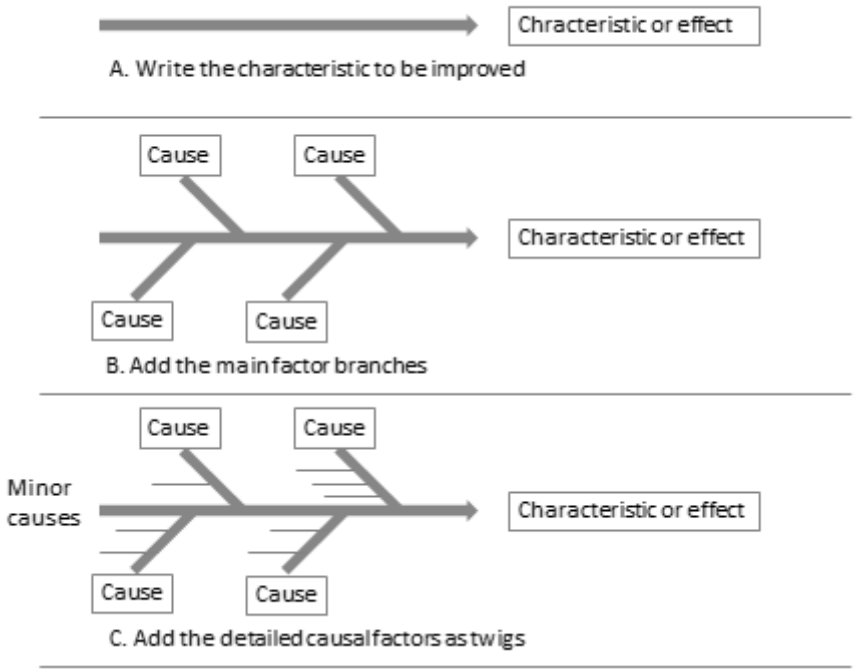

Figure 9. Steps in building a cause-and-effect diagram, adapted from Doggett (2005).

Bhote (1988) presents some weaknesses with CED and states that there is a risk that some causes might be missed and that it is very dependent on the group performing the CED. Sproull (2001) agrees and states that CED is heavily dependent on the group's knowledge about the problem and wrongly formed group will not be able to find all causes to the problem.

2.1.4.8 Pareto chart

Decisions that are taken for improving quality should be based on facts to secure that the right decisions are being made; therefore collecting data on the occurrence of identified causes is

important (Bergman & Klefsjö, 2010). This data can for instance show which of the identified causes that are the most common ones. The Pareto chart helps understanding the data by illustrating it graphically as shown in Figure 10. This graphical representations makes it more clear which problems that are the most common ones and by that which problems that should be prioritised to solve (ibid.).

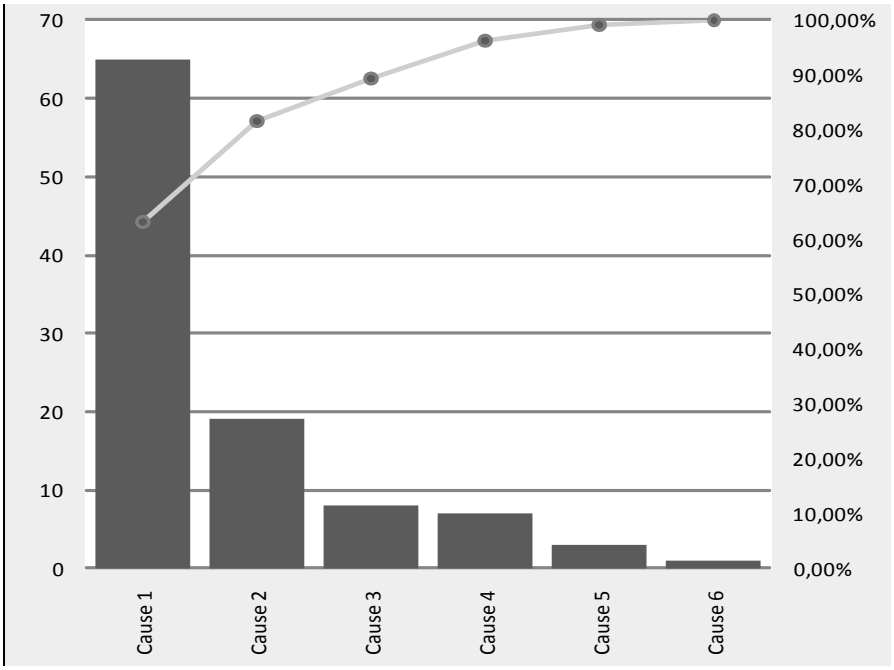

Figure 10. Example of Pareto chart.

2.1.4.9 Seven wastes

Making a value stream map of the organisation is of no value unless one intends to change it (Rother & Shook, 1999). Identifying and reducing the *seven wastes* is useful when trying to optimize a flow and making it more efficient (Hines & Rich, 1997). The seven wastes were first mentioned within the Toyota Production System and is part of the larger Lean concept. In order to reduce waste, one must first identify what waste is. Hines and Rich (1997) group activities conducted throughout the supply chain into three different groups:

1. Value adding
2. Non-value adding
3. Non-value adding but necessary

The value adding activities are activities that increase the value of the product. Examples of such activities are painting of components, welding and assembly. These activities actively contribute to finishing the product and thus increase its value. The second category, non-value adding, is pure waste and involves actions that are unnecessary and that should be eliminated completely. Examples of such activities are waiting times, double handling and stacking intermediate products. Necessary but non-value adding is the third category. These activities might be wasteful but still necessary during current operating procedures. Examples of such activities are walking long distances to pick up parts and unpacking deliveries. In order to eliminate these activities it is often needed to make large changes in the operating procedure such as for example creating a new manufacturing layout.

The seven wastes, as described by Hines and Rich (1997) can be seen in Figure 11. These are all non-value adding but some can still be necessary, which makes it more complex to remove them.

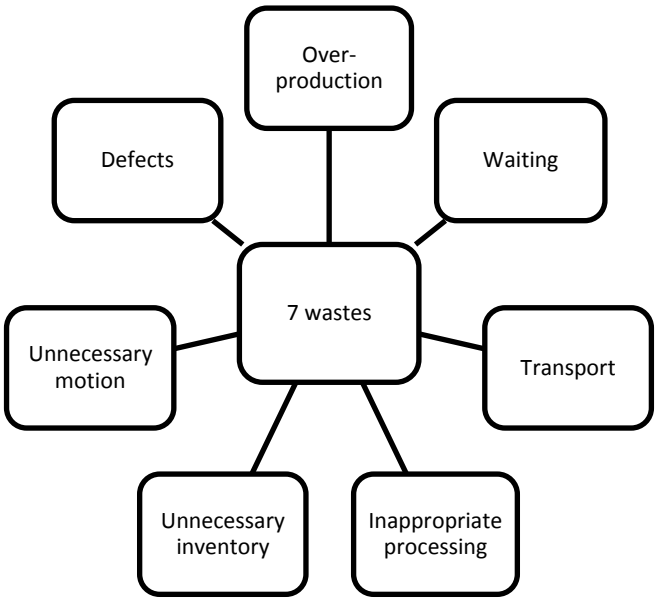

Figure 11. The seven wastes as presented in Lean production (Hines & Rich, 1997).

Overproduction is regarded as the worst waste as it discourages a smooth flow of goods (Hines & Rich, 1997). Such overproduction often leads to excessive lead and storage times. This can increase the time it takes for defects to be identified and also increase the risk of obsolete products.

If time is being used ineffectively, the waste of *waiting* occurs. This waste occurs in a factory setting when goods are not moving or being worked on. This waste can affect both goods and workers, causing each to spend time waiting. The ideal state should be a consequent flow of goods with no waiting time. If there is waiting time for workers, that time could for example be used for training, maintenance or improvement activities and it should not be used for overproduction.

The third waste is *transport which* involves goods being moved around. In an extreme context, any movement in the factory could be viewed as a waste and therefore total transport elimination should be optimal. However, that is usually not feasible or desirable due to machinery layouts and operations so instead a transport minimization is usually sought for. In addition, excessive movements and double handling are likely to increase the risks of damage and deterioration with the distance of communication between processes proportional to the time it takes to feedback reports of poor quality and to take corrective action.

Inappropriate processing is situations where overly complex solutions are used to simple procedures such as using a large inflexible machine instead of several small flexible ones. The problem with over-complexity is that it generally discourages ownership and also encourages the employees to overproduce goods in order to recover the large investment in the complex machines. It also encourages poor layout, leading to excessive transport and also poor communication. Thus, the ideal is therefore to have the smallest possible machine that is capable of producing the required quantity and quality, located next to preceding and subsequent operations.

Unnecessary inventory tends to increase lead time, preventing rapid identification of problems and increasing space, thereby discouraging communication. Thus, problems are hidden by inventory. To correct these problems, they first have to be found. This can be achieved only by reducing inventory. In addition, unnecessary inventories create significant storage costs and, hence, lower the competitiveness of the organization or value stream wherein they exist.

Unnecessary movements involve the ergonomics of a production process where operators have to, bend, stretch and pick up products when these actions could be avoided. This waste is not only direct but it also is tiring for the employees and thus is likely to lead to poor productivity, potential healthcare issues and, often, to quality problems.

The bottom-line waste is *defects* which affect the direct costs for a firm. The philosophy from Toyota is that defects should not be regarded as something to be traded off against other parts within the production but instead as opportunities to improve the production. Thus defects are collected so that they can be investigated and improved. An important part of the Toyota Production System is the continuous improvements and reduction of defects.

2.1.4.10 Control chart

After solutions have been implemented and a new quality level has been achieved, one wishes to secure that this level is retained; Bergman and Klefsjö (2010) present the control chart as a useful tool to for this purpose. The idea is to continuously collect and evaluate data from the improved process, in order to detect changes in the process that affects the quality level.

The starting point is to decide upon a process quality indicator (PQI), which is a quantitative measure correlating to the process's quality performance, such as the number of defective units. The PQI is expressed in a control chart, for instance as the arithmetic mean of observations ($\bar{x}$). One type of control chart utilising the arithmetic mean is the $\bar{x}$-chart, which is used to track deviations from an expected mean (μ). The arithmetic mean ($\bar{x}$) value is calculated from the number of observations that are taken in each sample according to $\bar{x} = \sum_i^n x_i/n$, where *n* is the number of observations in each sample.

The second step in setting up a control chart is to decide upon upper (UCL) and lower (LCL) control limits; as long as the PQI resides within the control limits the process is in statistical control and is seen as stable. A LCL is wished for since it brings attention to performance improvements, deliberate as well as non deliberate. The control limits are chosen by deciding upon the number of standard deviations ($X * \sigma/\sqrt{n}$) from the expected mean (μ), which is a consideration between the risk of false alarms and how quickly too large deviations are spotted. If $\bar{x}$ is normally distributed, the control limits can be set to $\mu \pm 3\ \sigma/\sqrt{n}$ with a reasonable relation between risk and the amount of false alarms. To clarify, when a control chart has an escalating PQI, as illustrated in Figure 12, this signals that something in the process needs to be adjusted.

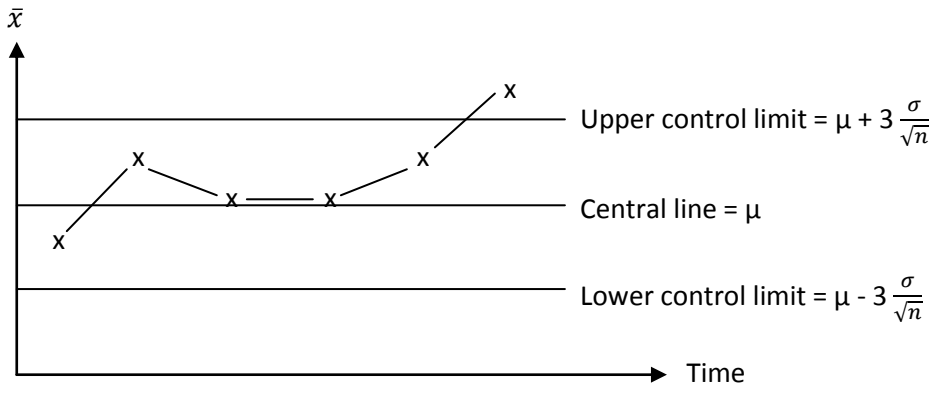

Figure 12. Control chart, adapted from (Bergman & Klefsjö, 2010).

When starting controlling a process, the μ and σ values need to be determined in order to set the control limits. An estimator ($\bar{\bar{x}}$) for μ is attained by taking a number of samples (*k*), preferably at least 20-25, comprehending *n* units each. The estimator is the mean of the sample means according to $\bar{\bar{x}} = (1/k) * (\overline{x_1} + \overline{x_2} + \ \ldots \ + \overline{x_k})$.

The standard deviation (σ) can then be calculated by using either the s-method or the R-method. In the former the standard deviation (*s*) for each sample (*k*) is calculated and then put into the formula: $\frac{s_1 + s_2 + \ldots + s_k}{k} * \frac{1}{c_4} = \frac{\bar{s}}{c_4}$. The value for c_4 is a list value that depends on the number of units (*n*) in the samples and can be found in Appendix 2. The value of $\bar{s}/c_4$ is used as the estimator for σ in calculating the control limits.

In the R-method the range (*R*), i.e. the difference between the largest and the smallest value, in each sample is calculated and put into the formula: $\frac{R_1/d_2 + R_2/d_2 + \ldots + R_k/d_2}{k} = \frac{\bar{R}}{d_2}$. The value for d_2 is a list value that depends on the number of units (*n*) in the samples and can be found in Appendix 2. The value of $\bar{R}/d_2$ is used as the estimator for σ in calculating the control limits.

2.2 Business relations

In today's business environment it is common notion that supply chains rather than individual companies compete against each other (Baiman & Rajan, 2002; Cousins & Spekman, 2003; Lambert & Cooper, 2000). As the ARA model illustrates, there are a number of inter-organisational aspects affecting a supply chain's performance. With this in mind it is evident that performance improvements will have to be carried out across organisational boundaries in order for supply chains to be as competitive as possible (Cousins & Spekman, 2003; De Crombrugghe & Le Coq, 2003), providing means for a total cost approach (Dubois, 2003). An important prerequisite for inter-organisational efforts is good relations (Luo, 2002), which are dependent upon among other things, social interaction, trust and commitment (Gadde, Håkansson, & Persson, 2010).

2.2.1 Trust and commitment

The concept of trust in an organisational setting refers to an actor's intention to accept vulnerability in a business relationship, based on expectations that the other party will not exploit this vulnerability (Dyer & Chu, 2011; Rousseau, Sitkin, Burt, & Camerer, 1998). There is thus an element of risk embedded, as trust is based on one party relying on another (Bachmann & Inkpen, 2011; Luo,

2002). Trust can be seen to be a substitute for control (Luo, 2002) and therefore a complement to contracts (Blomqvist, Hurmelinna, & Seppänen, 2005). Risk and interdependence, for instance as a result of investments, are consequently requisites for trust (Dyer & Chu, 2011; Luo, 2002).

A difference is made between inter-organisational and inter-personal trust, they are however closely related (Luo, 2002) as one affects the other (Blomqvist & Ståhle, 2000). For instance can a company representative such as a salesperson improve the perceived trustworthiness of the company by acting trustworthy (ibid.). Inter-organisational trust is defined as "the extent of trust placed in the partner organisation by the members of a focal organisation" and inter-personal trust is defined as "the trust placed by the individual boundary spanner in her individual opposite member" (Zaheer, McEvily, & Perone, 1998, pp. 142).

