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Supply Management

SUPPLIER DELIVERY QUALITY EVALUATION IN MAINTENANCE SUPPORTING SPARE PART BUSINESS

Miika Kiiski

0372676

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LIST OF ABBREVIATIONS

ARP	Age Replacement Policy
BRP	Block Replacement Policy
EVA	Economic Value Added

JIT	Just in time
SCM	Supply Chain Management
SMO	Supplier Management Orientation
TQM	Total Quality Management

1 INTRODUCTION

In many occasions, a modern technical product is a combination of the physical product and service attached to it. In the technical maintenance business this means that every part of every product should be kept in good condition and all the needed components should be at hand when needed. The scope should therefore be also in the quality of spare parts, especially, when considering businesses providing products that could have catastrophic or even fatal outcomes during malfunction situations. In order to lower costs and concentrate on a company's key products and services, outsourcing is required in today's global competitive business environment. The requirement for external parts and products create need for purchasing activities and supply chain management. As Hardt et al. (2007) describe so well the force of purchasing actions by pointing out that the value of purchased goods can be up to 70 percent of company's total costs. (Hardt et al. 2007:1) This indicates also that the supplier quality issues should be met with great importance in order to lower the costs, meet the customer requirements, decrease the risks, and as a consequence of these: all of the previous, run a successful business.

The purchasing process, and therefore the linking part between supply chain tiers, is an essential part of successful supply chain, and there are high requirements that it needs to fulfill. Specific standards have to be met, and the additional ones are required in order to maintain low costs and a good level of service. The objective of this thesis is to consider the purchasing process and the incoming delivery process, and the quality issues involved in this transaction. Therefore, the supply chain and quality issues in this transaction should be identified and defined before moving to the empirical study on supplier delivery process and the quality issues related to it. Through the utilization of statistical analysis, the most common quality issues, and the quality issues imposing the largest effect on the purchasing organization's own performance, could be identified and corrective actions taken. This performance is studied in this thesis from the standpoint in which the deliveries are received in the purchasing organizations' warehouse. However, the empirical part of the present thesis does not cover the purchasing for manufacturing. Because the manufacturing quality issues are commonly considered in previous studies (for example Choi 1999) the theoretical considerations about purchasing for manufacturing are also kept in consideration

in order to define the concepts of supply chain quality management. In addition to this, in the survey performed by Foster (2008), only key variable introduced that is related to the perspective of present thesis, was supplier relations. Lin et al (2005) on the contrary considered process quality as a part of their survey on supply chain quality management. In addition, Prajogo et al. (2012) take supply chain process in their research perspective as a part of their research considering the implementation of ISO 9000 quality certificate. In their journal publication Seth et al (2006) performed a research concerning service quality in supply chain. Their perspective to the supply chain quality management was to depict the issue from the 3rd party logistics provider perspective.

The focus of the present thesis is the issues related to the operational purchasing level supply chain process. Due to this limitation, the physical product quality issues do not belong to the primary concerns of this thesis, whereas the bilateral processes between the supplier and the purchasing organizations are of interest. Also, the issues related to the delivery timing are excluded from the study. Because the perspective is on the issues involved in the supply chain operations, the bilateral communication issues between supplier representative and purchaser are also considered. Although quality issues in supply chain have been considered extensively in the past, previous research considering supplier and distribution quality from delivery point of view was not found and therefore implications of the results cannot be compared or generalization to the theory could not be made in this thesis.

1.1 Conceptual framework and research questions

In the center of the issues related to the supply chain quality is the wideness of the actual definition of 'supply chain'. Therefore, the levels of supply chain and their quality defect engaging points are considered first. This is the first part of the conceptual framework of this thesis (See Figure 1) and when combined with the area of business of interest it leads to the first research question:

- What kind of supply chain does a technical maintenance and spare part business have?

After defining the concept of supply chain, quality and its measurement are considered. The effect of quality issues on the operational purchasing process can be identified as the second main research question:

- What are the main quality issues in processes in bilateral supply chain from distribution center point of view?

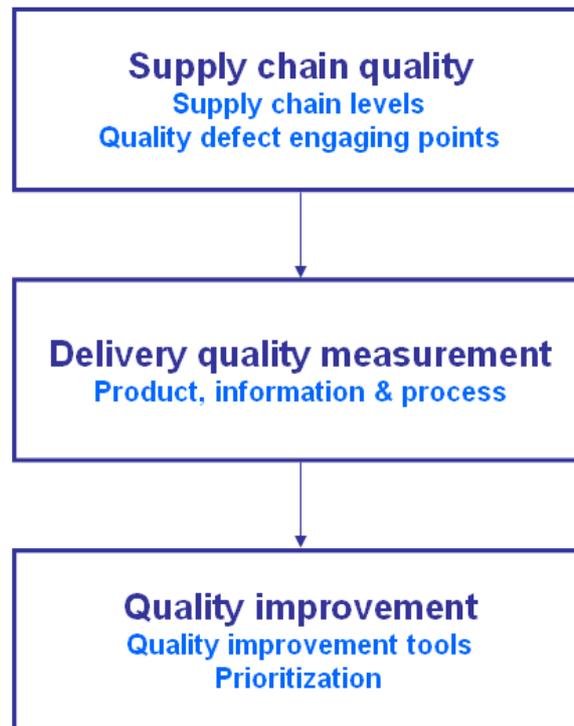


Figure 1. Conceptual framework of the thesis

As the second research question has its focus on the bilateral process, as the conceptual framework states, the measurements should involve, in addition to the obvious, the product, but also the information and the process quality. The measurement scope holds the key to the understanding of the quality in the bilateral communication of two tiers in a supply chain, and leads to constituting the third research question:

- What are the means of improving process quality from supplier to purchasing organization?

After specifying the third and final research question, it is obvious to state that the quality improvement actions should be prioritized and also the quality improvement

tools should be used to ensure the effectiveness and efficiency of the improvement actions.

1.2 Methodology and structure of the thesis

The present thesis is organized into various chapters. First, in the chapter two, the concepts of supply chain and the supply chain management are introduced. These perspectives are then expanded to the spare part business. In chapter three, theory about the supplier quality measuring and quality in supply chain are considered. After the introduction of the quality perspective to supply chain has been presented, certain quality improvement tools are briefly introduced. In the chapter four, a detailed empirical analysis of process quality issues in dyadic, supplier-to-warehouse, interface is performed, and the results from this analysis are introduced. The empirical part of this thesis is based on non-conformity error data collected during the year 2012 in one distribution center.

At first, ten non-conformity errors are gathered into four categories. Then prioritization is performed to decide categories for additional inquiry. After that, failure type categories with most delivery non-conformity errors are chosen to be considered in root cause analysis. The root cause analysis is performed by creating structural inquiries of the non-conformity error cases belonging to the chosen categories for purchasing professionals in order to discover the main reasons for the non-conformity errors. The results of the inquiries are then typified to more basic causes of the process quality issues by using cause-and-effects analysis. By using the results, efforts to describe, compare and explain the phenomenon is then performed (Hirsjärvi et al 2008: 130). In the case study at hand inquiry consisted of non-conformity error identification number, purchaser name, basic reason code, field for additional information, short problem specification, actions done by purchaser to solve the issue, the occurrence of the issue (re-occurring or one time failure), and purchaser's opinions about the cause of the issue and what could be the error preventative efforts to be done. On the basis of the cause-and-effects analysis, improvement actions are proposed. In the chapter five, conclusions drawn from the results are presented and suggestions for the future improvement projects are posed.

