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# LINKING SUPPLIER DELIVERY RISK TO OUTBOUND DELIVERY SERVICE PERFORMANCE IMPROVEMENT

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## TIIVISTELMÄ

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Asiakastyytyväisyyden tulisi olla jokaisen liiketoiminnan osa-alueen pääfokus. Usein toimitusketju on avainroolissa tämän päämäärän tavoittelussa varsinkin korjauspalveluja tarjoavassa liiketoiminnassa. Keskityttäessä materiaaleihin, joita tarvitaan palvelusopimusten alaisten laitteistojen korjauksessa, materiaalitoimitusten oikea-aikaisuus on kriittinen tekijä. Onko toimittajilta tulleilla myöhässä olevilla toimituksilla merkitystä korjaustoiminnan suorituskykyyn kun keskitetyn hankintayksikön jakelukeskus toimii puskurina toimittajien ja korjausliiketoiminnan välissä? Jos näin on, kuinka parannustoimenpiteet tulisi priorisoida? Nämä kysymykset ovat tämän tutkielman kaksi pääaihetta.

Toimittajien ja jakelukeskuksen palveluasteen kytköstä tutkittiin korrelaation ja lineaarisen regression avulla. Palveluaste määriteltiin sovitun toimitusajan puitteissa vastaanotettujen toimitusten suhteelliseksi osuudeksi. Tutkimuksen tuloksena havaittiin, että tilastollisesti merkittävä korrelaatio ja regressio ovat olemassa näiden kahden toimitusketjun rajapinnan välillä. Lisäksi, vastauksena toiseen tutkimuskysymykseen luotiin toimittajien jaottelu materiaalien saatavuusriskin kannalta sekä parannuskohteiden tunnistamisprosessi kaikkein kriittisimmille toimittajille. Vastaus toiseen tutkimuskysymykseen saatiin keräämällä ja muokkaamalla aiempia kirjallisuudessa esiintyneitä malleja ja testaamalla luotua mallia kohdeyrityksen tapauksessa.

# ABSTRACT

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Customer satisfaction should be the main focus for all of the parts of the business. Usually supply chain behind the business is in a key role when this focus is pursued especially in repair service business. When focusing on the materials that are needed to make repairs to equipment under service contracts, the time aspect of quality is critical. Do late deliveries from supplier have an effect on the service performance of repairs when distribution center of a centralized purchasing unit is acting as a buffer between suppliers and repair service business? And if so, how should the improvement efforts be prioritized? These are the two main questions that this thesis focuses on.

Correlation and linear regression was tested between service levels of supplier and distribution center. Percentage of on-time deliveries were compared to outbound delivery service level. It was found that there is statistically significant correlation between inbound and outbound operations success. The other main question of the thesis, improvement prioritization, was answered by creating material availability based supplier classification and additional to that, by developing the decision process for the analysis of most critical suppliers. This was built on a basis of previous supplier and material classification methods.

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## TABLE OF CONTENTS

## LIST OF SYMBOLS AND ABBREVIATIONS

| | |
|---|---|
| CEO | Chief Executive Officer |
| COT | Completely on Time |
| DMAIC | Define, Measure, Analyse, Improve and Control |
| ERP | Enterprise |
| FMEA | Failure Mode and Effects Analysis |
| IMP | International Marketing and Purchasing Group |
| JIT | Just in time |
| LT | Lead Time |
| MRP | Material Requirements Planning |
| PI | Performance Indicator |
| PO | Purchase Order |
| ROP | Re-order Point |
| ROQ | Re-order Quantity |
| SC | Supply Chain |
| SCM | Supply Chain Management |
| SL | Safety Level |
| SO | Sales Order |
| SP | Service Performance |
| TBC | Time-based Competition |
| TQM | Total Quality Management |
| QFD | Quality Function Deployment |