Inter-organisational trust is for example affected by legal regulations (Bachmann & Inkpen, 2011), company processes and routines (Dyer & Chu, 2011), company reputation (Bachmann & Inkpen, 2011; Blomqvist & Ståhle, 2000), and corporate culture (Blomqvist & Ståhle, 2000; Dyer & Chu, 2011; Lazear, 1999; Luo, 2002; MacDuffie, 2011). Inter-personal trust on the other hand is affected by how communication is handled (Morgan & Hunt, 1994) and the level of social interaction conducted between the parties in a business relationship (Bachmann & Inkpen, 2011; Blomqvist & Ståhle, 2000; Dyer & Chu, 2011; Gadde, Håkansson, & Persson, 2010; Havila, Johanson, & Thilenius, 2004; Luo, 2002).

In addition to inter-organisational and inter-personal, trust may also be divided into calculative and relational components (Bachmann & Inkpen, 2011), where the former is based on rational choice (Luo, 2002) and can be a result of aligning goals (Dyer & Chu, 2011) and/or legal regulations and certifications (Bachmann & Inkpen, 2011). Trust is thereby made out of several separate components and actors may thus trust each other in some respects but not in others (Gadde, Håkansson, & Persson, 2010).

Closely related to trust is commitment (Havila, Johanson, & Thilenius, 2004), which is defined as "an exchange partner believing that an ongoing relationship with another is so important as to warrant maximum efforts at maintaining it; that is the committed party believes the relationship is worth working on to ensure that it endures indefinitely" (Morgan & Hunt, 1994, pp. 23). Commitment is thus materialised in time and sense of urgency of relation related activities (Blomqvist & Ståhle, 2000) and entails sacrificing short-term benefits in favour of long-term relational investments (Gadde, Håkansson, & Persson, 2010). This cost of lost opportunity consequently makes it important to consider the pros and cons of pursuing a trust-building behaviour (Dyer & Chu, 2011). Lastly, the nature of commitment can be moral or calculative, the latter meaning that an actor is chosen because it is the less inappropriate (ibid.)

Trust and commitment are important properties of a business relationship as they lead to a cooperative way of working, which promotes long-term benefits over short-term opportunistic behaviour (Morgan & Hunt, 1994; Havila, Johanson, & Thilenius, 2004). They are thus important for building strategic alliances (Zaheer, McEvily, & Perone, 1998) and are crucial elements to business exchange (Gadde, Håkansson, & Persson, 2010). Commitment is also necessary to be able to reap relationship benefits as it comprehends relationship specific investments, for example (ibid.). In conclusion, developing trust is valuable as conditions for reaching network benefits of scale and scope are improved (Blomqvist, Hurmelinna, & Seppänen, 2005). A lack of trust on the other hand is

a common cause for alliance failures (Trompenaars & Prud'Homme, 2004). It can also have tremendous impact on business relationships, as the global financial crisis is an example of, which above all is a trust crisis (Bachmann & Inkpen, 2011).

There is a positive relation between trust and performance (Luo, 2002; Zaheer, McEvily, & Perone, 1998), a relation that intensifies as market uncertainty increases and resource interdependency gets stronger (Luo, 2002). The importance of trust to performance can however vary between firms and vary over time for a specific firm (ibid.). Trust contributes to increased performance since transaction costs are decreased (Bachmann & Inkpen, 2011; Zaheer, McEvily, & Perone, 1998) and that it encourages investments in the business relationship required for attaining relationship benefits (Gadde, Håkansson, & Persson, 2010; Havila, Johanson, & Thilenius, 2004). In addition, new ideas may be more easily developed and shared as knowledge may be commonly pooled and the winnings thereof are trusted to be shared in a fair way (Bachmann & Inkpen, 2011). A trusting relationship consequently makes out a competitive advantage (Dyer & Chu, 2011).

As mentioned, trust and commitment are intimately linked and according to some authors, e.g. Dyer and Chu (2011), Havila et al. (2004) and Luo (2002), commitment results in trust, while others, for instance Morgan and Hunt (1994) and Blomqvist (2005) claim that trust results in commitment. The relationship between trust and commitment is thus not clear with the relationship being a complex interplay them in between (Gadde, Håkansson, & Persson, 2010). For example, an actor needs to make commitment in a business relationship to seem trustworthy, while on the other hand an actor needs to be trusting in order to make commitments in a business relationship (ibid.).

As inter-organisational trust is influenced by company processes and routines, trust may be gained by the supplier selection process if it favours renewing contracts with existing suppliers rather than always utilising competitive bidding for new orders (Dyer & Chu, 2011). Also routines that deal with supplier problems can enhance trust, for example by providing assistance for effective problem resolution (ibid.). Processes and routines also contribute to trustworthiness by unifying the behaviour of the employees and by that decreasing the uncertainty of what response to expect from the company, regardless of which employee one interacts with (Blomqvist & Ståhle, 2000).

The employee behaviour is also affected by corporate culture as it can be developed to support trustworthy manners among employees (Blomqvist & Ståhle, 2000). However, differences in corporate culture may cause differing perceptions of what constitutes a trustworthy behaviour (Trompenaars & Prud'Homme, 2004). An example of this is that the perception of trustworthy behaviour may be that one follows present processes consistently, while others may appreciate a certain degree of flexibility to be a constituent of trust (ibid.). Additionally, differences in national culture can obstruct initial trust development and are thus a barrier in building trust (Luo, 2002), national culture is however not as important as corporate with regards to building inter-organisational trust (Dyer & Chu, 2011; MacDuffie, 2011). As corporate culture affects the behaviour of employees, trustworthiness can be achieved for instance by establishing a professional code of conduct (Bachmann & Inkpen, 2011). Also, actions can be taken to mitigate the ubiquitous issues caused by differences in culture, for instance by educating cultural differences and similarities to better accept diversity and by conducting inter-firm workshops where members of the different firms get to work together (Blomqvist & Ståhle, 2000).

Inter-personal trust is enhanced by positive emotions about the other party since a positive attitude gives an inclination towards a positive evaluation of the other party's character; additionally, the opposite relation is also prevalent (Jones & George, 1998). The importance of social interaction in building inter-personal trust is widely recognised, e.g. by Bachmann and Inkpen (2011) and Dyer and Chu (2011), partly because personal ties are strengthened and that it provides better possibilities to interpret the other party's behaviour and motivations (Dyer & Chu, 2011). Social interaction also entails giving advice, social support and recognition, which contribute to building trust (Blomqvist & Ståhle, 2000). However, developing trust by social interaction takes a lot of time and may therefore be quite uneconomical (Bachmann & Inkpen, 2011). It can also dissolve fairly easy, as a result of changes caused by internal conflicts or external threats, for example (Gadde, Håkansson, & Persson, 2010).

Inter-personal trust is also affected by how communication between actors is conducted and is particularly important when the possibilities for social interaction are limited (Blomqvist & Ståhle, 2000). By communicating issues timely, clearly and precise (ibid.) as well as communicating market intelligence, expectations and performance evaluations of the other party's achievements, trust can be enhanced (Morgan & Hunt, 1994).

2.2.2 Conflict and cooperation

Business relationships consist of conflicts as well as cooperative efforts, which are a natural outcome of actors' interests sometimes being contradictive and sometimes being coincidental (Gadde, Håkansson, & Persson, 2010). Conflict is closely related to the concept of power (Welch & Wilkinson, 2005), as conflict commonly is defined to be a result of an actor using its power to insist another actor to do things that are not in line with its goals (Rosenbloom, 1999). The impact of the conflict depends on the scope and intensity of the disagreement that is the base for the conflict (ibid.). Also the way in which power is applied affects the impact; a coercive approach will be destructive for the relationship, for example (Gadde, Håkansson, & Persson, 2010). The sources of conflicts thus are disagreements of some kind, which commonly relate to goal divergence, communication problems, disagreement over roles and/or differing perceptions of reality (Rosenbloom, 1999). Additionally, differences in corporate culture can be a source of conflict (Vargas-Hernandéz & Noruzi, 2009). Corporate culture may however also be a foundation for cooperation (ibid.). There are numerous definitions of corporate culture (Schein, 2004), with Trompenaars and Prud'Homme (2004) providing four such definitions, each representing a different dimension of the corporate culture according to Figure 13. In addition, corporate culture is affected by its national roots, which makes it important to understand the related national culture in order to understand the characteristics of the corporate culture (ibid.).

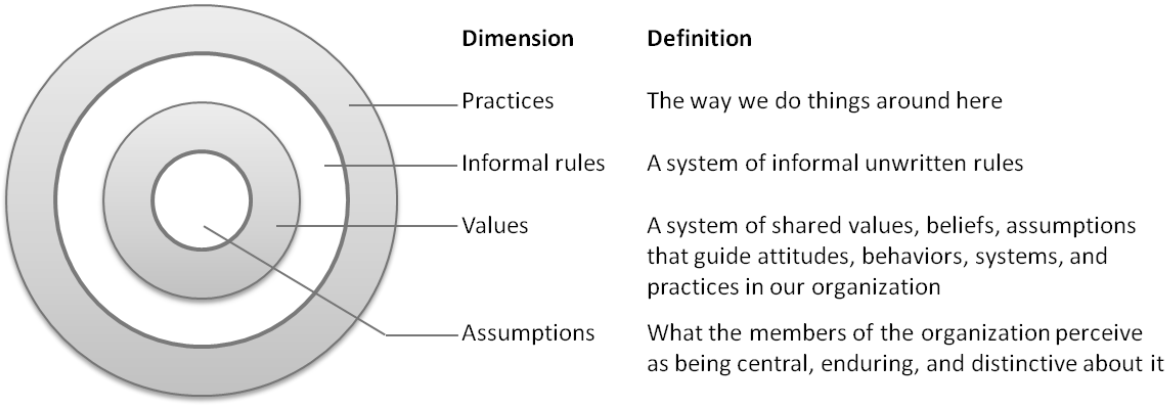

Figure 13. The dimensions and definitions of corporate culture, adapted from Trompenaars and Prud'Homme (2004).

As mentioned, both conflicts and cooperation are natural occurrences in business relationships, and by assessing the level of conflict and cooperation respectively, one can appreciate the characteristics of the relationship, as presented in Figure 14 (Gadde, Håkansson, & Persson, 2010). The figure thus prescribes that conflict is not inherently negative, but rather depends on how conflicts are handled; by handling them through cooperation, a foundation for creativity is provided (ibid.). Poorly handled conflicts can however lead to a decline in efficiency as they threaten core organisational processes (Vargas-Hernandéz & Noruzi, 2009).

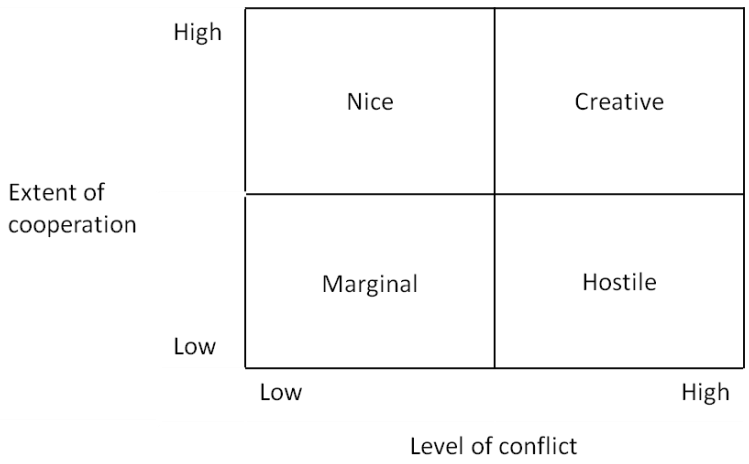

Figure 14. Relationship characteristics matrix (Gadde, Håkansson, & Persson, 2010).

Conflicts can be handled and/or prevented by various countervailing measures, for instance by learning how to handle conflicting cultures or negotiation strategies or by dealing with the structures and rules that affect the business relationship (Kolb & Putnam, 1992). An example of the latter is to attend to goal divergence between actors, which in agency theory is known as the agency problem (Eisenhardt, 1989). Eisenhardt (1989) describes the agency problem to arise when an actor (principal) hires another actor (agent) to perform a task and their respective self-interests cause them to have conflicting goals and additionally have different perceptions of risk. The principal thus wishes to make sure the agent is acting in line with the interests of the principal, which can be achieved by monitoring the agent by the use of budgeting systems and reporting procedures, for example (ibid.). Monitoring may however be costly and complex (ibid.) as well as risks undermining the agent's willingness to act in the best interest of the relationship (Stephen & Coote, 2007). In addition to the

issues mentioned above, a self-interest seeking behaviour among the actors may also lead to an overall loss of efficiency (Hennet & Arda, 2008; Vargas-Hernandéz & Noruzi, 2009).

In order to align goals and distributing risk between the principal and the agent, agency theory suggests utilisation of contracts (Eisenhardt, 1989) by which improved performance and decreased risk can be obtained (Hennet & Arda, 2008). Stephen and Coote (2007) find that in conjunction to contracts also relational behaviour, such as solidarity and trustworthiness, affects the possibilities for achieving goal alignment. The reasoning behind this is that social interactions among actors bring about strong relational bonds that support the generation of common relational norms as well as improve inter-firm cooperation (ibid.). Furthermore, Nan (2011) establishes that mutually increased awareness of business partner's interests and needs also provides support for constructive inter-firm cooperation.

The value of awareness and social interaction in resolving conflicts is supported by Asmus et al. (2006), who present a case where environmental activists and a multinational corporation sat down and engaged in a dialogue to resolve a dispute over how rainforests were affected by the company's business practices. By the counterparts being able to explain their positions they were able to understand the interests and needs of each other, and by engaging in social interaction a greater level of trust and acceptance was attained, which provided a greater possibility to affect the actions of the counterpart (ibid.).

Another source of conflict mentioned is communication problems. Closely related is the language barrier, which play an important role in the origination of such problems (Vargas-Hernandéz & Noruzi, 2009). Also more subtle aspects of communication such as body language and tone of voice affect how interaction is perceived (Schein, 2004). Conflicts may thus be avoided if actors in a business relationship are able to understand and communicate with each other without misconceptions (ibid.). This can for instance be achieved by utilising translators or learning a language to be able to communicate in a common language (Lazear, 1999). Language also relates to the problem of differing perceptions of reality, as different corporations attach different value to what is a good product, good quality, low cost, fast market entry etcetera (Schein, 2004). For actors to be able to communicate effectively it is thus important to establish common definitions, which may be achieved by educational interventions, for example (ibid.).

Finally, differences in corporate culture may be a source of conflicts in business relationships, as perception, values and behaviour of cooperating actors may not fit well with each other (Vargas-Hernandéz & Noruzi, 2009). By being aware of and understanding cultural differences, one thus can avoid conflicts caused by irritation and anxiety over an actor's seemingly irrational behaviour (Schein, 2004). Trompenaars and Prud'Homme (2004) complement that it is important to view differing cultures just as being different rather than being wrong, as a lack of respect for the differences can lead to mistrust between partners. A step on the way to gain a greater insight of national culture can for instance be accomplished by consulting bicultural competence (Lazear, 1999). Also numerous models for mapping the characteristics of corporate culture are developed, e.g. Trompenaars and Prud'Homme (2004), Goffee and Jones (1996) and Hofstede (1991). There is however no "perfect fit" to seek in a business partner to avoid conflict, as conditions for these vary (Vargas-Hernandéz & Noruzi, 2009), as does business environments and organisations (Goffee & Jones, 1996). What is more is that corporate culture may vary within an organisation and deviate between organisational units such as large divisions down to small teams (ibid.; Schein, 2004).

Although important, it is not the extent of cultural difference that is the main culture related conflict issue, but rather how the differences are handled (Trompenaars & Prud'Homme, 2004). A corporate culture may be more or less prone to handle conflicts in a constructive way; a conflict culture has a passive approach towards solving conflicts, characterised by competitive and anti-social behaviour, that first and foremost seek to fulfil self-interests (Vargas-Hernandéz & Noruzi, 2009). A more active approach signified by a cooperative and pro-social behaviour is preferable for finding solutions to conflicts (ibid.). This competitive versus cooperative characteristic is one of nine cultural dimensions identified by Trompenaars and Prud'Homme (2004) that form a corporate culture. It can be assessed by establishing which way of working that is seen to render the highest possibilities for success of an organisation (ibid.).