Because of the premise of the empirical case of the thesis, that was the observation of the need for improving the quality and therefore decreasing non-conformity errors in deliveries received from supplier, the way this research was done, was more of an induction than deduction, and no hypotheses were set in the beginning of the research. (Lee & Lings 2008: 7) The data had already been gathered during the year 2012 for the improvement purposes and the direction was rather from data to theory. (Eskola & Suoranta 1998: 19) In this research, the objective was to decrease the amount of operational and process related non-conformity errors in inbound operations of one distribution center. As a consequence of that, the research can also be categorized as case study and therefore the results will require additional research in order to achieve more general understanding of the phenomenon. (Eriksson & Kovalainen 2008:115)

2 SUPPLY CHAIN IN TECHNICAL MAINTENANCE BUSINESS

Purchasing is a part of an organization that links the upper tier in supply chain to the organization, thus the strategies and goals are derived from within the organization that it represents. The insight for these objectives can be attained from text books that specify and compile the objectives for purchasing. For example Smelzer and Siferd (1998) introduce main purchasing strategies by referring to Leenders and Fearon's (Leenders & Fearon, 1993) five major purchasing strategy categories:

1. Assurance of supply
2. Cost reduction
3. Supply support
4. Environmental change
5. Competitive edge

Because being an intermediary entity between the spare part manufacturer and the maintenance service provider, the main strategies for the technical spare part mediator organization should be cost reduction and assurance of supply. The former refers to the purchasing price reduction achieved from the increased purchasing quantities and the consequent scale related savings. The latter is the availability of the materials at hand when they are required for repairing efforts. Also, if the repair service provider and this intermediary organization are parts of the same corporation, the supply support strategy can be identified as a technical spare part business. The enlarged intermediary entity can also find new supply sources more efficiently and therefore the first category is also represented in this kind of business. The environmental aspect can be identified from the technical spare part business as spare parts can be moved in larger quantities to the central and local warehouses, and one providing agent also enables the enlarged possibility to gather and recycle the used products. The concept of supply chain ought to be defined at first in order to gain a more comprehensive understanding of these relations and strategies.

It is obvious, however, that these strategic goals that purchasing organization has chosen will only work if the suppliers deliver the required service as stated in contracts and their contracts are accurate in their planned quality of product and delivery

process. In order to perform efficiently, these viewpoints should be taken into account while making the strategic planning. In order to evaluate supplier performance, many assessment practices are presented. For example Lambert and Pohlen (2001) consider the supply chain metrics. Delbufalo (2012), and Olsen and Ellram (1997) discuss the trust and the relationship between a supplier and a purchaser. Smelzer and Siferd (1998) take a wider perspective by undergoing the risk factors in supply management within the contexts of transaction cost theory and the resource dependency model. Moreover, the supplier selection, assessment and purchasing decisions have been considered by Tang and Cho (2008), and Kannan and Tan (2002).

The quality point of view, which is in the heart of this thesis, has been considered by for example Kannan and Tan (2002) and Yeung and Pun (2006). They consider the topic from the point of view of a manufacturing company. They also consider the issue from a more general perspective by creating supplier quality assessment system by recognizing the factors of supplier quality and identifying the relative weights of the factors. In this thesis, only the process quality in deliveries is considered. The quality perspective to supply chain management is presented in Chapter 3. Next, the general ideas of the supply chain and the supply chain management are presented briefly. After that, a more focused viewpoint of the spare part business as a supporting part of maintenance business in general is taken into consideration.

2.1 Supply chain

The term of supply chain has been used in various meanings and contexts as Wisner and Tan (2000) introduce the concept. According to them, the base of the concept has evolved in wholesaling and retailing. They also claim that there are no widely accepted specification of supply chain and end up defining supply chain to include all value-adding activities beginning from raw material extraction through its processing steps to end user of the product. The basic structure of supply chain can also be illustrated as a three tier structure from a supplier through the internal processes and ending up to a customer. (Chen & Paulraj 2004:120) The concept can be extended even further to include recycling and re-use as stated by New and Payne (1995). Their illustration of the phenomenon with some modifications is presented in Figure 2.

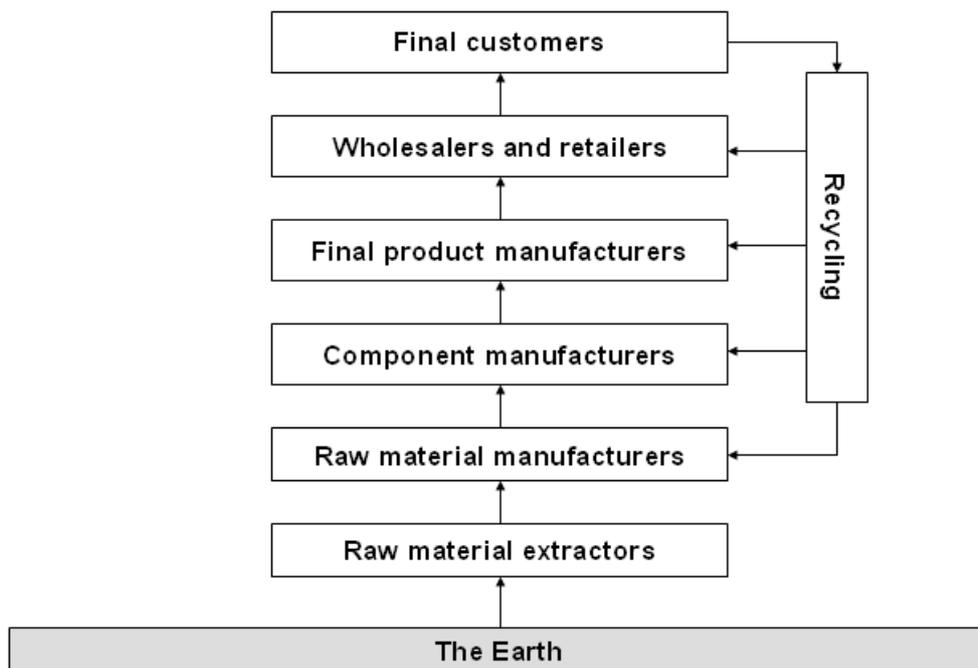


Figure 2. Supply chain

As can be noted from the two previous definitions, supply chain can be defined as very narrow structure, or alternatively, as a wide context from raw materials to end user, and further on to the point in which the material cannot be any longer recycled. From the narrow point of view, supply chain can be seen as “a network of materials, information, and service processing links with the characteristics of supply, transformation, and demand” as Chen and Paulraj (2003) describe the concept. This view has been expanded by Miemczyk et al. (2012) who compile the existing classifications of levels of analysis in supply chain management to three levels in order to help differentiate different kinds of analyses on the basis of their focus to environmental issues related to supply chain management. These three levels are: dyadic, chain and network levels. This classification is shown in Figure 3.