# 1 INTRODUCTION

Service performance or in other words on time delivery is one of the key indicators of succesfull sales organization in service business material support operations. Because of this, supply chain management efforts of a firm should take all efforts to meet the customer demands also from the perspective of delivery timeliness. For broker and retailing businesses as well as corporate centralized purchasing units inside supply lines, optimized material flow in supply chain is the key for profitability and growth. Therefore, it is necessary to link inbound operations to outbound service level in order to seek improvement actions in the supply chain (Giannakis 2007). Because of the limited resources, improvement process should be used in the most effective places and in a correct level of operations (Jalalvand et al. 2011). The basis for improvement is the constant race between supply chains in all levels of quality, productivity and cost management. For example Foster (2007) compiles this view under supply chain quality management that he defines as “a system-based approach to performance improvement that leverages opportunities created by upstream and downstream linkages with suppliers and customers”. Therefore, the improvement is not done only in one business interface, but in the whole extent of supply network. This is also pointed out by Kannan and Tan (2005) in their conlusions where they state that as firms are outsourcing and focusing in their core competencies, there is greater pressure to leverage customer and supplier performance in order to increase the firm’s own success.

The supplier management is therefore one of the main perspectives to successful operational improvement.  In order to find the focus suppliers, segmentation method is good and used tool for creating strategies for supplier and material management that are effective and functional. As supplier categorization is usually done by sourcing managers, the viewpoint in literature and practice is usually rather strategic than operational and therefore the focus is not optimally linking the performance of inbound and outbound operations. As improvement actions should be baselined to actual observations of organizational performance, Giannakis (2007) points out that performance measurement has been one of the main concerns for academics and managers.

On the other hand, supply chain management is according to Forslund and Jonsson (2009) largely about process integration in up- and downstream sides of the operations. To combine these two aspects of business operations, this thesis considers supplier management from material flow perspective. To do this, service level improvement is taken as main performance improvement focus area of the study. This is done in supplier interface, because as Stanley and Wisner (2001, 288) state "– purchasing's role is particularly important as an intermediary in the supply chain between external suppliers and internal customers who provide products and servicess for external customers". Furthermore, they point out that purchasing's service quality is made in supporting areas such as inventory control and warehousing. Therefore, for example safety levels are one of the key factors from outbound service level perspective.

The framework to the thesis is in the service business and furthermore in the material support operations for maintenance of technical equipment in a situation in which the total replacement of the equipment is not possible. In other words, the focus of this thesis is in spare parts support for service and service business, as the case study considers this framework. For this kind of business, it is important to be able to provide on time support of materials to the service business to minimize the downtime of the serviced equipment and therefore maximizing the end customer experience. As Prajogo et al. (2012, 128) point out in their conclusions, supplier development as a part of supply chain management has significant effects on delivery, flexibility and costs while supplier selection affects mainly to the quality. They continue that it is not needed for companies to implement broad range of supplier management practices, because it is more important for them to understand their own objectives and then select the specific supplier management practices to support the overall operations and gain the desired performance outcomes. In this thesis, this perspective is applied in business unit environment and with the overall objective of providing better delivery service performance for internal customers. From the perspectives and findings of Stanley and Wisner (2001) and Prajogo et al. (2012) the focus of this thesis can be encapsulated to connect the up- and downstream performance of supply chain from purchasing organization perspective and to create the way for improvements from delivery timeliness perspective.

As said, this thesis is combining two theoretical backround focus areas, supplier management and material management. In more detail, supplier and material categorization is considered to respond to the challenge of effectiveness towards improvement actions in supply operations. On the other hand, as inbound and outbound operations of warehouse or distribution center, that does not provide value adding services to the products, effective material management and material flow in material supply is taken into close consideration. This is done by using service level as a performance indicator, and by doing this, the material supply operations are linked to the sales operations and thereby to the end customer experience. Therefore, as service level is measuring the operational performance in dyadic level in both supplier and customer side, it is important to link these two parts of delivery chain together in order to study the possibilities for improvevents on this sector of business.

## *1.1 Conceptual framework and research questions*

Theoretical background of this thesis lies in supply chain management and supplier management. As the level of these two approaches to business are different, it can be said that the concept is in supply chain management which ends up to end customer, but the main focus still is in the supplier-purchaser interaction. Therefore, the approach is rather practical than theoretical based and also from business perspective more operational than strategic. Of course, strategic perspectives are taken into the analysis, but the main topic of service performance and material availability in distribution center is studied in operational level as delivery times are in the center of the analysis. The most basic level view to the conceptual framework is illustrated in figure 1.1.