The scoreboard that is used for evaluation contains two steps, the first one being to obtain statements on the following questions:

- Which of the priorities, A and B stated below, is more fulfilling to you personally?
- Judged by how it is measured and what it promotes, which is more important to your organisation?

A. *An organization can best go for competing aggressively.*
B. *An organization can best go for forging partnerships.*

The second step entails the respondents to allocate 0-10 points to each of the priorities, in the way that best describes the organisation's behaviour and insert into the matrix presented in Figure 15 to visualise the outcome. High scores on priority A (competing) is not necessarily bad as long as it is accompanied by high scores on priority B (cooperation) as well, since this leads to a state of cooptation, i.e. cooperation to compete (Trompenaars & Prud'Homme, 2004). The upper right corner of the matrix is thus the position to aim for as it renders a competitive advantage through building partnerships (ibid.).

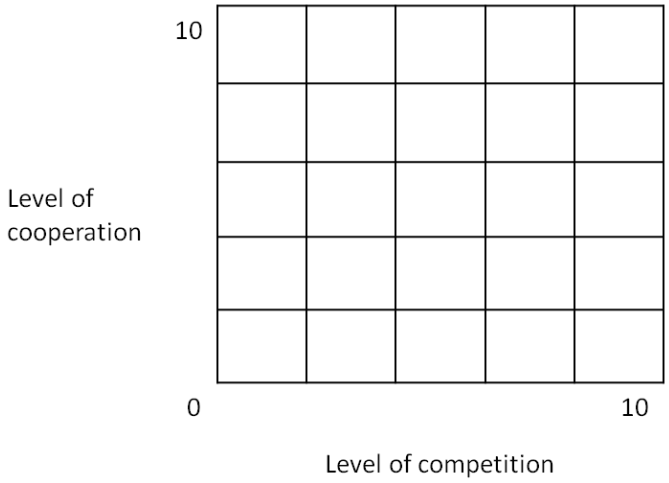

Figure 15. Competing versus cooperation orientation, adapted from Trompenaars and Prud'Homme (2004).

2.2.3 Power and dependence

Dahl (1957) defines power as the ability of an actor to influence another to act in the manner that they would not have otherwise. All business relationships are subjected to a balance of power; which has its roots in the resource dependency theory (Argyres & Liebeskind, 1999), meaning that actors to a varying degree are dependent upon other actors' resources (Pfeffer & Salancik, 2003). Pfeffer and Salancik (2003) also present a framework for assessing the level of dependence between actors; the framework state that dependence is affected by three dimensions: resource importance, concentration of resource control and discretion over resources. Resource importance is further divided into relative magnitude and criticality. The relative magnitude signifies what proportion of the total input that the resource presents and criticality is how important the resource is for continuing the business of the actor. Concentration of resource control relates to how many actors that are available for a specific resource and discretion over resources denotes the possibility to control the allocation and use of a resource. This control is generated by any of five influential factors: possession of the resource, ownership of the resource, control of access to the resource, control of actual use of the resource and lastly making the rules that regulate the resource. As an example, a purchaser controls allocation of resources, although not owning them (Pfeffer & Salancik, 2003). To conclude, power is affected by the dependence of specific resources and the control of those resources (ibid.).

A result of the resource dependency theory is that the more dependent an actor is upon another actor's resources, the higher relative power this actor will enjoy, thus creating an imbalance of power (Gadde, Håkansson, & Persson, 2010). There are basically four types of such power relations in dyadic business relationships, as shown in Figure 16 (Cox et al.,2001).

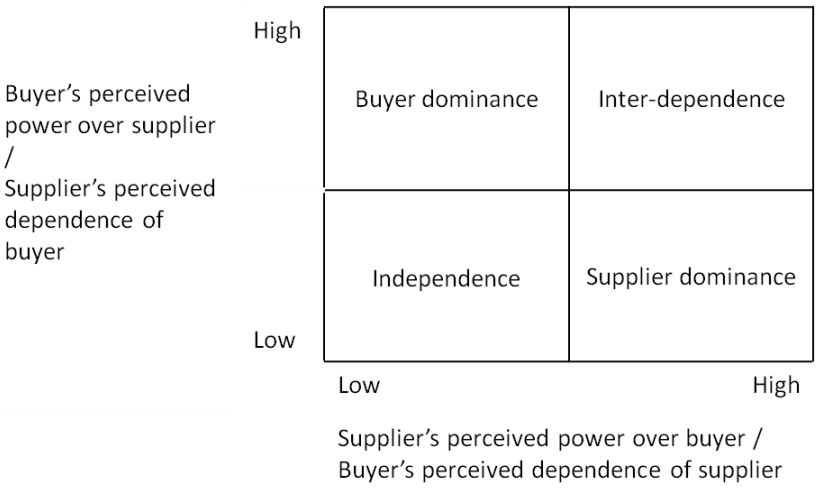

Figure 16. The exchange power matrix, adapted from Cox et al. (2001).

A power relation signified by independence may exist when there is a good availability of both customers and suppliers and there are low switching costs (Ritter, Wilkinson, & Johnston, 2004) as in the case of office consumables, for example. In this kind of relation, power can be exploited since actors easily can choose to conduct business with others in case conflicts get too severe (Gadde, Håkansson, & Persson, 2010).

In the event of a relationship with uneven dependency, the actor with the resulting power advantage may exploit this situation to influence the business as it finds preferable, even though the results doesn't lie in the counterparts interest (Lambert & Cooper, 2000). This can lead to conflicts and unstable relationships (Rokkan & Haugland, 2002). Imbalance can however also lead to stable relationships as long as the actor with the power disadvantage receives a perceived fair share of the value generated by the relationship (Hingley, 2005). There is nonetheless always a fear that the dominant actor abuses its power (ibid.).

Business relationships characterised by mutual dependency, commonly enjoy stable relationships (Cox et al., 2001). The power is balanced by exchanging resources (Pfeffer & Salancik, 2003), for example a company providing unique technology exchanging this resource for substantial order quantities from a customer; thus creating a mutual dependency. Interdependencies can also be self inflicted as in the case of increased focus on core competencies and the following sharing of technologies (Håkansson, 2006). For a comprehensive list of factors and situations affecting the dependency and following power relation, see Table 1.

Buyer dominance	**Interdependence**
Few buyers / many suppliers Buyer has high percent share of total market for supplier Supplier is highly dependent on buyer for revenue with limited alternatives Supplier's switching costs are high Buyer's switching costs are low Buyer's account is attractive to supplier Supplier offerings are commoditised and standardised Buyer's search costs are low Supplier has no information asymmetry advantages over buyer	Few buyers / few suppliers Buyer has relatively high percent share of total market for supplier Supplier is highly dependent on buyer for revenue with few alternatives Supplier's switching costs are high Buyer's switching costs are high Buyer's account is attractive to supplier Supplier offerings are not commoditised and customised Buyer's search costs are high Supplier has significant information asymmetry advantages over buyer
Independence	**Supplier dominance**
Many buyers / many suppliers Buyer has relatively low percent share of total market for supplier Supplier is not dependent on buyer for revenue and has many alternatives Supplier's switching costs are low Buyer's switching costs are low Buyer's account is not particularly attractive to supplier Supplier offerings are commoditised and standardised Buyer's search costs are relatively low Supplier has only limited information asymmetry advantages over buyer	Many buyers / few suppliers Buyer has low percent share of total market for supplier Supplier is not at all dependent on buyer for revenue and has many alternatives Supplier's switching costs are low Buyer's switching costs are high Buyer's account is not attractive to supplier Supplier offerings are not commoditised and standardised Buyer's search costs are very high Supplier has high information asymmetry advantages over buyer

Table 1. The attributes of buyer and supplier dependence (Cox et al., 2001).

As companies are motivated by self-interest it is natural for them to take measures that will alter the dependence situation to improve the bargaining power (Hingley, 2005). This can be achieved by increasing the control over resources and activities, either by direct ownership through investments in new resources and/or activities (Brito, 2001; Pfeffer & Salancik, 2003), or indirect by developing relationships with other actors, however resulting in new dependencies (Brito, 2001; Low, 1997).

Both Low (1997) and Pfeffer and Salancik (2003) also conclude that forming strong social relationships, increase interdependencies between actors and thus provide high entry barriers for new actors. In addition, Nair et al. (2011) propose the utilisation of a resource development strategy to improve bargaining power by altering the dependence between actors. Such a resource development strategy can be fulfilled by combining and recombining resources (Gadde, Håkansson, & Persson, 2010). Furthermore, Low (1997) argues that bargaining power is time-dependent, as demand for specific resources and activities vary over time.

Some business relationships require investments in resources on one actor's behalf as a prerequisite for further business; after such investments have been made, the dependency of the investing actor increases (Argyres & Liebeskind, 1999). In order to prevent a shift in bargaining power as well, contracts containing exclusivity clauses should be utilised under these circumstances (ibid.). Additionally, information can be used to increase the influence over other actors; by possessing more knowledge about other actors, resources and activities than the competitors (Håkansson & Johansson, 1992). This is exemplified by Fairhead and Griffin (2000), who present a case of an Irish plant belonging to a subsidiary of General Motors. The management of this plant identified the possibility of rationalisation efforts among the company's eight European plants and acted upon that knowledge. By gaining and utilising information about competing plants, the management team could provide a business case that included continued utilisation of the Irish plant and thus managed to stay in business.

In addition to increasing control as a means to increase bargaining power, an actor can work towards limiting dependence of scarce resources and by that, decrease the impact of low bargaining power (Pfeffer & Salancik, 2003). Pfeffer and Salancik (2003) present two ways to fulfil this strategy, one being to develop suitable replacements and the other one being to adopt diversification. Developing replacements can for instance mean changing the materials that are used in a product or changing the characteristics of the final product to fit another market than the present one. The authors exemplify the latter with a cereal producer that could complement the production of breakfast cereals with natural cereals, which were sold as snack foods and by that, establishing products in an additional market, which limited the dependence on the breakfast cereals. Diversification is described as a more radical approach as it concludes exploring other lines of business into new products, technologies, markets etcetera.

3. Method

There are mainly two different approaches for conducting research, quantitative method or qualitative method. The quantitative method usually aims to provide measurable findings such as for example diffusion of a product in a market (Eriksson & Wiedersheim-Paul, 2008). When using a qualitative method the researcher is interested in explaining why a certain phenomenon occurs and thus, examines content and patterns in the related context (ibid.). In this thesis a qualitative method is applied since the purpose of is to develop a framework for how MHC can reduce its lead times in cooperation with its suppliers. The qualitative data gained both in interviews and in literature and the findings from these sources is the basis for the developed framework for lead time reduction. Thus, an inductive research approach has been used. With an inductive stance, the theory is the outcome of the observations and findings (Eriksson & Wiedersheim-Paul, 2008). This differs from the deductive approach where the researcher aims to derive a hypothesis from a theory and then test it (Haig, 2005). The inductive strategy of linking data and theory is typically associated with the qualitative research method (Bryman & Bell, 2007).

3.1 Data Gathering

The collection of data was a central part of the work and in order to provide a good framework to MHC, the quality of the assembled data was crucial. The primary data was mainly derived from interviews, both with personnel within and outside MHC, but also from brainstorming sessions. The secondary data was collected by literature searches on relevant topics and observations of their internal network.

3.1.1 Primary data

Björklund and Paulsson (2007) states that primary data is newly collected data that is to be used in a specific study. The primary data from this study has been assembled through interviews with academics and with key personnel at MHC and other companies that have a strong emphasis on supplier management. The interviews with academics was less structured and aimed to give us ideas and guidance in the work process in order to find general information regarding the subject. Interviews conducted with corporate personnel outside of MHC aimed to provide us with information regarding how other companies work with supplier relations and inter-firm efforts. These interviews were semi-structured and aimed to provide us insights and tools from their ways of work. This results in that the findings from the interviewed companies emphasise different areas and can therefore not be compared directly to each other. The companies were chosen based on their long experience from working with supplier relations and well known procedures for this. MHC personnel were interviewed in order to get an understanding for their work and to map their processes. The empirical section is to a large extent based on the interviews with MHC personnel and the interviews with other companies. Not included in these interviews are the reoccurring discussions with the tutors at MHC. See Appendix 1 for a list of interviewees and interview templates.

In addition to the interviews, brainstorming sessions were used regularly in order to both get new ideas but also to secure that the information known was perceived in the same way.

3.1.2 Secondary data

Secondary data is information and data collected by someone else with other purposes than for the particular study. It is therefore important to remember that this data might be biased and that it might not be comprehensive (Björklund & Paulsson, 2007). The secondary data collected was both the literature used in the literature study and the empirical data regarding the processes that MHC works with. This was gathered from the company's Intranet.

An extensive literature study has been made in order to not be biased. The literature chosen to be included in this report is the one found relevant for the topic and it has been chosen in discussions with the tutors at MHC and at Chalmers. Most data has been found through online searches in different data bases for articles and through local libraries for the books that have been used.

The literature study is based on two different areas; process improvement and relationship management. Process improvements aim to provide an extensive framework on how to change and improve processes both within the firm and also in the interaction with other actors. It is centred on the PDSA (Plan, Do, Study, Act) method and includes the concepts of value stream mapping and cause-and-effect finding. The relationship management section aims to give a guide on managing business relations and how one can influence the relationship in a buyer-supplier situation. It includes concepts such as trust, commitment and power in business relations.

Secondary data have also been gathered at MHC. The data gathered here is presented in the empirical findings chapter and has mostly been gathered through the company's Quality Management System, Succeed. Here the process maps and relevant data regarding work processes and work descriptions have been gathered. Other sources such as the company's Supplier Performance Measurement system have also been used in order to find information.

3.1.3 Critique of method

In qualitative studies there are some factors to bear in mind. With the way the information is gathered, the data can easily be impressionistic and too subjective (Bryman & Bell, 2007). The criticism increases by the fact that it is difficult to replicate the study and thus, verify how the researchers came to the thesis's conclusions. It is for example difficult to perform the same interview twice and receive the exact same answers. In order to decrease these risks, triangulation of data has been done by combining information found in literature by information gathered at MHC and in interviews.

4. Empirical findings

The empirical data is mostly based on data gathered at MHC regarding the company's business environment, organisation and processes but it also includes information gathered from three interviews with three different companies and their take on lead time and supplier collaboration.

4.1 MHC

As stated in the introduction, MHC was formerly a textile company that has transitioned into the medical industry. The company has had various owners since it was started in the mid 19th century, but since 2007 the Swedish industrial holding company Investor has been the major owner of MHC with a 96 percent share. MHC headquarters are located in Gothenburg, Sweden, although an absolute majority of the 7000 employees are distributed worldwide, for instance among the nine manufacturing facilities in Belgium, Czech Republic, France, Finland, Malaysia, Poland, Thailand, UK and North America. There are also a total of 30 sales offices, located in Europe (21), the Middle East (1), Africa (1), Asia-Pacific (5) and North America (2). These cover the customer base, mainly consisting of hospitals and local treatment centres, in over 80 countries. MHC has since 2007 increased revenue from 767 MEUR to 1014 MEUR in 2011, with Europe, the Middle East and Africa (EMEA) as the largest contributor with 73 percent of sales. However North America (21 percent) and Asia Pacific (6 percent) show strong sales growth. Revenue is more or less evenly distributed among the two business units. In addition to the mentioned facilities, there are a number of distribution centres and local warehouses, which provide products to the market within two (Europe) or six (North America) days. Suppliers are spread worldwide, one reason being a limited number of possible suppliers for some materials. This can for instance be due to few manufacturers of specific materials and quality requirements determined by MHC and market regulations. (Mölnlycke Health Care, 2012)

Due to legal requirements and the characteristics of the goods produced, shifting suppliers is a process that can take over a year. Another characteristic of the supplier base is that it generally is few suppliers available for some material and that it under certain circumstances might be very hard to shift supplier. Due to this, MHC cannot choose supplier based on physical location either. This results in that there sometimes are long transport times between the supplier and factory. The goods supplied by the suppliers are usually bulky and of low value and is due to that, transported by boat. These transports can be up to six weeks if the supplier and factory are located on different continents. The transportation of the goods can be organised either by MHC or the suppliers.[3]

MHC's suppliers are in general larger than MHC and have their main businesses outside of the medical sector. Since MHC, and the medical sector in general, has larger demands on for example cleanness than customers in other industries, the supplier needs to take this into consideration. On the other hand, the marginal for the supplier are generally higher for these products than for products produced for other industries. Due to the general size difference between MHC and their suppliers, the yearly demand of a product for MHC can be just a few days of production for the supplier. This leads to that MHC sometimes need to buy large batches and that they are not the preferred customer of the supplier.