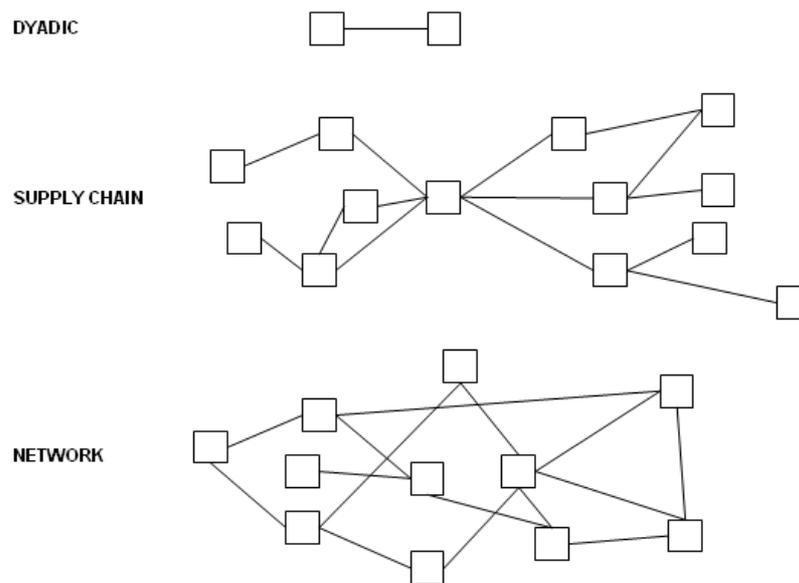


Figure 3. Levels of supply chain analysis

Miemczyk et al. (2012) define these three analysis levels in a following manner: the dyadic level consists of the immediate supplier and customer added with internal operations within the organization; the supply chain extends dyad level by adding one tier to both sides of the chain; and the network level analysis is the most complex model of these three including extended network, peripheral and indirect suppliers or other stakeholders that are not in direct contact with the company.

2.2 Supply chain management

Manufacturing industry and the product supplying chain of business entities have advanced significantly from the 1950s and 1960s mass product oriented thinking through strategic partnerships to the value chain thinking in the early 21st Century. (Tan 2000) Supply chain management as a concept was initially used in wholesaling and retailing business to describe development activities in logistics and distribution functions aiming to decrease lead times. (Wisner & Tan 2000) As for supply chain, in literature there is no exhaustive definition for Supply Chain Management (SCM). (Wisner & Tan, 2000) Li et al. (2005) conclude the dual purpose of SCM, performance for company itself and the whole supply chain, by using the definition introduced by Council of Logistics Management (2000) which defines SCM to be “systemic, strategic coordination of the traditional business functions and tactics across these business functions within a particular organization and across businesses

within the supply chain for the purposes of improving the long-term performance of the individual organization and the supply chain as a whole.” They also encapsulate the goal of SCM to be enhancing sourcing, manufacturing and delivery processes, and logical functions to work seamlessly and therefore to get supply chain to be “an effective competitive weapon”. (Tan, 2001) Wisner and Tan (2000) takes this even further by concluding from the results reported by Pagh and Cooper (1998), Davis (1993), and Scott and Westbrook (1991) that supply chain can reduce inventory while maximizing customer service by efficiently redistributing stock within the supply chain using effective postponement and speculation strategies. On the contrary to this perspective they report that in the dawn of the 21st century SCM view was concentrated more on the supplier side than to the end customer requirements. They also concluded that the more important aspects than the immediate price are the quality, customer service and the delivery criteria. (Wisner & Tan, 2000) Therefore, this could be seen as a total cost view for sourcing and purchasing operations.

Supply chain management postponement and speculation strategies are not without a few disadvantages. The lack of visibility or inaccurate information and forecasts about the estimated end demand might cause safety levels to rise during the supply chain caused by bullwhip effect in which sudden and fairly small fluctuation in sales demand might cause stock-outs and excess stock situations. (Lee et al. 1997) Bullwhip effect can therefore be seen as a tradeoff for risks, including visibility. Additionally it will result in a question such as: “Do we really know our supply chain and can we control it?” “What should we do to avoid getting fooled by this demand fluctuation effect?” As Lee et al. (1997) continue, the reason for bullwhip effect is the compiled forecasting errors during the supply chain. The effect will therefore increase when moved further from the point of the original demand fluctuation. They also specify a supply chain coordination framework in which information sharing, channel alignment and operational efficiency are the key initiatives to be taken to avoid bullwhip effect. (Lee et al. 1997) By comparing bullwhip effect to the focus of this thesis, it can be argued that the operational quality issues in dyadic purchaser-supplier relationship have fluctuation increasing effect and therefore can end up increasing safety levels in inventories in many other points of the supply chain, not only in this one transaction point between supply chain tiers.

As a part of business competence, the supply chain management is an important part of increasing competitive advantage in the market. As Lambert and Pohlen (2001) point out, supply chain is “a complex net of entities” and therefore the tiers with greatest potential for improvement should be found from supply chain and the improvement actions performed as an initial focus. Further, they divide supply chain management to a chain of entities linked by the customer relationship management and the supplier relation management. These two functions can be considered as a mirror image of each other.

In order to illustrate the effect of supplier-buyer relationship, Lampert and Pohlen (2001) use Economic Value Added (EVA) to point out the effects on improvements achieved due to successful relationship between supply chain tiers. They also conclude that most of the supply chain metrics do not include the whole supply chain, only a part of it. Therefore, if the whole supply chain is not considered, the total profitability improvement may come short or even have a value reducing effect on total supply chain. (Lampert & Pohlen 2001) As an example of this, by using purchasing portfolio matrix presented by Kraljic in Harvard Business Review 1983 (Kraljic 1983) and applying the strategic implications for supplier management from the matrix location point of view, only the previous tier is considered and therefore the larger supply chain effects neglected. They also show in their example case of Vendor managed inventories (VMI), and in similar cases where the division of tasks to be done in the transaction between tiers is changed, that the knowledge of the tasks moved should be at an equally high level in the supplier side as in the preceding customer side of the transaction in order to improve EVA.

The effective supply chain can also be seen from the collaboration and visibility point of view as Holweg et al. (2005) consider the issue. They also point out that the background reason for collaboration is “to create a transparent, visible demand pattern that paces the entire supply chain”. This viewpoint to the supply chain management highlight the need for visibility and the effects of poor information sharing in the supply chain, the bullwhip effect. They conclude the adverse consequences to be poor service level, high inventories and frequent stock-outs. Furthermore, on the contrary to previously presented classifications to the supply chain, they introduce the categorization of dyad supply chain collaboration to be the traditional supply chain, the in-

formation exchange, the vendor managed replenishment and the synchronized supply. They also conclude in their journal article that the benefits for the collaboration are the elimination of bullwhip effect, the reduction of the inventory levels, a better utilization of transportation resources and an improved control of the risk related to the materials supply. (Holweg et al. 2005) In addition, Chan et al. (2009) conclude in their research publication considering flexibility in supply chains that trust and software issues are two major barriers before the competitive advantages of flexibility in supply chain can be reached. (Chan et al. 2009) This can also be seen as an important input and outcome from supplier quality management. Trust is also raised as the second most important purchasing strategy of the supply chain management in survey reported by Wisner and Tan (2000).