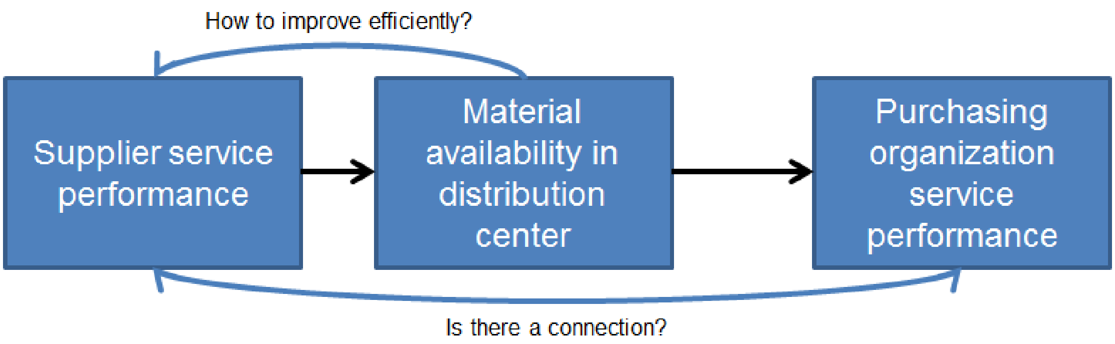


Figure 1.1 Conceptual framework of the thesis

As seen, the framework of this thesis includes two concepts in the top-most level: service performance and material availability. Service level can be, as the figure depicts, measured in both supplier-to-company and company-to-customer transactions. Between these is the concept of material availability, which in general can be defined simply to anwer to the question: Is the required amount of material available to be sold and shipped in the warehouse shelf when the customer demand takes place?

The more interesting part of the conceptual framework is the two questions between the boxes. As it is obvious that material availability is in relationhip with both ends and their service level, it is a fair question to ask that are there simple connection between these two service levels. This perspective was chosen to be the first research question of this thesis.

*Research question 1: Is there a statistically significant connection between inbound and outbound service performance of a distribution center?*

As the above research question is not specific enough in order to test it with unambiguous hyporthesis, additional sub ordinateresearch questions should be introduced. As there are two perspectives to be tested, the focus should first be in correlation and the in the more specific connection type such as regression. Therefore, the subordinate research questions can be stated as:

*Research question 1.1: Does correlation exist between inbound and outbound service levels of a distribution center?*

*Research question 1.2: Is the connection between inbound and outbound service levels of a distribution center linearly formed?*

Two separate hypotheses result from these subordinate research questions. The first one includes the correlation perspective and the second the linearity of the created model. The hypotheses are:

*Hypothesis 1: Inbound and outbound service levels of a distribution center correlate with each other.*

*Hypothesis 2: Linear regression model describe the best the relationhip of inbound and outbound service levels of a distribution center.*

These hypotheses are studied by using statistical analysis methods to study correlation and regression of delivery service performance in these two business interfaces.This is done by simple analysis between the service performances to test if it is possible to create a model that is simple to maintain and report, but gives as an outcome the answer to the question of should this phenomenon in supply side of a distribution center be taken as an improvement objective when outbound service performance is improved.

The second research question is then related to the upper arrow in the conceptual framework picture. The premise of this research question is that there is always need to improve and develop the interface between supplier and purchasing organization. To limit the scope of the thesis, only material availability has been taken into consideration. With these limitations, the second research question specified as:

*Research question 2: How can priorities be identified and prioritized in supplier management from lead time accuracy point of view?*

On the contrary to the first research question, the second research question is rather inductive than deductive as the focus of this part is to compile prior academic literature to create new piece of theory. Additionally, this part of research is qualitative as the research question does not indicate any hypothesis to be tested. The theoretical model will contain two parts, supplier segmentation and development processes to the most critical segment. As stated, the basis for these two parts is in the previous supplier and supply chain management literature.