[3] MHC interview, 2012-03-14

4.1.1 Procurement and replenishment processes

The activities that involve purchasing can be divided into two separate groups. The first group of activities is the replenishment process which involves all the daily or weekly activities of securing material and deliveries to the factory. The second group of activities are those that revolve around more strategic operations, such as contract negotiations.

4.1.1.1 Sourcing

The sourcing process is conducted by procurement managers at MHC. They are responsible for the supplier relationships and by that also for business negotiations, maintaining good relations with existing suppliers as well as identifying and evaluating new suppliers.

As can be seen in Figure 17, the process starts with a business need for a certain product and the first decision is whether or not a sourcing process should start; if there is an approved and accepted supplier already available, this process is not performed and this approved supplier is chosen.

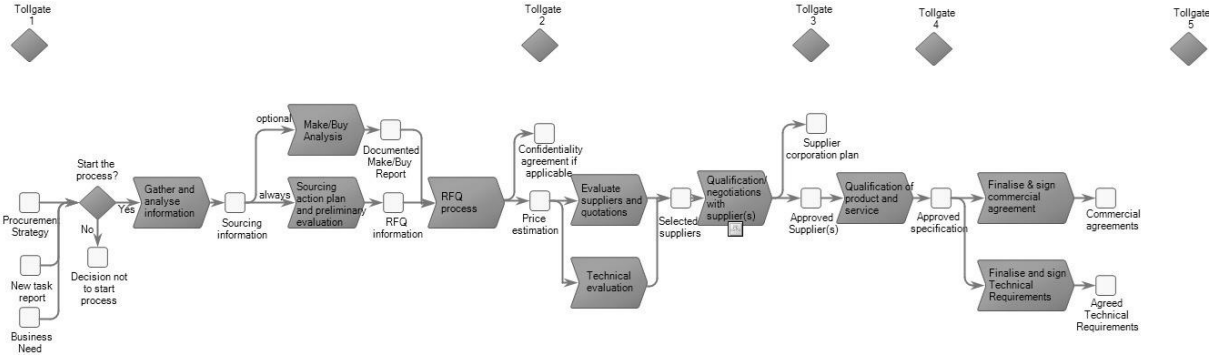

Figure 17. The sourcing process (Mölnlycke Health Care, 2012b).

If the sourcing process is triggered, a preparation for a request for quotation (RFQ) is done. The requirements within an RFQ are standardized and are based on:

- Quality
- Terms and conditions
- Prices
- Code of conduct
- Environmental issues
- Validity offer
- Financial
- Capability
- Capacity
- Suitability
- Fit to time plan

Some areas are more important than others, for example a possible supplier that does not follow the code of conduct and uses child labour is disqualified irrespective of its other qualifications. After suppliers have submitted their RFQs, these are evaluated and are used for deciding which supplier to continue with.

4.1.1.2 The replenishment process[4]

The replenishment process is mostly managed by the material planners located at the factories. They are responsible for the day to day work and securing that there is material available in order for the factory to be able to produce goods.

As can be seen in Figure 18, the process starts with checking if the materials are already available at the production site. If material is not available, a call-off is then sent to the supplier. The call-off is done by a material planner located at the factory in need of the material and all call-offs are done locally by each production site. The result from this process is a purchase plan that is sent to the supplier. The purchase plan is generated automatically through the ERP-system and sent by email to the supplier.

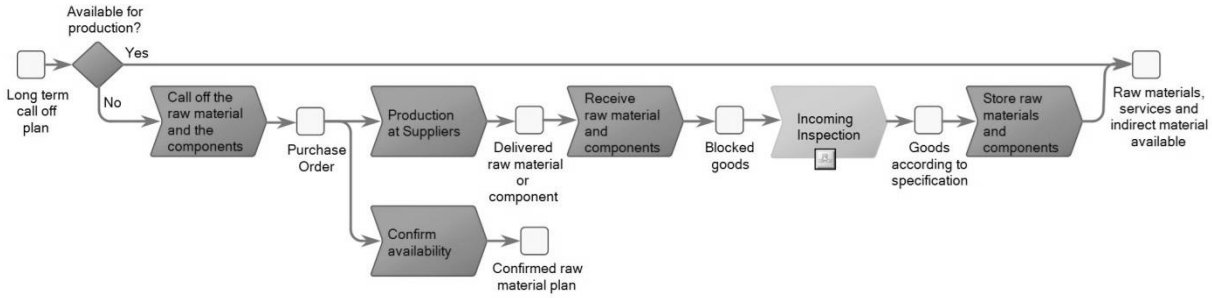

Figure 18. Call-off raw material and components (Mölnlycke Health Care, 2012b).

When the supplier has received the purchase plan it is required to confirm availability, including delivery date, of the requested material and should respond as soon as possible. Large, well established suppliers are generally better at this while smaller suppliers generally does not respond as frequently.

The planner orders a pick-up of the goods when the products are available at the supplier's production site. Most goods procured by MHC are bought Ex Works, which means that MHC is responsible for the transportation and the ownership changes at the supplier's terminal.

Together with these processes at MHC, is the supplier's procurement process; this is generally performed based on forecasts that are provided by MHC upon supplier's request. If the product procured is a product that the supplier keeps in stock and also promotes to other customers, MHC is generally a small customer and the forecasts given by MHC are added to the total of the supplier. The forecasts provided are extracted from MHC's ERP-system and are based on previous consumption rather than on expected sales, since this generally provides more accurate forecasts.

The largest problem within the replenishment process is raw material shortage due to late deliveries or quality issues with the supplier. These problems can result in shortage of finished goods, unwanted changes in production or stop in production.

The planners cope with long lead times by keeping extra safety stock and thus increase the tied-up capital together with running the risks of getting larger amounts of obsolete products. Long lead times are however not the only driver of safety stock levels, which are also increased due to the size of demand fluctuations and low service levels provided from the suppliers.

[4] MHC interview, 2012-04-23

4.1.2 Change and improvement management[5]

MHC has developed a process for managing and monitoring supplier performance. This process is called the Supplier Performance Management (SPM) process. The purpose with this is divided in five parts, namely:

1. Defining supplier non-conformities
2. Measuring supplier non-conformities
3. Solving and improving supplier non-conformities
4. Closing supplier non-conformities
5. Escalating supplier non-conformities

The KPI's that are measured are on-time delivery, quantity delivered, quality, awareness and correction as well as corrective and preventive action. The first three measurements are compared to what is agreed and acknowledged in the contract and purchase plan. The awareness and correction measures the suppliers problem awareness and if they can correct the problem or at least contain it within 48 hours. This includes that the supplier shall define, verify and implement the correction or containment to isolate effects of the problem until the definitive corrective and preventive actions are implemented. This is very important due to the high levels of quality that is needed in the healthcare industry. The corrective and preventive action measurement states that the supplier shall create corrective and preventive actions based on root causes within 14 days. This includes both detecting the root cause and the best corrective and preventive action to remove the root cause that will give capable results. The supplier shall also verify that actions will be successful when implemented without causing undesirable effects. If the corrective and preventive actions cannot be implemented within 14 days, the supplier shall present a detailed time plan/action follow-up list that will describe the future execution of presented actions. One of the main benefits with the SPM process is that is clarifies the expectations from MHC and that the expectations are the same regardless of which factory the supplier supplies.

4.1.2.1 Previous lead time reduction projects

MHC has previously done lead time reduction projects and is also currently working on one project. This project aimed to reduce the lead time for a flow from a supplier in China to the manufacturing plant in Thailand. The lead time was 10 weeks including the transportation from the supplier to MHC's manufacturing plant but the direct time needed to produce the products was only two days. MHC is not the supplier's largest customer but the largest within the healthcare sector and this sector often provides higher margins.[6]

There was no framework used when doing this project. Instead it was based on the experience of the people involved in the group responsible for the project and their knowledge regarding the subject. In order to identify the drivers of the long lead time, they made a value stream map over the production and assigned the supplier to make a detailed value stream map over the suppliers own processes. The project members at MHC were responsible for mapping the rest of the processes. As of now, MHC and the supplier have quarterly meetings with the supplier and contact almost daily regarding this project. The project is not finished as of now and thus the results from it are not known at this time.[6]

[5] MHC interview, 2012-03-14 and 2012-03-23
[6] MHC interview, 2012-03-02

During an interview with MHC, a risk was expressed that the persons that have the authority to engage in a joint lead time reduction project might not be the same people that make the decisions on the changes[7].

4.2 Benchmarks

Supplier collaboration is of growing importance for many companies. Autoliv, Flexlink and Volvo Powertrain (VP) all have different pre requisites and markets but they all view supplier collaboration and short lead times as important aspects.

4.2.1 Autoliv[8]

Autoliv Inc. is a company within the automotive safety area. The company's main products are seatbelts and airbags, comprehending a number other products as well, the company has the widest product offering of automotive safety in the industry. The customer base consists of most of the leading automobile manufacturers around the world, which are serviced from 80 facilities in 29 countries. As of 2010, 48 000 people are employed globally and the sales volume was $6,5 billion. Their largest markets are Europe which constitutes 53 percent of the company's total sales and North America which constitute 24 percent of total sales.

All the facilities have deployed Autoliv's own developed manufacturing system Autoliv Production System which is based on the Toyota Production System (APS). Currently, the company is working together with selected suppliers in order to align these with the APS, which is done in order for the suppliers to also gain the advantages that Autoliv has experienced from adapting the APS. Autoliv has developed its own manufacturing process called Autoliv Manufacturing System (AMS). The system is based on the Toyota Manufacturing System, which incorporates the lean philosophy. In order to be more efficient in the company's production, a Kanban-system is used, which allows it to be more flexible. Since Autoliv has a demand from their customers that the customers can change orders up to two days before products are shipped, they try to put the same demand on their customers. The company also expects a constant cost decrease of four percent yearly.

Autoliv believes that communication is a key issue and that language barriers should not be overlooked. It is therefore important to try to be very clear with what one mean in all situations to reduce misunderstandings. In order to help their suppliers to fulfil these requirements they have set up a program called Autoliv Supplier Development Program. The goal is to decrease the suppliers' cost and improve their performance. In this program, Autoliv works together with selected suppliers in order to increase their efficiency. Autoliv and a supplier conduct a VSM together and then Autoliv tries to help the supplier to improve their production processes. The improvement process is based on the knowledge of the supplier and the processes themselves. The supplier can keep all the benefits that are gained through this program. Except commitment to the program, all Autoliv requires is that the supplier lives up to the standards set in the contracts and is able to reduce its prices by four percent annually. By not sharing the profits based on the benefits gained, the supplier generally is willing to provide more transparency.

Autoliv believes that the best way to get suppliers interested in joining this program is to present the benefits that Autoliv has gained by working with these questions. By showing successful examples

[7] MHC interview, 2012-04-23
[8] Autoliv interview, 2012-03-28

and inviting the suppliers to Autoliv and presenting the company's production facilities it is much easier to get the supplier onboard. Autoliv does not believe that power in a relationship is the most important aspect when trying to convince a supplier, but rather the mutual monetary benefits that can be gained. Another important aspect is getting top management involved. Autoliv does not initiate an improvement program if the top management at the supplier is not onboard. The company also believes themselves to have a higher rate of success in the improvement program if personnel at Autoliv and the supplier have met during more casual and informal circumstances such as a dinner. Thus, they always try to have some kind of social gathering when inviting the supplier.

Autoliv changed the delivery structure of two components so that instead of receiving them from different sources, they only received it from one supplier. As can be seen in Figure 19, the changes resulted in that supplier B moved back in the chain and became a tier two supplier to Autoliv. The demand for the component delivered from supplier B was dependent on the demand for the component delivered from supplier A. This resulted in decreased complexity at Autoliv by reducing the amount of direct contacts with other actors.

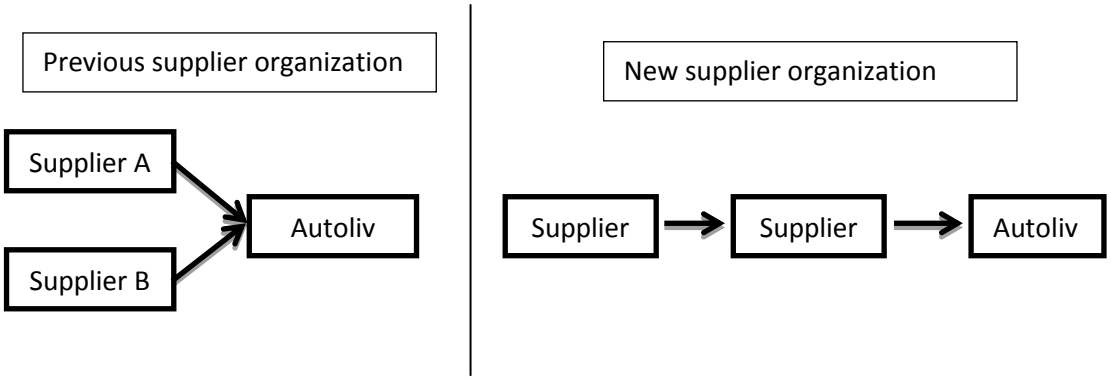

Figure 19. Changes in the actor layer at Autoliv.

4.2.2 Flexlink[9]

Flexlink AB is a manufacturer of flexible, modular conveyors and industrial automation equipment. The company headquarters located in Goteborg, Sweden is complemented by manufacturing, production and engineering facilities in Allentown, PA North America, Poznan, Poland and Kuala Lampur, Malaysia. Sales offices are situated in 28 countries, with partners in an additional 32 countries. Their largest market is Europe which constitutes 57 percent of total sales, which was around $200 million in 2010.

Flexlink's manufacturing is mostly assembly of components manufactured by their suppliers and customizing the assembly to their customer's needs. Thus, the company needs to have good relationships with their suppliers since they produce the company's core products. The majority of suppliers are located in Europe due to that it is there largest market. This enables short transport times and responsiveness to customer demands.

In order to decrease costs, Flexlink has shifted to using some suppliers in China. This sourcing choice is however only made for products which have stable demand and low fluctuation in order to not jeopardise availability. For the most important products, Flexlink uses suppliers in close proximity of

[9] Interview with Flexlink, 2012-03-12

the company's markets. These suppliers generally have been supplying Flexlink for a long time and they have developed a good relationship between each other.

The lead time from suppliers, excluding those in China, is approximately one to three weeks. This time includes both supplier production and transportation time. In order to keep a short lead time, the suppliers keep raw material for Flexlink's products so that they can start producing them as soon as an order is sent from Flexlink. Flexlink, on the other hand, agrees to cover the costs for the raw material if it becomes obsolete (ibid.). The reason for having the supplier keeping stock of raw material instead of finished goods is that the costs of obsolete goods are lower and that the production time is short.

4.2.3 Volvo Powertrain[10]

Volvo Powertrain (VP) is a business unit within AB Volvo, one of the world's largest providers of transport solutions for commercial use. VP has the main responsibility for the development and production of the power train, i.e. the engine, gearbox, and driven axles. The company supplies the business areas in the group, for example Volvo Trucks, Volvo Construction Equipment, and Volvo Buses, with its solutions.