2.3 Purchasing in maintenance and spare part business

In the technical maintenance business, such as real property or machinery repairing, not only the maintenance operation itself, but also the availability of the required spare parts and tools are a must in order to run a successful business operation. These, which in many occasions are after sales services, have an increasing importance as a competitive factor in the industry of capital goods. (Pfohl & Ester, 1999) As Martin et al. (2009) point out; spare part supply has been considered in various publications in the past.

As a conclusion, Martin et al. (2009) state that information sharing across supply chain gives substantial benefit also in the spare part supply chain. They identify three implementation-related issues: the relationship inequity, the information availability, and the spare parts and information exchange platform. In addition, they claim that while forecasting the break-down timing of the serviced product, the further the decision is from the maintenance field operations, the higher the risk for error in fault timing estimation.

As a basis for the spare part demand forecasting, the age replacement policy (ARP) or the block replacement policy (BRP) can be identified. The ARP is a method for service providing that is based on the part replacements upon failure, or preventatively, at predefined utilization time. In the BRP, on the contrary, changing of the parts is performed not only when a fault has occurred, but also after the predefined

time period. (Boulet, Gharbi & Kenné, 2009) The difference of these perspectives is that the ARP requires constant following of the utilization time of the equipment and is therefore more difficult to implement than the BRP that considers only the time past since the adding of the component. In this thesis, the replacement policies are not further considered, but the basic strategies for the service business should be understood while considering the technical spare part business, as its supply chain and demand aspects. In addition, even though the BRP seems easier to apply from the operations perspective, keeping track of the spare part installations globally can be seen very difficult to implement, because the scale of operations.

On the basis of issues considered in this chapter, the answer for the first research question can be presented. At first, dyadic relationships should be expanded to the supply chain perspective and even further to the network view. From the basic view of supply chain shown in Figure 2.1, the spare part supporting business can be thought to have an intermediary role between the suppliers and the service providing companies. In the Figure, this intermediary role would be then the same as with wholesalers and retailers. Also, even though the empirical part of this thesis considers mostly dyadic relationships, the supply chain of the spare parts can be seen from a chain perspective. If also maverick buying is included, the chain view can be expanded even further to the network level. Even though maverick buying may be seen as a largely negative approach, in some cases, the local purchasing could also be the most cost effective way to purchase and therefore the network perspective is also present.

3 QUALITY IN SUPPLIER MANAGEMENT

Quality as a concept can be considered from almost all points of view in business. According to Foster's (2008) introduction of the field of research, the typical points of view in the quality management have been the internal, the process based, and the external, customer based perspectives. He points out that managing and partnering with upstream companies results in benefits to the downstream of the supply chain. This implies that the quality improvements in purchasing operations can cause an indirect savings in costs.

One of the purchasing objectives is to minimize quality costs in inbound materials, which can be done by using supplier quality profile in the supplier selection. As Arjan J. Van Weele (2005) remarks, this is usually not enough and therefore the major focus should be the quality improvement, not only the present quality level. (Van Weele, 2005: 18) In the text books of purchasing, quality is usually divided into eight dimensions according to the division by Garvin (1984: 101) being: Performance, reliability, serviceability, conformance, durability, features, aesthetics and perceived quality. When deciding the right quality, Lysons and Farrington extend these eight dimensions with three additional dimensions by adding price, customer specifications and durability into the context. They also point out that it is the optimum quality, rather than the best quality, that should be sought for the application in question. (Lysons & Farrington, 2006: 267)

The field of the supplier management can be seen as compiled from three concepts: the Supply chain management, the Purchasing management and the Quality management as illustrated in the Figure 4. In addition to the context view, Batson (2008) defines the emphasis of the supplier management to be two-fold; from one point of view it is on the organizational relationship between the supply chain tiers and their performance outcome of the supplier, and from the other point of view the emphasis is on the correspondence to the expectations of the purchasing organization. (Batson 2008) The present thesis, the considered parts of this three dimensional view considered are more focused on the Purchasing management and the Quality management than on the Supply chain management.



Figure 4. Context of Supplier management (Batson, 2008)

After providing the basic background of the supplier management, Batson (2008) summarizes the supplier management trends to belong into four categories: Direction-Setting processes, Core procurement processes, Supporting or Enabling processes and Customer-Supplier relationships. This categorization gives an extensive and improvement centered classification besides the previously introduced supply chain and supply chain management classifications. The first trend consists of the strategic sourcing, the supplier responsibility in design and development, the optimized supply chain and supply base and the improvement in the supply chain integration. The core procurement trend considers the buyer's role, the information flow and the supplier certification as the focus of the study. Research considering the supporting or enabling processes has its focus on benchmarking, continuous improvement and process flow. The Customer-Supplier relationships consider the communication and supplier relationship issues. (Batson 2008)

As Shin et al. (2000) considers the supplier management orientation (SMO), they study the phenomenon of supplier management through a framework of supplier and buyer perspectives. In their framework, the supplier performance consists of the cost, the quality, the delivery reliability, the lead time and the on-time delivery. The buyer (or the purchaser) performance is defined as consisting of the product performance,

the product reliability, the product conformance and the product durability. They conclude that, as a result of their research, both the supplier and the buyer will benefit from improvements in the supplier management orientation. One of their findings was that the main contributors for the performance characteristics of SMO are the long-term supplier relationships, the supplier involved product development, the reduction of the supplier base and the quality focus. (Shin et al. 2000)

3.1 Quality management

One way of understanding the improvement aspects in the corporate level is to enhance the profitability by improving the quality in all the aspects of operations performed. As Kannan and Tan (2004) point out the need for improvement is that competitive pressure is calling at the same time improved product quality, increased responsiveness and shorter lead times, but yet at lower costs. They also introduce three initiatives to tackle these demands: Just in time (JIT), total quality management (TQM) and the SCM. In this thesis, the time based quality, and therefore the JIT is excluded from the scope and only the remaining two of the viewpoints are considered. In the earlier chapter the SCM was already introduced. The findings of Kannan and Tan (2004) indicate that the strategic commitment to quality appears to be the most consistent driver for business performance. In addition, they define TQM movement as an “organization wide customer focus driven culture that is based on continuous improvement employee empowerment, and data driven decision making“. Furthermore, they add that the focus should be on all stages of the development and production.