## *1.2 Methodology*

The scope of this thesis is divided in two perspectives. On one hand, the service performance is studied in the interface between supplier and distribution center and on the other hand supplier classification model with development processes is created on the basis of previous research. As the objective of this thesis is to test the relationhip of inbound and outbound related service performance to each other by using statistical analysis to test the defined hypothesis, the research approach is therefore theory testing or in other words deductive (Saunders et al. 2009, 124-125). The process is the same as Saunders et al. (2009) refer, the sequential approach including five steps that have been introduced by Robson (2002). These five steps are deducing a hypothesis from theory, expressing the hypothesis in operational terms, testing the hypothesis, examining the results, and modifying the theory in the light of findings. The examination of results in this case is in general the phase in which it is stated if the test results confirm the theory or not. Therefore, the final step is done only if the results do not completely confirm the underlying theory. In general, the design of this thesis is mixed method research on sequential manner as the premise of qualitative phase is the result of quantitative analysis. Some amount of coding is used in literature analysis in order to build a framework that fits to the case study context and also justifies the made decisions in model building phase. (Saunder et al. 2009, 151-153)

The basis for the quantitative research includes the annual data of year 2013. For the sample selection, propability sampling is used to ease up the analysis. Four stage sampling process specified in Saunders et al. (2009, 214) is used to create the test sample data in order to test the defined hypothesis. Two sample sets are used to test the hypothesis. At first, the suppliers that provide materials that have the most outbound lines from the distribution center are taken into consideration. As this sampling type does not represent well the whole population, also systematic sampling is used. This sample set is built so that every tenth supplier is taken when suppliers are arranged by the amount of outbound delivery lines of the distribution center at issue connected to the materials provided by the supplier. (Saunders et al. 2009, 226-227)

Additionally, delivery data is collected to single spreadsheet to which the on-time delivery is coded to be 1 and late delivery to be 0. By using this method, all of the deliveries are given the same emphasis and percentage of on-time deliveries are calculated from the relevant time frame. In the case study, weekly service levels are analysed. In the coding phase of the study, nominal and discrete integer data (delivery time in days) is converted to dichotomous or in other words, two level data. After this conversion, relative share of on-time deliveries are again approached from continuous perspective (percentage) and this resulting data is then used in the analysis phase of the study (Saunders et al. 2009, 416-419). Additionally, basic statistical descriptive graphical presentation methods are used to illustrate the findings of the analyses. Histogram and box plot are used to illustrate the delivery time. After that, linear regression model is used to test the hypothesis (Montgomery 2005, 374-378).

The results of the deductive research are used to create the novel approach to the supplier segmentation, and therefore this second step can be seen to take an inductive approach (Saunders et al. 2009, 125-126). As the qualitative research approach is not usually linear and straight forward, it gives the possibility for the research to deviate from the original chosen plan if the research design is specified to give this possibility. Usually this is caused by the fact that multiple unexpected factors occur that could not been anticipated when the research plan was created. This leads to circular in which the process goes back and forth between the steps of the research plan (Eriksson & Kovalainen 2008, 26-31).

In this thesis, the second part of the research plan is to create a model and therefore, the outcome is highly connected to the results of the first, quantitative, part of the study. As literature review is done to build a foundation to the theory building phase of the thesis, there are also moments in which more information is needed in order to succesfully create the supplier segmentation model and development processes related to it. Furthermore, the foundation is combined from theoretical consepts and actual empirical research results as is adviced to be done by Eriksson and Kovalainen (2008). It is also important to use these previously built theories and found research results to direct the research process of the thesis as well as the focus in order to frame it (Eriksson & Kovalainen 2008, p. 41-43). This approach is more considered by Saunders et al. (2009, 147) as they use the spiral model to explain the qualitative research process. In this methodology cycle of diagnosing, planning, taking action and evaluating, is arranged so that after evaluating phase the next round of spiral starts again from diagnosing phase, but now the analysis is done on top of the previous cycles. The supplier segmentation model presented in this thesis is built by using this spiral research strategy (Saunders et al. 2009, 148).