VP has approximately 9000 employees and delivers on a yearly basis 200 000 heavy duty engines, 125 000 transmissions, and 45 000 marine drives. The company's sourcing of material and components yearly amounts to 3.6 Billion Euro. The core values of the company are shared with the Volvo Group and contain three areas; quality, safety and environmental care.

Having acquired Renault along with Mack Trucks in 2001 and later on UD Trucks in 2007, VP's supply base consisted of over 1000 suppliers. By sourcing more strategically since 2001, for example going from transactional purchases and annual negotiations to coordinated and cross-functional purchases as well as developing common platforms for the power train, VP has been able to reduce its supplier base to approximately 100 suppliers. Strategic sourcing is of importance to VP since the cost of purchased material stands for 75-80 percent of the cost of the finished product.

VP put large demands on their suppliers already in the supplier selection process, demanding a two day lead time. The company also monitors the suppliers and their performance continuously, especially the service level. If a supplier does not live up to the standards set in the contract, they can be fined. For VP, lead time is of crucial importance and if a potential supplier is unable to meet the terms of delivery they will not be employed. This is a general concept within the automotive industry and generally all customers in the industry have the same demands. VP also requires suppliers to have consignment stock within proximity to their production sites so that they can ensure exact delivery precision. They can thus, use a supplier with production located far away if they provide stock nearby.

Since VP put a large emphasis on decreasing lead times already in the contracts, they do not have any lead time reduction frameworks. Nonetheless, the company does have frameworks that aim to improve the supplier in general in order for them to live up to the standards set in the contracts. It can for example incorporate increasing service level, increasing the quality of the goods supplied or reducing risks.

[10] Volvo Powertrain interview, 2012-03-28

Sharing information with suppliers is vital for continuous improvements. VP has a portal set up where suppliers can log in and check their performance. By allowing the supplier access to a database, VP can reduce the amount of work required to inform suppliers of their service level etcetera.

Lastly, VP is of the impression that social interaction with suppliers improves the chances of a successful partnership. By meeting staff from the supplier in person and not only on phone and by email, one can better work together and solve problems.

5. Analysis

This chapter covers an analysis of earlier presented findings and is focused on answering the stated research questions:

- How can lead times be improved by cooperating with suppliers?
- How should MHC work with suppliers in order to improve lead times?
- How can MHC visualise the financial benefits gained from lead time reduction?

The analysis starts with evaluating a total cost approach and the ARA-model at MHC, followed by analyses of what will be important for MHC to do in order to decrease lead times.

5.1 Total cost approach

As presented by both Gadde et al. (2010) and Jennings (1997) a total cost approach needs to be utilised on outsourced material rather than evaluating the price tag alone. Many of the indirect costs, such as storage and capital costs contribute to the total cost and are directly related to lead time, as lead time makes it harder to plan and thereby contributes to the build-up of safety stocks, which in turn generate costs for, among other things, tied-up capital and obsolescence. In order to develop the ability to utilise a total cost approach it is therefore of the essence to have notion about the costs that lead time generates.

In order to secure a total cost approach it is important to establish and measure various KPIs and KIIs. In addition it is also crucial to measure the performance level prior to changes to get a benchmark. MHC currently has the SPM process that tracks the performance of the suppliers but it only measures reactive performance measurements. Having a performance measurement of reducing lead time can conflict with some of the reactive performance measurements such as service level due to that the suppliers might not want to challenge themselves and run the risk of decreasing its performance with regards to the other measurements. This is an important aspect to consider when initiating an improvement effort with a supplier. MHC has stated from top management that they have a long-term goal of reducing lead times and it is therefore important when initiating improvement efforts to ensure that the performance measurements measured in SPM are not negatively affected by these efforts.

5.1.1 Quality in processes

By utilizing the concepts of activity re-configuring, resource re-combining and actor re-positioning one can change and improve the processes for a firm. By interacting with their suppliers on these different levels, MHC can both change and improve its processes in order to shorten lead time.

Autoliv did a re-positioning of an actor when they moved a first tier supplier to be a second tier supplier. By doing this, they decreased the complexity in the supplier network due to having fewer suppliers and improved the planning by only getting materials from one supplier instead of two. When MHC makes changes in the actor layer, it is important to be aware of the changes that will follow in the resource and activity layers and how these changes affect the possibilities to adhere to market needs. For instance the pros and cons of making such a change as Autoliv had done. This generated a less complex supplier network, while on the other hand Autoliv decreased the control of the resources the company depends on, which can generate risks regarding supply and technology development. When conducting a re-structure of the actor layer or else, it is important to consider how lead times are affected by this change.

In order to re-combine resources it is important to first identify which the most critical resource elements are and which actor that has the best possibilities to conduct a given activity. What resources are held by the actors within the supply chain and how can MHC best utilise them? This is a key question to ask when re-combining current resources in the supply chain. In a lead time perspective it is important to define the resources that best can provide short lead times and choose to use those. If several actors within the supply chain have the same resources it is thus beneficial to choose the one that can provide the shortest lead time.

By re-configuring activities MHC could either improve the current activities or completely change the activities by outsourcing current in-house activities or add outsourced activities to the in-house production. The example provided regarding Swefork and their outsourcing of the welding process gives an example of the benefits one can gain by doing this. Swefork gained an improvement due to that the company doing the welding process was more specialized and had better capabilities for handling this process. MHC could gain benefits by mapping the company's current activities and evaluating if a supplier is more capable of handling these activities or if an activity currently conducted by a supplier would gain benefits being conducted in-house instead. When evaluating these activities MHC should also evaluate the possibilities of improving them without moving them. This could provide benefits that could be more easily acquired due to the fewer amount of changes needed to conduct them. Another aspect that possibly could reap benefits is to evaluate if coordination of activities could be improved. This is a key element when reducing lead times due to that low coordination often results in storage time which can be seen as non-value adding. By better coordinating activities that lie at MHC, the supplier and in between them, MHC could possibly decrease lead times.

By mapping actors, resources and activities one can more easily identify the drivers for lead time, it is therefore important to evaluate if changes can be made in the related layers mentioned in order to shorten lead times.

5.2 Improving quality

Given the definition of product quality presented by Bergman and Klefsjö (2010), lead time can be seen as a quality dimension of a product. Long lead times can thus be looked upon as a lack of quality and are by that suitably treated as a quality problem.

According to Bergman and Klefsjö (2010) it is important to work systematically with quality improvements. MHC has no commonly established such way of working in inter-firm quality issues, making the PDSA cycle a suitable way to structure the activities required for problem solving to secure an ample effort.

i. The first step of the PDSA cycle, *Plan*, should start with describing the problem (Bergman & Klefsjö, 2010). The starting-point for an effort aimed at reducing lead times naturally is that the lead time is too long. In the case with MHC it should also be concluded that the lead time is too long for a specific item from a specific supplier to a specific MHC facility, in order to end up with a clearer problem description. Although the quality improvement effort is performed in cooperation, the owner of the problem description should be the one initiating the effort, i.e. MHC in this case.
ii. The next thing to do is to establish the performance gap that is to be dealt with (Bergman & Klefsjö, 2010); if the present lead time is 42 days and the needed one is 37 days there is a

performance gap of five days to fill (see Figure 20). A benefit of establishing the performance gap is that it gives an idea about what measures that can be necessary to take. If the needed lead time would be four days in the presented example and one knows that a reason for the long lead time is an ocean freight taking several weeks, that situation will render totally different solutions than if the gap is relatively small. By defining the gap, MHC can align their expectations on the outcome with the supplier's expectations and create a common understanding for goal of the coming effort.

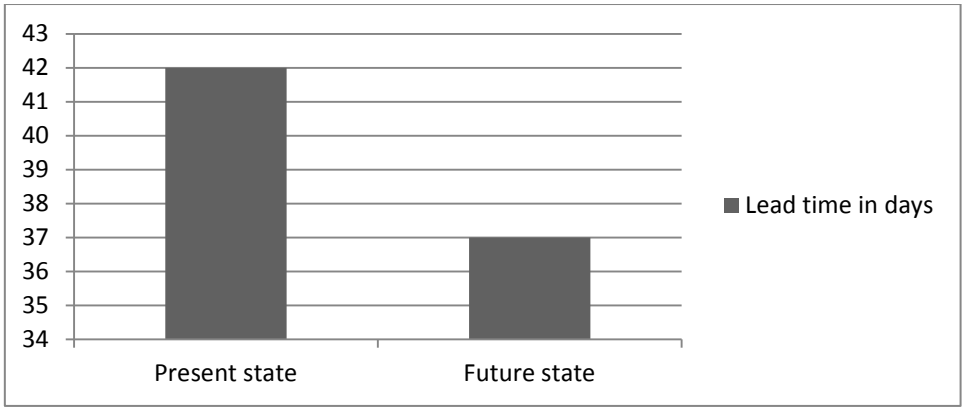

Figure 20. Lead time performance gap.

iii. Another important part of the Plan stage is to break down large problems into smaller and more manageable ones (Bergman & Klefsjö, 2010). Taking on the total lead time all at once would be complicated since it comprises a series of activities, as presented in chapter 3.1. It is therefore a good idea to clarify the activities' contribution to lead time. This can be done by conducting a VSM, as presented by Rother and Shook (1999), which both gives what activities that constitute the lead time and the duration of the respective activities. The total lead time is consequently divided into the lead times of the activities constituting the replenishment process and the problem with long lead time is thus broken down into smaller and more manageable problems. Depending on how detailed the first VSM is, it may be necessary to conduct another one on the chosen activity in order to better understand its constituents, as exemplified in Figure 21. Since the VSM will comprehend activities at MHC, the suppliers and in the interface them in between, it would be preferable to conduct parts of the VSM jointly, for example activities linking the companies together, such as the ordering process. To ease conducting of the VSM, the companies can perform a VSM of activities that are isolated to the respective company and join the two VSMs to get the complete picture. The transportation mapping could be placed with the party in charge of ordering the transports for simplification.

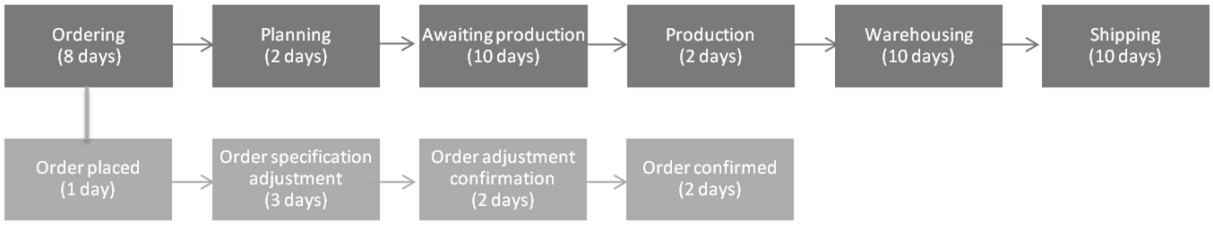

Figure 21. Examples of activities identified in VSM.

iv. In order to choose which activity to attend to, the Pareto chart presented by Bergman and Klefsjö (2010) can be used for illustrating the activities' relative contribution to lead time as exemplified in Figure 22. Preferably the activity with the largest lead time is dealt with first, since this will have the highest impact on the total lead time. However, with respect taken to the performance gap and the nature of the activity, another activity can be chosen if it is estimated to be less resource demanding while still managing to fill the performance gap. For instance if an ocean freight constitutes the longest activity lead time and the performance gap is quite narrow, it may be less costly to decrease the second largest lead time while still achieving the needed total lead time. Additionally, the choice of activity will also be affected by and decided upon by MHC and the supplier jointly.

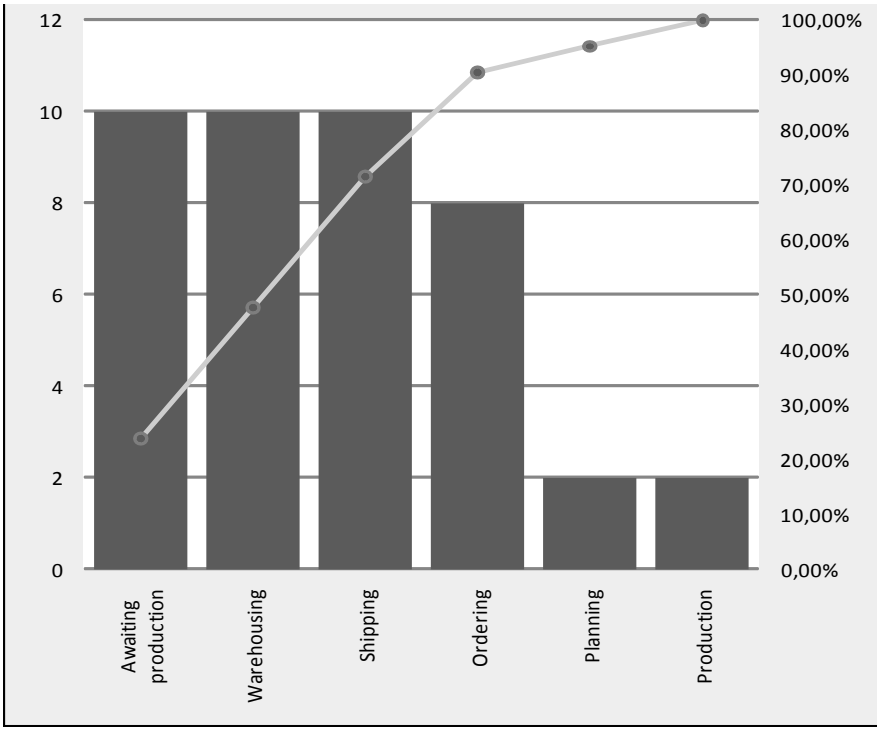

Figure 22. Example of Pareto chart.

v. After a specific activity has been chosen to work with, potential root causes for the activity's long lead time is to be identified (Bergman & Klefsjö, 2010), which is necessitated by a cause-and-effect diagram as presented in chapter 2.1 and exemplified in Figure 23. While conducting the diagram it can be valuable to keep the seven wastes presented by Hines and Rich (1997) in mind. For instance non-value adding time in *waiting* and *transports* can be causes for long lead times. Of course also value-adding time may be driving lead times and show improvement potential, however focusing on non-value adding time will likely render easier to implement solutions. Performing the cause-and-effect diagram may or may not benefit from having participants present from both MHC and the supplier, depending on what problem is in focus. Performing a cause-and-effect diagram of an activity such as the manufacturing operations at the supplier, may not benefit from the attendance of MHC personnel, for example.

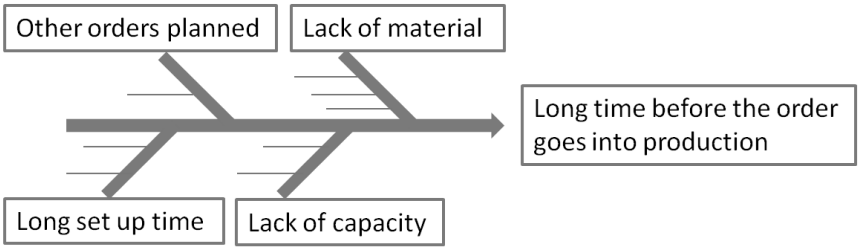

Figure 23.Example of a cause-and-effect diagram.

vi. To verify the assumptions made about which causes that lie behind the lead time, data regarding the occurrences of the identified cause needs to be collected and compiled (Bergman & Klefsjö, 2010). Again the Pareto chart comes to use in illustrating the commonality of causes, as exemplified in Figure 24, and by that helps the choice of which cause to attend to. Additionally, task v. and vi. can be repeated over again until a sufficiently detailed level of the causes is attained, as will be exemplified by describing task vii. and viii. It seems obvious that the party, whose activity is affected, is also the one responsible for collecting and compiling this data.