In many companies, the Six sigma approach to quality improvement actions has been implemented in the organizations. As Schroeder et al. (2008) point out in their introduction to the issue, there have been some controversial opinions about the effectiveness of this approach. They also point out that one main reason for this can be that, that the research considering the effectiveness of the Six sigma approach has been quite limited and no exhaustive definition for the quality improvement has not been introduced. Therefore, Schroeder et al (2008) proposed the definition for the Six sigma to be: “Six sigma is an organized, parallel meso/structure to reduce variation in

organizational processes by using improvement specialists, a structured method, and performance metrics with the aim of achieving strategic objectives.“

Previous views, such as, for example the scope taken by Vonderembse and Tracey (1999), consider quality management from the manufacturing point of view. The viewpoint is therefore to some extent wider than the one in the supply chain, but as in manufacturing, also the supply chain consists of consecutive entities, internally in company or externally as a chain of consecutive entities. Total quality management and its success in organization can be studied from various points of view. Taylor and Wright (2003) consider in their research considering factors effecting TQM success in organizations. They conclude that especially the managers need to understand the nature, the purpose and the achieved benefits of TQM in order to gain the success the books and the consultants of the TQM imply. They also state that the employee focus on improvement actions should always be in the customer satisfaction to achieve the best tangible outcome.

3.2 Tools for quality improvement

As quality is an essential part of a successful business, many quality improvement tools have been created to help the identification of quality defects and their causes. These improvement tools can be divided into two groups: technical and system related. (Tarí & Sabater 2004) Some of the tools consider also prioritizing which is the key element of an effective quality improvement process. Tarí and Sabater (2004) have used seven quality improvement tools that they have collected from the works of Ishikawa (1985) and McConnell (1989). These seven quality improvement tools are: flow charts, cause and effects diagrams, Pareto charts, histograms, run charts and graphs, X bar and R control charts, and scatter diagrams. Cause and effects diagrams and Pareto chart are taken into a closer review in this chapter, and they are also utilized as a part of performing the empirical study included in this thesis. Pareto chart was used for prioritizing the improvement action point of view and cause and effects analysis was performed for the selected error types. These two quality improvement tools were chosen to be used as they were the most convenient for the case in question and also because the other improvement tools were not suitable to be used to analyze the gathered data. The cause and effects charts were also used

to visualize the error cases in order to improve the outcome of the debate considering the improvement actions. Many quality improvement tools have been developed to help to improve production quality (Russell & Taylor, 1998: 108-109) and therefore only a few of these improvement tools can be directly used in the supply chain management. When quality problems are identified and the quality problems to be considered are chosen, for example cause-and-effects analysis can be used to specify the reasons behind the quality failure. After identifying the causes of quality problems specifically enough, corrective actions can be designed to be taken to eliminate or decrease the effect of the problem. (Russell & Taylor, 1998: 112) In the empirical part of present thesis, these two quality improvement techniques are used to identify the quality improvement tasks to be conducted.

3.2.1 Pareto analysis

The cause of poor quality can be identified by using Pareto analysis that was invented by the quality expert Joseph Juran in the 1950s who named the method after 19th century economist Vilfredo Pareto. The idea of Pareto analysis is that most of the quality problems and costs are caused by only a few reasons. Because of this, solving these causes that have the biggest effects will end up giving the best cost impact. (Russell & Taylor, 1998: 108)

Pareto analysis can be performed by identifying quality errors and categorizing them, measuring the relative percentages of categories and placing the categories in a cumulative order. After that, categories are chosen to be investigated until a certain limit, for example until 80 percent of quality problems are reached. By using this method, the quality improvement actions can be prioritized, and time, efforts and resources saved.

3.2.2 Cause-and-Effects Analysis

In order to find the improvement objectives, the causes and effects of the problems should be considered in more depth. Cause-and-effect diagrams are used for identification of these mediatory factors in order to convert the quality issue into improvement actions. As illustrated in the Figure 5, general cause-and-effect diagram con-

sists of specified quality problem, cause categories and the identified causes. (Russell & Taylor 1998: 112)

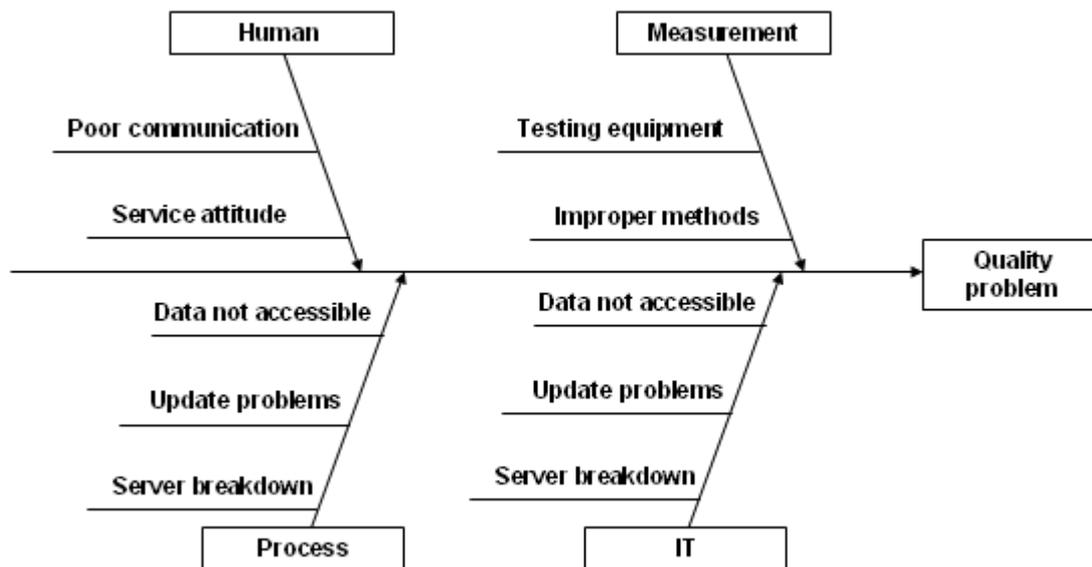


Figure 5. A General Cause-and-Effects Diagram (Russell & Taylor 1998: 113)

As can be seen from the Figure 5, cause-and-effects diagram is a visual way of analyzing the problem. In this thesis, it was also used as a basis for discussions of the improvement actions that were organized for the purpose of gathering the ideas for improvement actions.