## *1.3 Structure of the thesis*

At first, introduction to the topic, scope of the thesis and the used research methodology is presented. After this, literature review is performed in chapters two and three. The first literature review chapter considers supplier development in the context of material and supplier segmentation models. Chapter three includes supply chain management perspectives to delivery accuracy and supplier service level from consept, measurement and development perspectives.

After literature review, the empirical part of the thesis is reported. In this part, qualitative analysis and its results are presented at first. After that, supplier segmentation model for material availability improvement perspective is constructed. General level development processes are specified after the creation of segmentation model. Additionally, improvement strategy for the most critical supplier segments identified in the performed supplier segmentation model is proposed. After the case study part of the thesis, discussion and conclusions are presented.

# 2 SUPPLIER AND PURCHASED MATERIAL SEGMENTATION

It is every firm’s and business unit’s goal to perform business with at most cost effective way. In order to reach this goal, risks should be managed and processes developed to find the ways to, at the same time be cost efficient, but give the best possible customer service. As customer point of view should be kept at the top of the priorities, this will affect the whole corporation as a forward driving force for business and process development. Furthermore, as cost effectiveness and risk management are some of the other goals, prioritization should be performed for development and controlling actions. This objective can be partly obtained by the means of supplier management.

In this thesis purchasing operations are divided the same way as Kraljic (1983) did in his article “Purchasing must become supply management”. The idea of portfolio models in not new, as according to Nellore et al. (2000) the idea dates back to the 1950’s and Markowitz’s (1952) article about portfolio selection in the management of equity investments. Portfolio models have been used in strategic planning, in which supply management belongs to, since then (Nellore et al. 2000, 245) and as Olsen and Ellram (1997a) state; Boston Consulting Group’s growth/share matrix is maybe the most used portfolio model. The benefit for using portfolio models in managerial decision making is specified by Turnbull (1990, 20-21) to be the possibility it gives to the management to graphically illustrate the position and currect health, the projected future position as well as desired future possession of the company. On the basis of these portfolio analyses, management can then identify the key strategic issues to be taken into closer attention (Turnbull 1990, 21). It is also stated that portfolio models should be used so that the limitations of the models are taken into account and the usage of the portfolio models should be done (Turnbull 1990; Olsen & Ellram 1997a; Nellore et al. 2000).

In this chapter, material categorization models from purchasing perspective are considered first and after that previously introduced ways for supplier segmentation are outlined. This same view is explaned by Hallikas et al. (2005) by dividing supplier classification to continuum approach and portfolio approach. The former can be seen as one dimensional approach that classifies the suppliers to a segment in continuous line between two extremes. For example, suppliers can be segmented by identifying the relationship depth and categorizing the supplier to line between arm’s length relationship, and pure partnership. The second classification perspective, portfolio approach, suppliers are divided to groups by using two dimensions (Hallikas et al. 2005). These dimensions have been chosen to be the most convenient for the analysis. Also complexity of dimensions should be considered as too large complexity will be too resource consuming and too low complexity would not fulfill the purpose of the analysis in a proper way, or in other words some relevant and necessary perspectives might be left out of the analysis (Olsen & Ellram 1997a). Rezaei and Ortt (2012) criticize also the classification models in use by pointing out that the models in use are static and that the excessive amount of different classifications should be combined to under one more general and complete classification model. Therefore, they suggest this model to be calld as multidimensional, but in the end, it is again one two dimensional approach to supplier classification.

In addition to the material and supplier classification models, it is possible to inspect the procurement situation itself. This can be done by using for example buyclass framework as Anderson et al. (1987) did while referring to Robinson et al. (1967) theory of buyclasses. This framework considers purchasing situation by its novelty, problem novelty, the amount of information required and amount of consideration of alternatives to be investigated. As this framework does not consider actual material flow perspective of supply operations, it is not further introduced in this thesis.

Kraljic (1983) rationalizes the need for supplier and purchased material categorization to be the long-term availability ensurance. Especially he considers critical materials for production and the most cost-effective way of managing the procurement operations of these materials. Furthermore, he claims that in order to ensure this approach to be successfully taken care of the perspective should be more in strategic than operational purchasing (Kraljic 1983, 110). This was stated already on the 1980’s and has after that gained a lot of visibility to which this thesis will also go more in depth in this chapter. It gives also one of the main premises of this thesis by considering the categorization of supply operations in both material and supplier level. As Olsen and Ellram (1997a) conclude, the material and supplier level analyses are not separate from each other, but are successive steps in the analysis which ends to prioritization of action plans according the these predecessor steps.