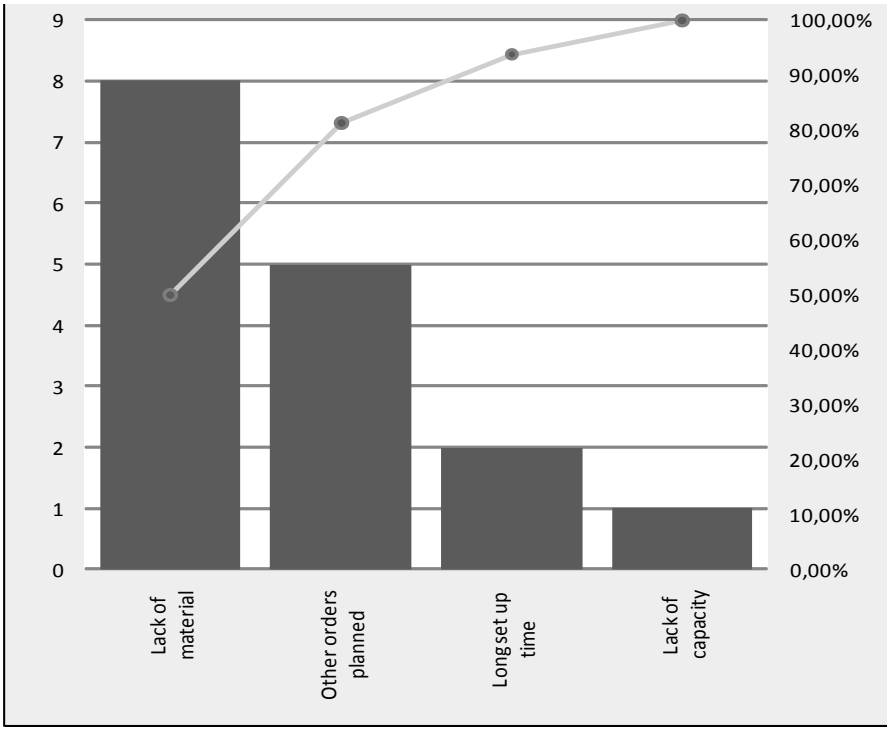

Figure 24. Example of Pareto chart.

vii. After choosing a specific cause, this is now the focal problem of another cause-and-effect diagram, as exemplified in Figure 25. By performing this diagram, the resolution of the problem will gain greater detail and what will be the necessary solutions will consequently become clearer.

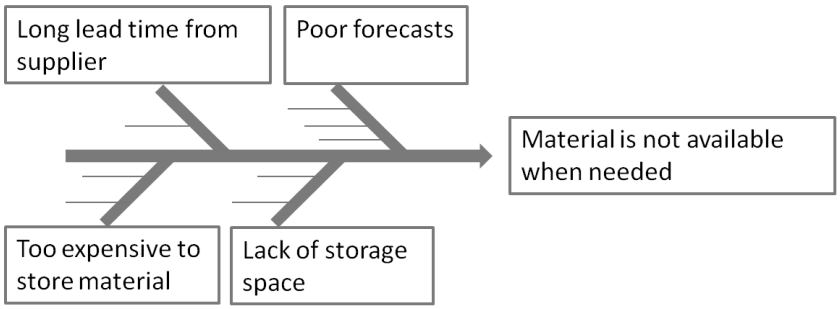

Figure 25. Example of a cause-and-effect diagram.

viii. Again collecting and compiling data into a Pareto chart should be performed to verify the assumptions made in the cause and effect diagram. See Figure 26 for an example.

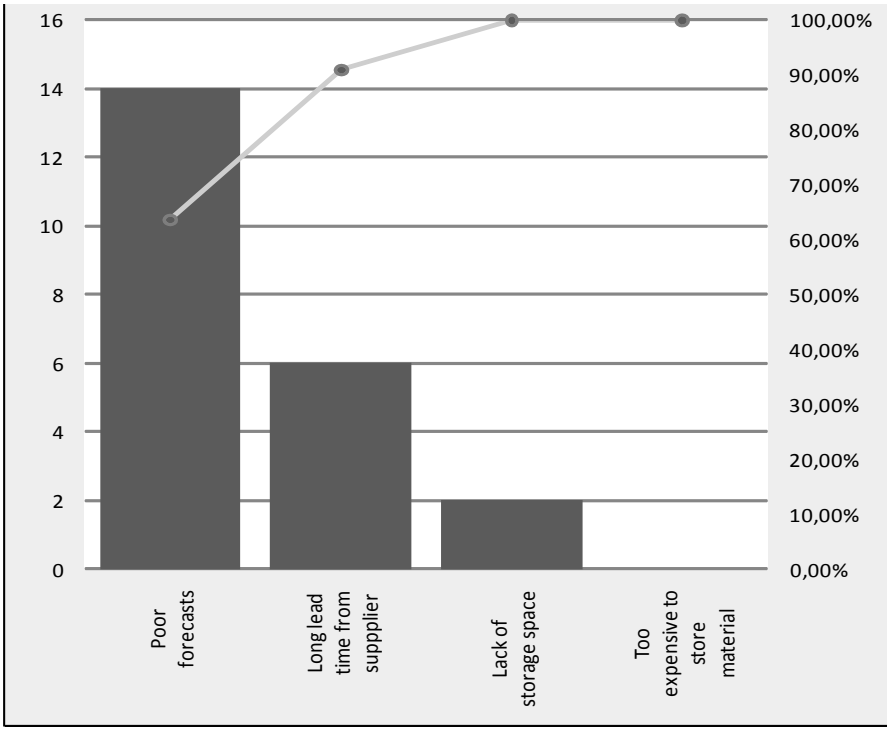

Figure 26. Example of Pareto chart.

ix. The final task of the *Plan* step is to form solutions to solve the problem and choose which ones to implement; these will be given by the last cause-and-effect diagram (Bergman & Klefsjö, 2010). Deciding upon which solutions to implement may be a crucial one as MHC might prefer a solution that the supplier disapproves. This could be for a number of reasons; one being that the solution does not contribute any winnings for the supplier or even impedes the supplier's possibility of serving other customers. In the case of MHC having a power advantage in the relationship, this can be used to force the supplier to accept a solution; however as presented by Gadde et al. (2010) this could have a destructive effect for the business relation and therefore should be avoided. Consequently, a cooperative spirit is the preferable route to take in deciding upon which solutions to implement.

i. The second step of the PDSA cycle, *Do*, comprehends implementing the chosen solutions (Bergman & Klefsjö, 2010). As mentioned in chapter 3.1, having decided upon solutions jointly may not be sufficient if the top management of the supplier not have been embraced in the decision making. Therefore securing top management's approval is important to retrieve in the previous step, i.e. choosing solution.

i. The third step of the PDSA cycle, *Study*, is conducted in order to make sure that the implemented solutions have had the expected effect (Bergman & Klefsjö, 2010). Once again the Pareto chart is useful to illustrate if the occurrence of causes have decreased after the solutions have been implemented. When one is convinced that a new higher quality level has been achieved it is important to continuously control so that it is maintained (Bergman & Klefsjö, 2010); for which a control chart is a suitable tool. For improvement efforts dealing with lead times, the process quality indicator (PQI) to be used in the control chart can be the lead time for a specific activity, as exemplified in Figure 27. The actor that should be responsible for the control chart should naturally be the one who is responsible for the activity.

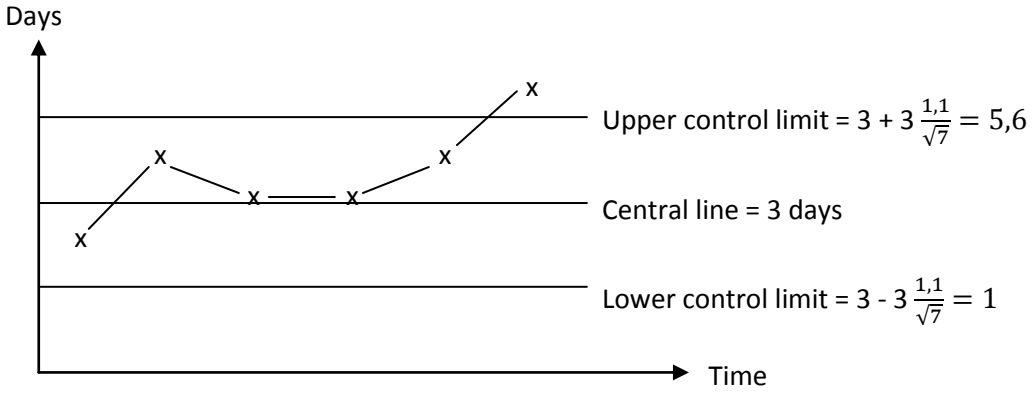

Figure 27. Example of control chart.

i. The fourth step of the PDSA cycle, *Act*, deals with improving the improvement process itself (Bergman & Klefsjö, 2010) and should by that benefit from input from both MHC and the supplier. This step also comprehends implementing the solutions to be found effective, on a wider set of activities if applicable. This means that MHC might be able to provide effective solutions to a wide range of suppliers without having to perform the entire PDSA cycle for the same problem over again. It also means that if the supplier has derived a generic quality improvement it can benefit the company in additional customer relations.

5.3 What to consider in inter-firm efforts

The factors affecting a make or buy decision presented by Jennings (1997) clarifies the choice made by MHC to source various materials from suppliers. As MHC not uncommonly needs small quantities in relation to the supplier's total production volumes and economies of scale are present, the capability dimension as well as the cost dimension point in the direction that sourcing material is the most valid alternative. Hence, solving the issue of long lead times by in-sourcing is in most cases not conceivable.

Following outsourcing of material, the issue of long lead times becomes more apparent, as outsourced material is more prone to be subjected to long lead times as the supply chain may increase in length and in width according to Lambert and Cooper (2000). This is also the situation for MHC that has suppliers spread world-wide, leading to extensive and complex distribution networks. The company's distribution network is therefore prone to have long lead times, and given the many drawbacks resulting from long lead times that are presented by literature and the empirical data, these are an issue that needs to be addressed. As lead times are affected by both MHC, suppliers and the interface the companies in between, efforts should be performed in cooperation to increase the possibilities for effective and efficient improvement efforts according to, among others, Cousins and Spekman (2003).

As presented by Luo (2002), good inter-firm relations are a prerequisite for inter-organisational efforts, which are dependent on for instance trust, commitment and how conflicts are handled, according to Gadde et al. (2010). This calls for a more extensive analysis of, firstly, which suppliers MHC should approach for joint efforts, secondly, what aspects that affect the possibility for MHC to initiate joint improvement efforts, and thirdly, what aspects that are important to consider in such efforts to provide a successful outcome. These concerns are analysed in the following chapters.

5.3.1 Choosing suppliers

A starting point for choosing suppliers for joint efforts will be one which considers the financial leverage on the resources that needs to be invested. This comprehends estimations of how much the safety stock level may be decreased, which would render a decrease in tied-up capital, needed storage space and obsolescence. What was discovered during these interviews is that the safety stock level is not driven by lead time alone; it is therefore imperative to investigate the specific influence of lead time case by case, in order to not end up with an over-optimistic calculation. In addition to cost savings related to the safety stock, there are also a number of potential savings that are harder to estimate, such as less effort spent on rush orders, stock-outs and re-planning manufacturing operations. The value of decreasing lead times can also be estimated in the views of decreasing the risk in the supply chain or the value of increasing the flexibility of the same. The idea with calculating savings at this stage is to get a rough estimation of the potential savings to judge whether or not launching an improvement effort will be financially beneficial. A calculation format, as presented in Appendix 3, does therefore only consider the financial effects that are somewhat straightforward to estimate, making the format user friendly, while still providing a good enough cost-benefit analysis.

In conjunction, as stressed by Vargas-Hernandéz and Noruzi (2009), the supplier's approach to conflict and cooperation should be appraised since it will have a significant effect on how conflicts, which will most certainly appear, are handled. This is thus important to consider as it will have

significant effect on the success of the joint improvement effort. By utilising the scoreboard presented by Trompenaars and Prud'Homme (2004) the supplier's attitude can be assessed. By relating this result to the relationship characteristic matrix Figure 14 presented by Gadde et al. (2010), the potential of joint efforts may be evaluated. Preferably a behaviour indicating possibilities to end up in the right hand upper corner, which provides an environment signified by creativity. The progressive efforts that are claimed to be achieved in this type of relationship require that also MHC qualifies for such behaviour. As perceived during the interviews with MHC personnel, the level of conflict is to be kept to a minimum as great respect is paid to honouring co-workers as well as suppliers. This provides many possibilities as positive emotions provides a trustworthy behaviour as pointed out by Jones and George (1998), but at the same time inhibits the company from reaching the progressive state that signifies the creativity quadrant of the relationship matrix. To conclude, with respect to the relationship characteristics matrix, the most important thing is to secure that the supplier's characteristics won't lead to a hostile relationship as this may not only deteriorate the joint improvement effort but also the relationship itself.

In addition, as came out during the Autoliv interview, a joint improvement effort will be easier to manage and less resource demanding if the supplier is used to working with improvements in a structured way, hence such a supplier is preferable to choose. On the other hand, a supplier that has no extensive experience of improvement efforts may have a lot of improvement potential and by that provide significant efficiency gains without a great amount of resources invested.

5.3.2 Initiating joint efforts

To be able to conduct joint improvement efforts, the supplier obviously needs to be interested in such efforts. There are several aspects affecting this interest, firstly it is important to have the supplier's top management commitment, which was greatly emphasised by Autoliv. Without top management commitment it will be hard for personnel further down the rack to accept and prioritise a joint improvement effort. During interviews with MHC personnel a scenario worse than top management not giving consent to a joint effort would be if a joint improvement effort is accepted and initiated by supplier employees with sufficient power to do so, but without the power to implement changes. The risk is that the joint effort will come to an abrupt end if top management declines implementation of needed changes, resulting in resources put in, but without reaping the benefits thereof. Hence, top management commitment is important to secure, both to be able to initiate a joint improvement effort, but also to secure the forthcoming implementation of changes that are necessary in order to reach the benefits of the effort.

According to Autoliv, top management commitment is enhanced by a cost-benefit analysis showing financial winnings for the supplier; also ideas from an important customer will receive higher attention from top management than from less important ones. One of the suppliers also pointed out that potential revenue increase also worked as an incentive to engage interest in joint efforts. In addition, as brought forward by Autoliv it is easier to attract the interest from top management if one can provide examples of successful joint efforts. The company also points out the value of the supplier having a positive approach to change for improvement. Top management commitment is thus influenced in several aspects, which provides the possibility to establish commitment in various ways. The identified aspects, i.e. cost-benefit, power, showing good examples and approach to change, are further elaborated on in the following chapters.

5.3.2.1 Cost-benefit

An aspect influencing top management commitment is that it is of great importance to be able to present a favourable cost-benefit analysis of an improvement effort. The reasons for the long lead times of course affect the magnitude of demanded investments, e.g. it may be less resource demanding to improve an ordering process than to improve set up times in process industry. Nevertheless a customer contributing a significant amount of revenue will have higher volumes to distribute invested efforts to and by that making a joint improvement effort with such a customer likely to be more profitable than with a smaller customer. This relation between contributed revenue and profitability of a joint effort is an issue for MHC, as the company is a relatively small customer to many of the suppliers, according to MHC personnel. This means that MHC will have to find alternative measures to financially motivate the supplier.

Firstly, as mentioned in the Autoliv interview, a joint improvement effort commonly leads to generic improvements that can be utilised in the supplier's other business relationships. This means that solutions generated in a MHC initiated effort can be applicable to a wider customer base and by that gain increased leverage on invested resources. Generic improvements typically relate to process improvements of order handling, manufacturing and material handling.

Secondly, as pointed out by MHC personnel there are some suppliers that have a consignment stock with MHC; these suppliers may be easier to motivate into shortening lead times as the cash flow of these companies are directly related to lead time. On the other hand, MHC will likely not perceive lead times to be an issue when using such an arrangement, although MHC indirectly pays the costs for long lead times in the consignment stock fee.