3.3 *Quality and performance evaluation in supply chain*

In the 1980s, the supplier quality did not receive much attention in the European or the US companies as supplier was not identified to play an important role in the overall performance and competitiveness of an organization (Trent & Monczka 1999) Quality and performance in supply chain was not seen as a part of the product and service quality in both company's internal and external processes. Moreover, Stanley and Wisner (2001) state that the product and service quality issues have been usually studied from the external point of view. In this thesis, the main focus of the study is the dyadic, external interface between purchasing organization and the supplier. The final scope of the improvement is, however, to provide better service to internal customers that in this case are the maintenance service providers. These improvement actions may therefore have potential to improve the service quality provided to

the external end customer which is, in the maintenance business, the equipment owner. (Stanley & Wisner 2001)

Foster (2008) defines supply chain quality management as “a systems-based approach to performance improvement that leverages opportunities created by upstream and downstream linkages with suppliers and customers”. Traditionally, supplier performance evaluation has been performed by using vendor rating or vendor assessment techniques that use the supplier performance criteria in a linear manner. Karpak et al. (2001) criticize this view and propose an optional performance evaluation method “visual interactive goal programming” (VIG) to be used instead so that the trade-off points of view in the supplier performance evaluation can be considered interactively and graphically. Only a couple of years earlier, Trent and Monczka (1999) presented their series of questions to help to assess organizations sourcing activities and their state. This questionnaire focused on supply base, supplier quality measurement and rewarding practices, supplier improvement targets, supplier process and method certification, resource commitment to supplier development, and supplier involvement in product and process development. As a conclusion, they point out the opportunities these points of view create to generate competitive advantages, but they also add that realizing these benefits requires time, expertise, resources and systems. They also recommend the issue to be monitored by the executive managers and therefore highlight the importance to the total business performance.

4 ANALYSIS AND DISCUSSION

In technical maintenance business, centralization of spare part procurement process can be seen as a way to cut costs and improve maintenance operator effectiveness by centralizing the sourcing operations to one supporting organization. As this point was already presented in earlier chapters of this thesis, it also must be stated that while some of the quality issues can be thereby inspected, and testing of actual functional performance remains to be validated by maintenance field operator who actually tests the technical quality of the product while performing the maintenance operations. In these kinds of quality issues, separate quality feedback function is needed in order to coordinate quality improvement actions with the supplier. Because of this, only visual checking is performed in centralized distribution centers.

As technical maintenance business is scattered geographically around the equipment owners, some centralization to the country and local warehouses can be arranged, but in order to achieve economies of scale the international distribution centers are justified. Especially, because there are thousands of mechanical, electrical and other accessories to be stored, it is not profitable to stock all the needed spare parts and other accessories in one country warehouse to be used only once in a year or even more infrequently. The scope of this analysis is to find the most usual delivery quality error issues noticed in the visual checking performed by inbound operations of these international distribution centers; study the effects of the issues and provide improvement actions to purchasing organization.

4.1 Performing the analysis for non-conformity errors

In this chapter, analysis of data about warehouse inbound non-conformity errors, gathered during the year 2012, is reported. The non-conformity error data gathering was already a part of inbound process, and therefore the basis of the data gathering was already designed in to the inbound procedure. As the result of the empirical part of the present thesis, most common error reason types, their causes and improvement actions are presented. The analysis is a case study consisting of data from one spare part supplying department of global company. Analysis can be divided into three consecutive parts.

The first empirical part of the thesis is to analyze non-conformity errors via analysis from data gathered during the year 2012. Measured ten error types were then gathered to categories based on their similarities. The second part of the analysis is to take sample cases and seek root causes for the errors. This part of the analysis is qualitative in nature. Further on, structural inquiry for purchasing professionals that are in everyday contact with the suppliers will then be performed in order to gather opinions about the reasons of the error sample cases. In third part, improvement actions are proposed to be performed in order to decrease the operational non-conformity errors in received deliveries at the warehouse. These proposed improvement actions will then give an answer to the third research question.

4.2 Failure types

In this study, failures were sorted by using nine specified reason types and the rest failures were sorted to be “other reasons”. Failure types and their relative amount of failures are shown in figure 4.1. Four of the reasons are information related (types 1 to 4), two of the reasons are delivery quantity related (types 5 and 6) and three of the reasons are related to physical part features (reasons 7 to 9).

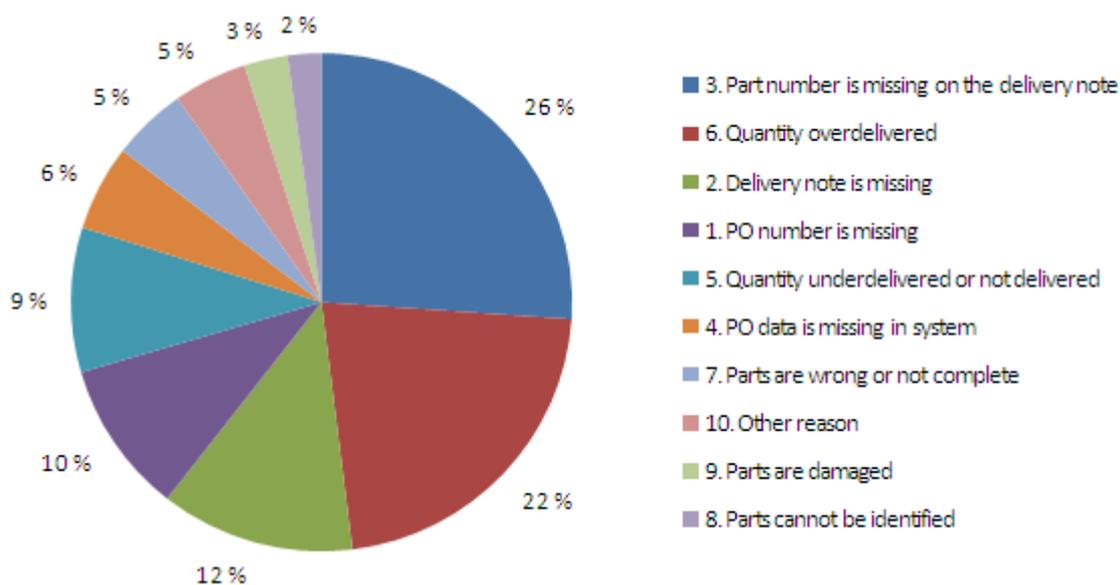


Figure 6. Non-conformity error types and their relational segmentation

As can be seen from the figure over half of the problems in inbound are caused by lack of information. This information shortage can occur in delivery note or informa-

tion system of receiving party. Delivery note information shortage is failure that can be seen as caused by supplier routines that are not compatible with ordering party routines. Also failure types five and six are related to incompatibilities between supplier and purchasing organization routines. From failure type analysis point of view, it is clear that considerations of these two main issue categories are justified not only because of the used working hours of purchasers to solve the issues, but also because of their effect on service level of the business. The latter means that for example when sales order is placed to be sent as soon as possible when purchasing order is received, which can be the case with not stocked merchandise, solving time of the quality issue is possible delay also for outbound delivery and therefore has an effect on the level the whole intermediary organization can provide service to next tier customer which in this case is maintenance business provider.

4.3 Non-conformity defect root causes

As discussed in previous section, used failure types can be divided into three groups data related, delivery quantity related and physical part feature related. It was also seen that over half of the quality issues in inbound are caused by the first group and over 30 per cent was caused by the second group. The analysis of these two groups includes therefore over 80 % of failures in inbound.

The cause-and-effects analysis was done for these two selected error categories by creating survey appointed to purchasing organization in order to find more detailed reasons for included quality challenges. 60 information related error issues and 37 quantity related error issues were selected as a sample to be reviewed by purchasers. The selection was done by choosing samples from different size suppliers to get wider perspective of issues at hand. After reviewing the selected cases, major redundancy in error causes, responsible parties and error types could be seen. Therefore, it was decided that second round of surveys was not needed.