The basis for supplier segmentation and categorization is in strategic planning and marketing, as customer segmentation via using portfolio models has been the driving force also for managing supplier base (Olsen & Ellram 1997a, 101). Furthermore, Olsen and Ellram (1997b) grouped research of buyer-supplier relationships to three different parties of researchers: Marketing literature, purchasing literature; and literature made by the International Marketing and Purchasing Group (IMP). They also codified the previous research to conseptual, empirical and to a class that combines these two research approaches. Olsen and Ellram (1997a) define supplier management to include supplier selection, purchase order management, product delivery, quality control and payments related to purchase orders. They conclude that via effective supplier management, company's logistics costs can be decreased and furthermore financial perforemance improved. As all development actions require investments, supplier development is not an exception and as Day et al. (2010) point out, if company decides to invest in supplier realtionships it must allocate its limited resources on a most effective way. For this, supplier segmentation is a tool to execute performance improvement in supplier relationship management and it should therefore be used to put the efforts to the supplier relationships that are expected to return the highest value for purchasing organization (Choi & Krause 2006). Additionally, Olsen and Ellram (1997a, 103) point out that the process of performing this categorizing work for the materials can be even more important than the categorization itself as it forces the decision-makers to discuss and agree the importance of different types of products, suppliers, and relationships.

Several names of the topic has been used in previous publications such as supplier segmentation, supplier categorization and supplier classification. In this thesis, all of these names are used in the meaning of dividing suppliers to several groups in order to manage supplier base effectively. As material and supplier segmentation models have significally different perspectives, they are divided to separate subchapters. This perspective is also recommended by Olsen and Ellram (1997a, 103) to be taken as they point out that multi-step approach should be taken to respond to the criticism towards portfolio approach.

## *2.1 Material categorization in supply management*

Portfolio models for supply material categorization have received much attention since its birth in the 1980's. The origin of portfolio models is stated by Nellore et al. (2000) to be in Markowitz's article published as early as 1952. The best known supplier segmentation model has been said to be Kraljic's (1983) model in which he builds a two dimensional material categorization matrix that divides the purchased materials into four groups. Kraljic's material categorization model has had significant effect on industrial purchasing and has been widely used by researchers as well as in the business environment, although there are also other models developed to framework material management from purchasing perspective (Gelderman & Semeijn 2006, 211).

### *2.1.1 Material categorization models in inventory management*

In most cases, the priorization of inventory management efforts is done through categorization of materials. In order to keep the focus in the most important materials, priorization methods should be used. As Tersine (1988, 512) points out inventory control procedures should isolate those items requiring precise control from other items that can be controlled with less precision." From this perspective, two models can be introduced, ABC inventory analysis and XYZ material classification.

ABC classification method can be defined as analysis technique that ranks the materials or items according to their annual turnover as Scholz-Reiter et al. (2012) define the method shortly.  Tersine (1988, 512) continue to define the classification so that class A materials dollar volume accounts for 75 to 80 percent of the total inventory value while representing only 15 to 20 percent of inventory items. Furthermore, B materials dollar volume accounts for 10 to 15 percent of the inventory value, but represents 20 to 25 percent of inventory items. The C class includes the low value items and therefore it represents only 5 to 10 percent of the total inventory value, but includes 60 to 65 percent of the items in storage.

The other way to create basic material classification from operational perspective is the XYZ-model. In this approach, materials or items are categorized to classes from the basis of the regularity of their usage. Scholz-Reiter et al. (2012) summarize this classification method so that X-materials have some extent of constant consumption and major fluctualtions for material in this group are rare; Y-materials have stronger fluction in consumption than in X group materials and these items have usually trend-moderate or seasonal reasons for the fluctuations; and Z-materials that have completely irregular consumption. Although, the regularity can be measured by using variation, the XYZ-categorization can be approached by invenstigating the amount of sales. On the contrary to the classification methods presented in the next sub-chapter, ABC and XYZ categorization methods are derived from demand side of operations not from supply side, but as supply side of operations is closely connected to the offering side, these material classification models should be also considered in supply side.