Thirdly, one of the interviewed MHC suppliers considers the future potential revenue as one parameter when choosing which customers to engage in joint improvement efforts. The supplier can thus see a joint effort as a more long-term investment in the business relationship, and by that showing commitment to the same. This approach will increase trust in the relation according to e.g. Morgan and Hunt (1994), which is beneficial for a number of reasons. For instance trust is important for building strategic alliances (Zaheer et al., 1998) and is positively related to performance (e.g. Luo, 2002). The supplier's intention in showing this kind of commitment to a presently small customer is to be provided increased sales volume. Since the Surgical division of MHC has not extensive volume growth to distribute directly, volumes need to be shifted around suppliers in order to meet the expectations from suppliers reasoning as described here.

Intimately linked to calculating the financial benefits of a joint improvement effort is how the winnings should be distributed between the parties. This should be decided upon and clearly stated in this initial phase; if postponed, there is a risk that the party that have made investments increases its resource dependency and by that decreases its bargaining power relative the other party (Argyres & Liebeskind, 1999). If the party with the power advantage abuses this, the business relationship will be subjected to distrust (e.g. Dyer & Chu, 2011) and conflict will arise (Rokkan & Haugland, 2002). This will harm the relationship and not only inflict on the possibilities for future joint efforts but on the relationship in whole (e.g. Gadde et al., 2010; Trompenaars & Prud'Homme, 2004). Autoliv deals with the issue of benefit sharing by stating that the company will only claim the expected yearly negotiated price reductions, even though improvements may be significant, for instance due to being generic and by that benefit the supplier's other businesses and customers. Autoliv however beliefs

that the chosen approach shows a trustworthy behaviour that, together with strong performing suppliers, benefits the company in the long run, a belief that also is supported by e.g. Morgan and Hunt (1994). Hence, clear rules for benefit sharing should be decided upon early on in the process to establish trust which increases the supplier's willingness to commit to inter-firm process development efforts. These rules could be stated in contracts (Argyres & Liebeskind, 1999) or orally if a trusting relationship is at hand (Blomqvist, Hurmelinna & Seppänen, 2005). Choosing the latter poses a risk (e.g. Bachmann & Inkpen, 2011), but showing mutual trust at the same time provides many benefits as presented by e.g. Zaheer et al. (1998) and ultimately results in competitive advantage (Dyer & Chu, 2011).

5.3.2.2 Power

Another aspect influencing top management commitment is that of the relative power between the customer and the supplier; Autoliv claims that this power relation does not affect the interest from the supplier to engage in joint efforts. However, resource dependence and the power generated thereof means that a powerful customer has the ability to influence the supplier's decisions regarding such efforts, according to Lambert and Cooper (2000). It is thus useful for MHC to increase its power and decrease the power of the suppliers for increasing the possibilities of joint efforts, however as clearly noted in the previous chapter, applying power is a delicate task that requires discretion.

By using the list of factors presented in Table 1, one can quickly get a sense of what kind of power relation that characterises a specific business relation. Relating to the exchange power matrix (Figure 16) presented by Cox et al. (2001), MHC will benefit from power in the "buyer dominance" quadrant. This gives opportunities to exercise power on a supplier, however the incentive to use power for joint efforts in this situation likely is small, since joint efforts will bring the companies closer and move the business relation towards one signified by inter-dependence, thereby leading to a loss in power. In the "supplier dominance" quadrant MHC will have restricted possibility to attract the supplier's interest for joint efforts. The "inter-dependence" quadrant provides the strongest incentives for two firms to engage in joint efforts as the resource dependence is levelled between the parties. In conclusion, if a business relation is characterised by supplier dominance, MHC might need to take actions to increase power to attract the supplier's interest for joint efforts.

The foundation for power is elaborated on by Pfeffer and Salancik (2003), who claim that resource dependence is affected by resource importance, concentration of resource control and discretion over resources. This means that power for instance is generated by contributing with a relatively large share of a supplier's revenue, something that also is stated in Table 1. It also means that power is affected by controlling the resources (Brito, 2001), which not necessarily means possessing them (Pfeffer & Salancik, 2003). By developing strong social relationships with supplier's personnel and top management, interdependencies can be increased according to e.g. Low (1997), thus leading to an increased influence over the decisions taken by the supplier. This conclusion is also supported by Morgan and Hunt (1994), who state that commitment is an effect of trust, which is attained by, among other things, social interaction according to Dyer and Chu (2011).

The situation described above essentially deals with attaining and utilising power to influence a supplier's interest to engage in a joint effort, although not being totally convinced of the own benefits in doing so. This may hamper the actual commitment to such an effort, resulting in sub-

optimised solutions. Another way to utilise a power advantage, which is more progressive, is to secure goal alignment between the parties. This creates a profound base for cooperation as both parties benefit from the same solutions, since the agency problem as presented by Eisenhardt (1989) is mitigated. It is likely that goal alignment also is possible to achieve without having a power advantage; by developing a relation signified by solidarity and trustworthiness, Stephen and Coote (2007) claim that the possibilities for goal alignment increase. The latter point may be a crucial one for MHC, due to a common lack of power in business relations, as a result of suppliers not perceiving themselves to be resource dependent upon MHC.

The level of trustworthiness is affected by a number of aspects, for instance the ones brought forward by Bachmann and Inkpen (2011); inter-organisational trust at MHC is supported by comprehensive legal regulations characterising the healthcare industry and by a solid company reputation. It is also supported by a corporate culture emphasising to work in a constructive and cooperative spirit with suppliers. Inter-personal trust is also supported by this corporate culture as well as the company's professional code of conduct. It is also strengthened of that MHC personnel are aware of and knowledgeable about differences in national culture, due to the company's multi-cultural workforce. The final contribution to inter-personal trust is social interaction with supplier personnel, which in this case means top management; it is unclear whether the level of social interaction with this group is sufficient to generate trust. One way to increase the level of top management interaction would be to conduct a supplier event as Autoliv does, which provides opportunities to strengthen the ties with and between suppliers. To conclude, MHC states an overall trustworthy behaviour which provides possibilities for aligning goals with suppliers, even though a lack of power is present in a business relationship.

5.3.2.3 Showing good examples

Yet another aspect influencing top management commitment is the possibility to show examples of successful joint efforts; Autoliv claims that it is valuable to be able to show such examples to raise the interest of the supplier. As Autoliv has a supplier development program which aims at sharing the knowledge of working with Lean principles, the company's efforts takes a broad grip on the supplier's way of working in implementing the Lean philosophy. The lead time improvement efforts that this study is focused on have not got the same extensive impact on the supplier's organisation, however the utilisation of good examples is something worth considering even in less comprehensive efforts. As pointed out by Autoliv, the value of good examples is that they clearly illustrate the benefits that can be gained by engaging in a joint improvement effort and thereby also contribute in attaining top management commitment.

The examples that are used by Autoliv have been collected over several years, which also the knowledge and experience of joint efforts have. MHC has in relation to Autoliv likely more to learn in this respect and although some inter-firm improvement efforts have been conducted, MHC is in need of experience, both for conducting such efforts and for attaining good examples to show. The pilot projects that are planned to take place within the coming year can pose as examples, which make documentation and evaluation of these very important.

5.3.2.4 Approach to change

The final identified aspect influencing top management commitment is the supplier's approach to change. The experience of Autoliv is that having a power advantage the companies in between is not

the most important prerequisite for the possibility of initiating joint improvement efforts. It is rather a matter of the supplier's approach to change for improvement, which is supported also by the interviews conducted with MHC suppliers. This means that if a supplier works with improving processes etcetera, be it in a standardised and structured way or not, the corporate culture is one implying that such efforts are valued as beneficial and important. Hence a more open sighted view on changes for improvement is present and by that a positive attitude towards performing joint improvement efforts in general can be expected from such a supplier.

5.3.3 Conducting joint efforts

The two previous chapters deal with issues and aspects related to choosing appropriate suppliers and initiating joint improvement efforts; this chapter reviews relational issues and aspects to consider throughout the duration of such efforts. According to Trompenaars and Prud'Homme (2004) a cooperative spirit is essential in attaining creativity. This reasoning is supported by the relationship matrix (Figure 14) presented by Gadde et al. (2010), and attaining creativity is consequently related to how conflicts are handled. As illustrated by the matrix, conflicts need to be handled by cooperation, if not, a state of hostility will appear (Gadde, Håkansson, & Persson, 2010) and efficiency will be reduced (Vargas-Hernandéz & Noruzi, 2009). This is also supported by e.g. Hennet and Arda (2008) who claim that a self-interest seeking behaviour leads to an overall loss of efficiency. A creative environment is thus perceived to benefit efficiency.

Sources of conflict commonly relate to goal divergence, communication problems, disagreement over roles and differing perceptions of reality (Rosenbloom, 1999), which all can be related to and affected by both corporate (Vargas-Hernandéz & Noruzi, 2009) and national culture (Trompenaars & Prud'Homme, 2004). The many different sources of conflicts gives that they can take a number of forms and impact different functions, processes, relations etcetera. One way of interpreting the matrix (Figure 14) is that a project benefits from conflicts, as they are necessary to reach creativity. It is however conceived that the meaning of conflicts in this respect, first and foremost means conflicts resulting from different perceptions of reality, rather than conflicts due to communication problems, for example. That is, a project benefits from receiving input from people with different perspectives, since solutions will regard a wider range of aspects. To conclude, it is not likely that all types of conflicts have the ability to provide value and some types should therefore be avoided.

5.3.3.1 Creating a cooperative spirit and avoiding negative conflicts

As argued for above, a cooperative spirit needs to be developed in order to gain value from conflicts. According to Stephen and Coote (2007) strong relational bonds improve cooperation, which also trust and commitment does (Morgan & Hunt, 1994). The latter is supported by Bachmann and Inkpen (2011) who state that trust lets ideas be more easily developed and shared between parties. As social interaction affects the level of trust (e.g. Bachmann & Inkpen, 2011) is can be concluded that social interaction affects trust, which in turn leads to a cooperative spirit. Consequently, the participants of an inter-firm project should interact, not only on a business level, but also on a personal level, something that also was expressed by Volvo Powertrain.

Furthermore, to end up with a relationship signified by cooperation the concerned parties need to develop an awareness of each other's interests and needs (e.g. Nan, 2011). Morgan and Hunt (1994) complement this statement by claiming that trust is gained by sharing intelligence and expectations. It also gains from communicating timely, clearly and precise (Blomqvist & Ståhle, 2000). It can thus

be concluded that effective communication builds trust, which in turn generate a cooperative spirit. In addition, communication problems are one of the sources of conflict that is presented by (Rosenbloom, 1999). Insufficient communication is also brought forward by e.g. Schein (2004) and Autoliv to be a source for problems. This further emphasises the importance of effective communication, as conflicts emerged from communication problems, such as misunderstandings, lack the ability of generating any value to an improvement project. Dissolving conflicts of this kind can be resource demanding and move focus away from the purpose of the project as well as consume energy of the involved participants. Effective communication can be reinforced by agreeing on what should be communicated, by whom and when. Also common definitions should be developed, as should quantitative measures of notions that generally are expressed qualitatively, such as “good quality” and “quick delivery”.

In addition to the elements of communication treated above, communication problems can be closely related to differences in culture as well (Vargas-Hernandez, 2009) as for instance body language (Schein, 2004) and behaviour (Vargas Hernandez, 2009) are different and differently interpreted. These differences cannot be avoided at this stage of the project and conflicts due to them can best be mitigated by being aware of and understanding the cultural differences (Schein, 2004). This can be achieved for instance by consulting bicultural competence (Lazear, 1999). This is a constructive way of dealing with cultural differences, which likely increases trust, as a lack of respect for the differences can lead to mistrust between partners according to Trompenaars and Prud’Homme (2004).

Altogether, trust is imperative to develop since it affects the prospect of cooperating. In addition to the elements of trust treated above, also aspects concerning inter-organisational and inter-personal trust are of importance. These have been treated above in the Power chapter and conclude that MHC states an overall trustworthy behaviour.

6. Discussion

Costs and problems with long lead times were presented in Chapter 1 together with the need for a structured way of reducing them. By analysing and combining relevant theory, company examples and MHC's pre-requisites, a framework for working with reducing lead times in collaboration with suppliers has emerged.

The framework developed can be broken down into three steps; choosing supplier, initiating effort and conducting effort. All steps are important but the most effort is placed on how to conduct the effort and it is based on the PDSA cycle.

6.1 Choose supplier

Choosing the correct supplier to work with when trying to reduce lead times is crucial and is divided into three steps. First, it is important to do and evaluate a cost-benefit analysis of the costs and benefits that MHC will get from conducting the project. Will the benefits of reducing the lead times compared to the costs of conducting the project? In order to calculate the monetary benefits from reduced lead time a simple calculation format, as in Appendix 3, can be used. This can be important in order to get internal commitment from top management at MHC.

Second, one needs to evaluate the suppliers approach to cooperation in the relationship with MHC. Is it a relationship based on trust and commitment or is information withheld? Here it is important to evaluate MHC's power position towards the supplier. This is usually based on the amount of purchased material compared to the suppliers total sales but it can also potential new contracts sales and the suppliers profit margins from the goods sold.

The last step to consider is suppliers approach to making performance improvements. If the supplier is continuously improving their own processes, it is more likely that they will be interested in conducting a joint project.

6.2 Initiate effort

In order to initiate the effort it is of most importance to get a good commitment from the supplier and especially from top management at the supplier. This is done by showing them the potential benefits that the supplier can gain by doing a joint project and how they can use the benefits gained.

MHC could also use their power position in the relationship and convince the supplier to engage in the contract. However, it is important to not abuse one's power position since it might impair the relationship and decrease future commitment from the supplier.

By presenting good examples MHC can further increase the commitment from the supplier. It is therefore important to track the benefits from previous projects in order to have them available when doing new projects. The good examples could also be examples from internal projects at MHC.

The supplier's approach towards change is an important aspect to consider. If the supplier in general is reluctant to make changes, there is a larger risk that the suggested changes will not be implemented and cause the project to fail.

6.3 Conduct Effort

Conducting the effort is based on the PDSA cycle and the first step is planning the project. Planning the project is the most emphasised step in this framework and is intended to be the base for the whole quality improvement effort.

6.3.1 Plan

The first step is to describe the problem. This would generally consists of that the lead times are too long but also contains the effects caused by the specific long lead time. With a defined problem description it is easier to have a common understanding of the problem.

By establishing and stating a performance gap between the current lead time and the demanded lead time, several benefits can be gained. It creates a common understanding from both MHC and the supplier for the magnitude of the project and also sets the standard for the size of the project. A project aimed to cut the lead time in half would probably require greater efforts than a project aimed to decrease the lead times with ten percent.

The defined problem needs to be divided into smaller problems in order to make it more manageable. By conducting a VSM of the activities involved one is better able to identify which parts of the replenishment process that drives the lead time. These activities should then be mapped in a Pareto chart in order to choose the activity, or activities, with the largest potential. One could continue to make another more detailed VSM of the selected activity in order to divide it further and also make another Pareto chart with the new activities from the new VSM. This is an iterative process and should be conducted until the activities are sufficiently manageable.

After choosing activities it is important to find the root causes driving the lead times. This should be done by using a cause-and-effect diagram. The cause-and-effect diagram should be done in a group and the group should be formed depending on which activities that have been chosen. With defined root causes one should create qualitative measurements to track them. This should then be tracked for a sufficient duration of time and result in information regarding which root causes that influence the problem the most. Putting the measured information into a Pareto chart should help visualize it. One could consider making a new cause-and-effect diagram of the root causes in order to more easily get a clear picture of the effects causing it.

The last step in the planning phase is to choose a root cause and decide upon the changes needed to solve it. The supplier and MHC might disagree regarding which changes that should be implemented which could result in conflicts. MHC could use its positional power but this could be risky due to the long-term effects that it can cause on the relationship.

6.3.2 Do

The second step in the PDSA cycle is to implement the changes. This step requires commitment from the supplier and if the project was started with a low level of commitment from the supplier there is a risk that the implementations will be rejected by the supplier. The supplier might also be more reluctant to make the changes based on their views on change management.