Cause-and-effects diagrams were used to specify the cause categories and identify the causes for all of the selected original non-conformity error types. As a result of the analysis, the information was collected to tables. 33 different root causes were identified and four primary causing parties were found in the survey. 21 of identified root causes were caused by information related non-conformity errors and 15 of the

root causes were related to quantity based errors. Two of the root causes were related to both main error categories. The main causing parties for non-conformity errors were supplier, transportation company, second tier supplier and purchasing organization. Also three main error types; human, process and IT; could be identified from the responses. In table 4.1 the relation between identified root causes related to information related non-conformity errors is presented.

Table 1: Identified root causes for information related non-conformity errors

Identified root cause	Information related		
	1. PO number missing	2. Delivery note missing	3. Part number missing on delivery note
Attitude / service reluctance	x	x	x
Poor communication	x		
Delivery information changed			x
Information changed not checked and updated			x
Material code changed			x
Purchasing organization material code not in supplier system			x
Wrong material code in supplier system			x
Order handler changed during delivery preparation	x	x	x
Carelessness		x	x
Automated communication problem			x
Only supplier material code in delivery note			x
Part number can't be updated to supplier system			x
Delivery note not attached correctly or at all to package		x	
PO information not in delivery note		x	
Two orders in one delivery, not marked		x	
Information not transferred	x		
Only supplier info in delivery note	x		
Documentation changed with another delivery documentation	x	x	x
Delivery note taken from delivery and not returned		x	x
Delivery changed with delivery to another customer	x	x	
Delivery delivered to wrong customer		x	

As can be seen from the table, some of the reported information related issues seem to have contradictory error types as reported. For example it is questionable to report reason types 2 and 3 as causes for same cases. This could be seen to have caused by taking multiple deliveries into the created issue, because these deliveries were received in same shipment. The same issue occurs with reason codes 1 and 3. By understanding the background of this phenomenon, the argument of inconsistency can be therefore ignored because of the obvious explanation.

Most of the information related errors are caused by changes and updates made in purchaser organization or supplier organization. Second group of reasons that can be identified is human performance issues and third one is transportation related

errors. In table 4.2 causing parties and error types related to identified root causes in information related non-conformity issues is presented.

Table 2: Identified causes, causing parties and error types, information related errors

Identified root cause	Causing parties		Error types	
	Primary causing party	Secondary causing party	Primary error type	Secondary error type
Attitude / service reluctance	2nd tier supplier	Supplier	Human	
Poor communication	2nd tier supplier		Human	
Delivery information changed	Purchasing organization		Human	Process
Information changed not checked and updated	Purchasing organization		Human	
Material code changed	Purchasing organization		Human	Process
Purchasing organization material code not in supplier system	Purchasing organization	Supplier	Human	IT
Wrong material code in supplier system	Purchasing organization		Human	Process
Order handler changed during delivery preparation	Supplier		Human	Process
Carelessness	Supplier		Human	
Automated communication problem	Supplier	Purchasing organization	IT	
Only supplier material code in delivery note	Supplier		Human	IT
Part number can't be updated to supplier system	Supplier		IT	
Delivery note not attached correctly or at all to package	Supplier		Human	Process
PO information not in delivery note	Supplier		IT	
Two orders in one delivery, not marked	Supplier		Human	IT
Information not transferred	Supplier		Human	
Only supplier info in delivery note	Supplier		Process	
Documentation changed with another delivery documentation	Transportation company		Human	Process
Delivery note taken from delivery and not returned	Transportation company		Human	
Delivery changed with delivery to another customer	Transportation company		Human	
Delivery delivered to wrong customer	Transportation company		Human	

According to above table, communication and attitude related causes are mainly caused by second tier suppliers that in most of the cases have some reason not to give best service. For example, if second tier supplier is competitor in same or another field with the purchasing. Errors with updates and information change communication are the most commonly caused by human, IT or process failures between purchasing organization, supplier and warehouse. As expected, the largest amount of error causes is related to supplier. Most of these error root causes are related to markings in delivery note or the data in the supplier system. Also process defects, human errors and IT quality problems between supplier and purchasing organization IT systems are causing these non-conformity errors. The majority of transportation company related problems are caused by human errors during the transportation. The problems with the transportation company should be handled via quality improvement actions performed by transportation company, but some actions can still be proposed to be carried out by supplier and purchasing organization to decrease risk of errors in warehouse inbound.

The second non-conformity error category chosen to the deeper investigation is quantity related errors. The viewpoint of these issues compared to previous is relatively different, but some similar root causes were identified. Identified root causes in quantity related issues are shown in the table 4.3.

Table 3: Identified root causes for quantity related non-conformity errors

Identified root cause	Quantity related	
	Underdelivery	Overdelivery
Counting mistake	x	x
Carelessness	x	
Delivery note unclear	x	
Delivery quantity changed, but not informed or not in delivery note	x	
Partial delivery not informed or unclearly informed in delivery note	x	
Two orders in one delivery, not marked		x
Changed PO data not sent to warehouse		x
Earlier delivery for received quantity in PO		x
Material code not updated by supplier		x
Material in clarity		x
PO information not the same between systems		x
PO updated, but rounding value not checked		x
Sales unit in clarity		x
Wrong quantity sent and confirmed than in PO		x

The most common and obvious reasons are counting mistakes and carelessness. Usually also quantity checking procedure can differ in supplier from purchasing organization's warehouse quality checking procedure, and therefore counting mistake can also mean for example that supplier is performing quantity checks by making comparison between expected and actual weight of package and receiving warehouse is counting piece by piece. The methods of quality checking used in receiving warehouse should be therefore communicated clearly to supplier in order to avoid these issues from happening. The second larger group of root causes is related to unclear or not complete delivery notes and the third main group is IT related as can be seen from table 4.4 in which presents relations between root causes, causing parties and error types in quantity related non-conformity error issues.

Table 4: Identified causes, causing parties and error types, quantity related errors

Identified root cause	Causing parties		Error types	
	Primary	Secondary	Primary	Secondary
Changed PO data not sent to warehouse	Purchasing organization		Human	
PO updated, but rounding value not checked	Purchasing organization		Human	
Counting mistake	Supplier		Human	
Carelessness	Supplier		Human	
Delivery note unclear	Supplier		IT	
Delivery quantity changed, but not informed or not in delivery note	Supplier		Human	IT
Partial delivery not informed or unclearly informed in delivery note	Supplier		Human	IT
Two orders in one delivery, not marked	Supplier		Human	IT
Earlier delivery for received quantity in PO	Supplier		Human	
Material code not updated by supplier	Supplier		Human	
Material in clarity	Supplier	Purchasing organization	IT	
PO information not the same between systems	Supplier	Purchasing organization	IT	
Sales unit in clarity	Supplier	Purchasing organization	Human	IT
Wrong quantity sent and confirmed than in PO	Supplier		Human	

The causing party behind quantity related non-conformity errors is the most commonly supplier, but in some of the cases also purchasing organization is the responsible entity behind the error. It could also be noticed that quantity errors seem to be caused by human or IT errors, but many of these reasons could be seen also caused by error-sensitive processes.

4.4 Improvement actions

Because of the large amount of information related non-conformity errors that can be seen as caused by lack of knowledge in supplier side about what are the minimum requirements for the delivery from process side of view. In other words this means that supplier should have understanding about the delivery quality checking process in distribution center and this knowledge should be communicated to supplier delivery preparation and outbound operations. Because the supplier usually has wide variety of customers and therefore making contract with very detailed demands about deliveries cannot usually be made, the solution should be simple. For this, standard delivery notes with required minimum information that should be added to the delivery note when shipping to customer at question should be proposed to be used in supplier outbound deliveries. Additionally, check list to assure conformity with distribution center's inbound processes, should be brought to supplier outbound operations. These issues should be communicated to the suppliers by collecting the basic conformity related information to a document including the previously introduced issues and for example the information of how quantity verification is performed in de-

livery center. Training considering these issues should also be provided for supervisors who are working in supplier outbound operations.

The use of standardized delivery notes would only solve a part of the information related problems, because in many cases the reason for non-conformity error is missing delivery note. In these cases, as seen in previous sub-chapter, delivery could be missing because of supplier or transportation company. In order to avoid delivery note from disappearing during the shipment or reduce the risk for supplier to forget to add delivery note, another delivery note should be added into the delivery package and therefore by opening the package in distribution center, if no delivery note can be acquired from outside or received with the package, it would be possible for distribution center to use this back up delivery note acquired from inside the package to identify purchasing order, received materials and their represented quantities. This could also help the personnel of distribution center to sort out unclear markings or specify package specific information, and therefore decrease even further the amount of non-conformity errors. In addition to changing supplier processes, also inbound process in distribution center should be changed so that packages are opened before this kind of non-conformity issues are raised and purchaser contacted.

The other issue related to distribution process changes is the use of only supplier specific material codes in delivery notes. In most of these issues, supplier should be demanded to mark both material codes to delivery note. This might sometimes be impossible due the information system supplier is using. The supplier order handling program might not be capable for handling both supplier material code and customer related information. Also, to demand supplier outbound to manually add the information would be highly inefficient way of resolving the problem. Therefore, in these specific cases, the proposed solution would be to use supplier related material codes as a reference for inbound booking in distribution center and therefore some changes are proposed to be performed to inbound process.

In addition to supplier being the only responsible causing party for the information related non-conformity errors, also purchasing organization as a causing party should be considered. As was seen in both, information and quantity related, non-conformity categories, changes and updates done by purchasing organization considering mate-

rial data, and purchasing order materials and quantities, should be taken into closer review. Because most of the issues are caused by human errors, for example purchaser forgot to inform supplier about the changes, the purchasing process should be investigated. One clear and obvious improvement action could be therefore to introduce basic checking list to be used by purchasers. This would help the purchaser to cope with this kind of basic and redundant process without the need of remembering all of the issues that should be taken into account while creating or changing the purchasing order.

It was also noted that there are some special cases in which second tier suppliers could be considered as the fault responsible party. In these cases, there is usually a reason for second tier supplier not to provide first-class service. For example this might be simply competing relationship to receiving and therefore their actual customer. In these cases, solution proposal would be therefore to hide the actual customer and purchase the materials so that only supplier information is shown to second tier supplier and also the material flow would be through supplier warehouse or location. This might cause some additional expenses for the broker company and therefore also the actual purchasing company, but would also improve the total process predictability and decrease the non-conformity related costs. The disadvantage of moving materials through supplier location could be the increased amount of transportation needed and therefore this might not be suitable in companies with environmental certification such as ISO 14001. Another disadvantage is that transportation costs might increase and therefore the cost of handling the non-conformity errors could be even lower than the increased transportation costs. Reducing the direct and indirect non-conformity error related costs should be therefore the main motivation for all of these improvement actions, and the priority order for performing these improvement actions should also be considered from cost perspective.

5 CONCLUSIONS

The objective of the thesis was to introduce the supply chain management and the related quality management. This was performed by introducing the supply chain management and quality management as a part of a larger framework and then narrowing the perspective of the thesis to only consider operational quality issues in bilateral, dyadic, relationship between the supplier and the buying organization. It was discovered that there are only few research published considering the operational quality in the supplier-purchaser transaction focusing especially on the service business. Therefore, more general theories were introduced, and then the perspective was narrowed to consider the service business, and subsequently to consider technical spare part business. The perspective of the spare part business for supply chain management was identified to be similar to brokerage and wholesaling. As a part of quality management theory, a classification between process and product quality was considered.

As an answer to the first research question, supply chain of technical spare part business was identified to be similar to wholesaling. The second research question considered the quality in the bilateral supply chain. One answer could therefore be introduced from the point of view of the requirements set to supplier performance. According to Shin et al (2000) the requirements for supplier consists of cost, quality, delivery reliability, lead time and on-time delivery. In addition to this perspective, non-conformity errors could be added. It can also be concluded that an exhaustive list of quality issues could not be specified, because there are multiple approaches to the issue.

The analysis part of the thesis was based on the data gathered in the year 2012 in spare part support department of a global company. Original data was grouped into four categories on the basis of the similarities in the identified quality issues. These categories were information based, quantity based, product physical quality based and other quality issues. After categorizing, prioritization to select categories for further study was performed. Information and quantity related process quality errors were selected. An inquiry for the purchasing professionals in the department was then performed in order to create cause-and-effects diagrams of the two selected

error categories. A questionnaire in the inquiry included also a query about the propositions for improvement actions. The gathered and the additional improvement actions acquired from the project group were then presented.

The third research question can therefore be answered by using the results of the analysis. The proposed improvement actions suggested based on the findings of this thesis are the predefined delivery note with specified mandatory fields, the check list for the supplier outbound operations considering conformity of the sent deliveries, adding a second delivery note inside the package in the supplier outbound operations, the creation of a check list and a standard process for purchasing organization considering steps of purchasing order changes and updates, and using the supplier warehouse as intermediary destination point when ordering via supplier from the second tier suppliers. In addition to this, an additional training about the distribution center conformity verification process was proposed to be held for the supervisors who are working in the outbound operations of the largest suppliers. A few modifications were also proposed to the inbound process of the distribution center.

The nature of this study was case related and considered data from only one distribution center of a global company. Therefore more research should be performed in order to generalize the findings of this thesis. For instance original measurement non-conformity issue types should be reviewed and also the data collection should be changed so that each of the non-conformity issue could only have one issue type. Additional research concentrating on the support organizations in service business should also be performed with an emphasis on the quality and total supply chain perspectives. More specific research issues identified are: How to decrease the risk associated to competitor related parts, what is the effect of integrated data system in decreasing the amount of process related quality issues and Just-in-time in supplier delivery quality. In addition, the effect of supplier size to process quality could also be an interesting research topic.

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