6.3.3 Study

With the changes implemented it is important to measure the effects of the changes. A control chart should be used to monitor the shortened lead time in order to measure the success of the project.

One could also measure the effects of shortened lead time such as fewer rush orders and smaller safety stock to find the monetary effects.

6.3.4 Act

In addition to using the information to trigger commitment one should also use it to improve the project process. MHC should evaluate each project and develop the processes in order to improve the process of reducing lead times together with their suppliers. This is an important part that should be improved in order to make even more successful projects in the future. Furthermore, this step will be important for MHC to perform for the planned pilot projects in order to attain good examples to show suppliers.

7. Conclusions

Improving performance, such as decreasing lead time, in a collaborative spirit in between actors will benefit from having a framework as the one here presented. The framework not only provides a systematic way of improving performance, but also emphasise the consequences that follows from conducting efforts of this kind across company borders. More specifically, performance is to be improved by attending to problems affecting quality dimensions, such as lead time, and should be solved by identifying and eliminating the root causes of problems. Furthermore, the success of inter-firm efforts relies heavily on relational aspects such as trust and commitment. These are of course also important when conducting a similar effort within one company, but different perceptions and behaviours will be more noticeable, for instance due to misaligned goals and differences in corporate culture. It is therefore of great importance that everyone engaged, i.e. personnel at both the customer and the supplier, are aware of and accept for instance cultural differences and the possibilities and drawbacks these generate, in order to handle conflicts in a cooperative spirit.

For MHC, the framework provides a process that complements the already established processes and contributes with widening the scope of the company's efforts to include a greater part of the supply chain. By that, the possibility of attending to issues with a total cost approach is significantly improved. A result of the findings is that MHC carefully has to consider which suppliers that are chosen to engage in joint improvement efforts; although a supplier initially has a positive attitude, relational aspects will have considerable effect on the success of the effort. Therefore attention has to be paid to, for instance the supplier's approach to handle conflicts and how reliable the supplier is in committing to agreements. Closely related to choosing an appropriate supplier is of course also attracting the interest of the supplier. As MHC not uncommonly is a small customer there is likely low financial leverage for the supplier to reap directly from MHC's purchasing volumes. Therefore attention has to be paid to in which ways the supplier's interest can be affected, making for instance social relations valuable to develop and the ability to provide examples of generic improvements necessary to retrieve. In the cases where MHC although enjoys a high level of power to influence the supplier's decision, the findings of the paper show that it is important to not force the supplier into an engagement by abusing this power. Rather a more constructive approach should be sought for, since the success of the project relies on genuine interest and commitment from both parties.

It is clear that long lead times generate costs, for instance as a consequence of greater forecast errors which causes the necessity for higher safety stocks and an increase of rush orders. The issue boils down to not being able to swiftly follow customer demand, which at times will render too low stock levels and lost sales as well as too high stock levels and obsolete material, tied-up capital and warehouse space. The cost parameters so far noticed here can be quantified with relative ease compared to the value of for instance increased flexibility and product updates reaching the market faster. It can be concluded that the value of decreasing lead times hence is greater for products with high fluctuation in demand. The calculation format provided in Appendix 3 is an easy to use tool that MHC can use for visualising the financial benefits of decreasing lead times.

Companies' increased focus on core competence has caused greater dependence on suppliers, which has rendered the supply chain to be the competitive entity, rather than the individual companies thereof. The competitiveness of the supply chain hence depends on the actor's ability to cooperate and jointly drive performance improvement efforts. In addition, supply networks are spread worldwide, making communication harder, which in combination with corporate and national culture

differences, increases the risk of misunderstandings. It has therefore been valuable to investigate which implications that relational aspects can have on inter-firm improvement efforts. Furthermore, the study provides insights to what aspects to consider in choosing suppliers and what aspects that affect the success of the initiation and performance of such efforts. These insights are valuable since being aware of and considering them will increase the possibility of efforts being successful.

As mentioned, companies should cooperate across supply chains in order to improve performance and maintain competitiveness. Therefore it would be valuable with research examining what aspects that a supplier selection process should incorporate in order to Increase the likelihood of long-term successful business relations. For instance if aspects, such as corporate culture, that affect relational dimensions should be incorporated. If they should, it would also be beneficial to bring clarity to which aspects that are most important to consider. In conjunction, it would also be of interest to establish if the degree of importance varies depending on what type of joint effort that is at hand, e.g. product development or process development. If a need is identified it would apparently also be of great value to develop a model to use for assessing such aspects. Another possible area for further research that relates to a supplier selection process is whether it is more valuable to take on a supplier that works with improvements continuous than one who does not.

Closely related to the relational aspects is the issue of misaligned goals; although the actors in a supply chain need to cooperate, they are still separate entities with self-interests to fulfil. This affects the acceptance and implementation of solutions, thus making goal alignment a very important and presumably challenging issue to alleviate. Therefore conducting further research on goal alignment through contract design or other measure has the potential to be beneficial for a wide corporate audience.

Furthermore, the issue of inter-firm transparency could be further investigated. For instance what benefits and drawbacks that comes with transparency and how it can be attained. It would seem likely that transparency is closely related to sharing information across company borders, orally as well as in script. With this comes the interesting issue of how such information flows should be managed in order to be effective and efficient while still paying attention to politically sensitive issues such as ownership.

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Appendix 1 – Interviews

This appendix contains all relevant and available information regarding the interviews and interviewees. Not all interviews were conducted with a template and thus a template cannot be provided from these interviews.

List of interviewees

This is a list of all interviewees excluding the interviewees with the suppliers. These are not presented due to confidentiality.

Personal at MHC

Ann-Christine Strigén, Raw Material Procurement Director Surgical, Goteborg

Christian Sievert, Global Service Director, Goteborg

Dan Pavlicek, Component planner, Karvina

Daniel Malm, Supply Chain Director - Planning, Goteborg

David Pavlicek, Material Planning Team Leader, Karvina

Katerina Tomaskova, Purchasing Manager,Karvina

Paul Bakker, Procurement Director Components, Manchester

Petra Andersson, Strategic Commodity Manager, Goteborg

Staffan Bröte, Value Stream Director, Goteborg

Sven Nilsson, Project Manager, Goteborg

Thomas Pettersson, Senior Supplier Quality Assurance Engineer, Goteborg

Personal at interviewed companies

Andres Laas, APS Engineer, Autoliv (Together with a group from different divisions)

Jenny Lilliehöök, Purchasing Manager, Volvo Powertrain

Per Siesing, Director of Supply Chain, Flexlink

Peter Lindvist, Corporate Development, Flexlink

Academics

Anna Dubois, Professor at the institution of Industrial Marketing at Chalmers University of Technology

Interview Templates

The interviews were semi-structured and the interview templates were only a guide for the discussions. Not all interviews were done with a template so templates are only available for these interviews.

Interview template – Suppliers

The goal with the interview is to find out how Mölnlycke Health Care (MHC) can reduce lead time in collaboration with you as a supplier.

Company introduction

What characterizes the operations of your company? High tech, process / labour intensive, high product variety, etc.?

    - Slitting, perforating
- What products are you selling to MHC?
    - How long lead time do you promise for those items?
    - What does the lead time consist of? Generally…
- Where are your factories located?

Change management

Do you have any processes regarding change management? Do you keep track of them and how many have you done recently?

- How do you work with performance improvements?
        - KPIs
- How do you feel about joint (with customers) lead time reduction projects?
    - Have you done any before? If so, how did it go? Why did it go so?
    - What would trigger your interest for such a project?
- What KPI:s do you have on the customer side of your firm?
    - What are your target KPI levels?
    - How do you work with improving your KPI:s?
    - Claims, number of sq meters, produce, customer satisfaction

Lead times

- What requests does MHC have on lead times?
    - Have you been able to meet these requirements?
    - What affects the possibilities to meet their requirements? Other customers, production process, MHC demands etc…
    - How are MHC requirements in comparison to other customers?

- What affects the possibilities to improve the lead times?
    - What information from MHC could help you shorten the lead times?
    - Can you keep extra stock of MHC goods? Would that decrease lead times? Would it affect prices? Would it take commitments from MHC?
        - Finished goods?
        - Raw material?

    - Can you see any benefits in reducing the lead times to your customers?

- Do you get forecasts?
    - How do you manage them?
    - Would you want anything to change there?
- How close do you work with the planning department?

Operations and planning

- Do you need to send back orders to MHC often? Wrong specifications etc.
- Do you have an automatic system for transferring orders or do you do it manually?
- Are resources booked in your system as soon as the order is confirmed? Why/why not?
- Do you check the raw material manually?
- How is your planning linked to MHC's planning?
- How often do you feel you get emergency orders?
- Do you see any weaknesses in the cooperation?

Interview template – MHC Planners

The goal with the interview is to understand the material planners' role.

Planner's role

- What does your work consist of and what are your responsibilities? (planning, ordering etc.)
    - What authorities do you have; what can you affect?
- Can you describe your supplier portfolio?
    - Good suppliers?
    - Bad suppliers?
- Which KPIs are the planner measured on?
- What are your biggest issues? (related to material planning, acquisition etc.)
    - What consequences do they have?
    - How could they be resolved?
- How often do you place orders to suppliers?
- How does your relation to the supplier look like? (frequency, depth, collaboration on problem solving etc.)
- How do the attributes of the relation affect solving issues related to the supplier?
- Would you change anything in your role that could help improve lead times? (New responsibilities etc.)
- When do you contact your suppliers? Only when there are problems?
- How is the forecast data quality MHC? Do you feel that the sales persons (at MHC) understand your position?
- Do you get support from the lead buyer when there are problems?
- How accurate do you feel the forecasts are?

Lead time

- How does the length of these affect your work?
- What are, according to you, the largest consequences of long lead times?
- How could you as a planner support and contribute to the progress of a lead time project?

- Have you been part of projects that aim to reduce lead time?

Overall

- Which activities/processes do you see as possible to change in order to shorten lead times? (both at the supplier and at MHC)
- How large amount of your work is manual and how much is automatic?
    - Do you double check the automatic orders?

Interview template – External companies

- Presentation of our thesis
- The goal with the interview is to find out how your company work with process improvements together with your suppliers

The company's pre requisites

- The customer's expectations (quality, time, price – which has the highest priority?)
- Demand pattern (fluctuating?)
- Geographic placement of suppliers
- Lead time from suppliers

Process improvements

- How do you generally work with improving processes? Is the way of work standardized?

Lead time reduction

- What priority does this have for your company?
- Who (purchasing, supply chain etc.) is responsible for decreasing lead times?
- In which phase (product development, choosing suppliers, contract negotiations, improvement projects for current products) do you see the most potential and where do you put in the most effort? Why?
- Which activities do you focus on when conducting lead time reduction projects? How are they prioritized?

Supplier relations

- How is the relationship maintained?
- Which contact areas are there between you and the supplier (Purchasing, R&D, quality etc.)?
    - What frequency and depth (e-mail, meetings etc.) do these relations have?
    - Are there any standardized agendas? What is brought up and why?
    - Is this adapted depending on how the relationship is categorized?
- Power balance in the relationship?

➔ How do these bullets affect the possibility for conducting lead time reduction projects?

Performance improvements

- How do you work together with the supplier in order to improve performance (lead times, stock levels, etc.)?
- Have you conducted any joint improvement projects?
    - Reactive or proactive?
    - Who's initiative?
    - Workflow?

Contracts

- How much emphasis is placed on lead time when designing contracts?

Measurements

- Which KPI's are used to measure supplier performance? Why these?
- How is target levels set for lead times (or other KPI's)?
- How do you measure and follow up actual performance?
- Would it be beneficial with more KPI's? Which?

Appendix 2 – Values for control chart

Sample size *n*	c_4	d_2
2	0,7979	1,128
3	0,8862	1,693
4	0,9213	2,059
5	0,9400	2,326
6	0,9515	2,534
7	0,9594	2,704
8	0,9650	2,847
9	0,9693	2,970
10	0,9727	3,078
11	0,9754	3,173
12	0,9776	3,258
13	0,9794	3,336
14	0,9810	3,407
15	0,9823	3,472
16	0,9835	3,532
17	0,9845	3,588
18	0,9854	3,640
19	0,9862	3,689
20	0,9869	3,735
21	0,9876	3,778
22	0,9882	3,819
23	0,9887	3,858
24	0,9892	3,895
25	0,9886	3,931

Appendix 3 – Calculation format

PRESENT STATE

Safety stock	
Capital cost	
Product value per unit	€ 10,00
Number of units in stock	5 000
Amount of tied up capital	**€ 50 000,00**
Days in stock	30
Interest rate	14,00%
Annual capital cost for tied-up capital	**€ 575,34**
Warehouse space cost	
Number of product units in stock	5000
Product units per warehouse space unit	100
Cost per warehouse space unit	€ 100,00
Annual cost for warehouse space	**€ 5 000,00**
Cost for obsolescence	
Product value per unit	€ 10,00
Amount of obsolete product units	50
Annual cost for obsolescence	**€ 500,00**
Cost for damaged goods	
Product value per unit	€ 10,00
Amount of scrapped product units	5
Annual cost for obsolescence	**€ 50,00**
Total annual cost related to safety stock	**€ 6 125,34**
Rush orders	
Shipping cost per rush order	€ 150,00
Man time per rush order	2
Cost per man time	€ 60,00
Cost per rush order	**€ 270,00**
Amount of rush orders	5
Annual cost for rush orders	**€ 1 350,00**
Manufacturing and operations planning	
Man time per re-planning	8
Cost per man time	€ 60,00
Cost per rush order	**€ 480,00**
Amount of re-plannings	5
Annual cost for re-planning	**€ 2 400,00**
Lost sales	
Sales value per product unit	€ 15,00
Amount of items out-of stock	100
Annual cost for re-planning	**€ 1 500,00**
Total annual cost	**€ 11 375,34**

FUTURE STATE

Safety stock	
Capital cost	
Product value per unit	€ 10,00
Number of units in stock	3 000
Amount of tied up capital	**€ 30 000,00**
Days in stock	30
Interest rate	14,00%
Annual capital cost for tied-up capital	**€ 345,21**
Warehouse space cost	
Number of product units in stock	3000
Product units per warehouse space unit	100
Cost per warehouse space unit	€ 100,00
Annual cost for warehouse space	**€ 3 000,00**
Cost for obsolescence	
Product value per unit	€ 10,00
Amount of obsolete product units	50
Annual cost for obsolescence	**€ 500,00**
Cost for damaged goods	
Product value per unit	€ 10,00
Amount of scrapped product units	5
Annual cost for obsolescence	**€ 50,00**
Total annual cost related to safety stock	**€ 3 895,21**
Rush orders	
Shipping cost per rush order	€ 150,00
Man time per rush order	2
Cost per man time	€ 60,00
Cost per rush order	**€ 270,00**
Amount of rush orders	5
Annual cost for rush orders	**€ 1 350,00**
Manufacturing and operations planning	
Man time per re-planning	8
Cost per man time	€ 60,00
Cost per rush order	**€ 480,00**
Amount of re-plannings	5
Annual cost for re-planning	**€ 2 400,00**
Lost sales	
Sales value per product unit	€ 15,00
Amount of items out-of stock	100
Annual cost for re-planning	**€ 1 500,00**
Total annual cost	**€ 9 145,21**

ANNUAL SAVINGS

Safety stock	
Capital cost	
Decreased tied up capital	€ 20 000,00
Decreased cost for tied up capital	€ 230,14
Warehouse space cost	
Decreased warehouse space	€ 2 000,00
Cost for obsolescence	
Decreased obsolescence	€ 0,00
Cost for damaged goods	
Decreased amount of damaged goods	€ 0,00
Total annual savings related to safety stock	**€ 2 230,14**
Rush orders	
Total annual savings related to safety stock	**€ 0,00**
Manufacturing and operations planning	
Total annual savings related to safety stock	**€ 0,00**
Lost sales	
Total annual savings related to safety stock	**€ 0,00**
Decreased tied up capital	**€ 20 000,00**
Total annual savings	**€ 2 230,14**