### *2.1.2 Portfolio categorization models*

As stated previously, there are other frameworks for purchased materials classification than Kraljic (1983) purchasing portfolio model. As an example buyclass framework used by Anderson et al. (1987) was mentioned earlier. As purchasing portfolio approach with two dimensional and four categories has got a lot of attention (Gelderman & Van Weele 2003, 207), it is used as an example in this thesis as well to illustrate the idea of categorization models of purchased materials. To generalize the material management approach to supply management, the basic illustration can be stated as seen in figure 2.1.

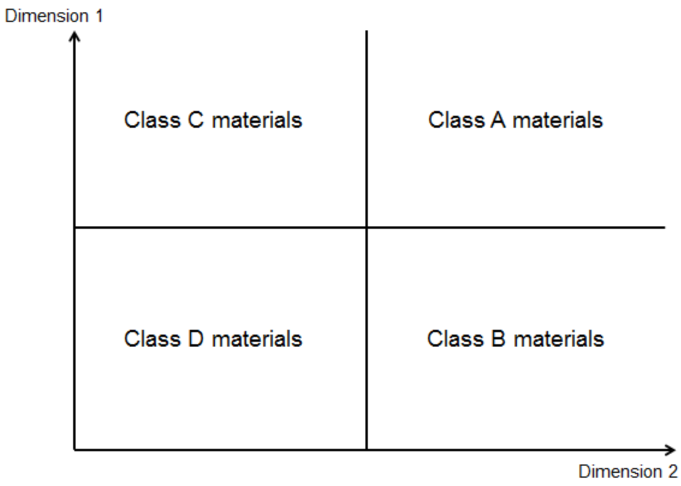


Figure 2.1 Two dimensional material classification matrix

After dividing the purchased materials to these classes, some predefined management processes are applied to the material classes. The purchasing portfolio approach gives the possibility to prioritize the classes so that the improvement and development actions can be done in most value maximizing order. Kraljic’s (1983) purchasing portfolio is possibly the most known approach and therefore it is used to introduce the method. The dimensions used in Kraljic’s matrix are supply risk and profit impact, and classes are named to be strategic, leverage, bottleneck and non-critical materials. This framework is shown in figure 2.2.

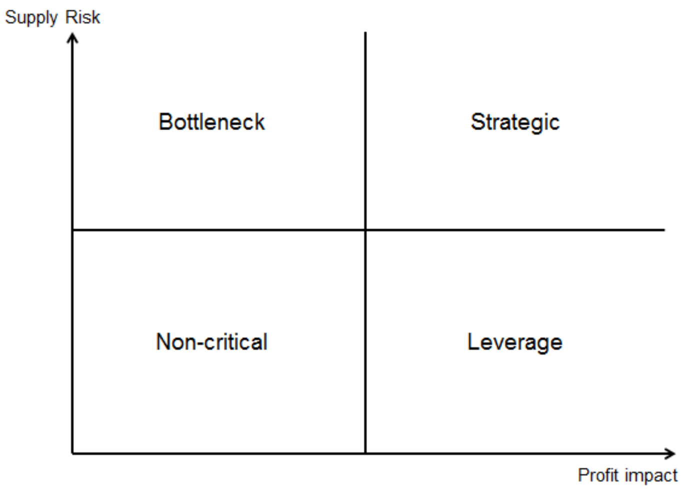


Figure 2.2 Kraljic's (1983) purchasing portfolio framework for material classification

The dimension of profit impact in Kraljic (1983, 112) segmentation model may be one of the following three factors or combination of these factors that are: volume of the purchases, percentage of total purchase cost, and impact on product quality or business growth. On the other hand, supply risk is stated to be measured as availability, number of suppliers available in the market, competitive demand, make-or-buy opportunities, and storage risks and substitution possibilities. By combining these features of material procurement situation, the mentioned four classes can be then understood to bring the outcome that aims to simultaneously minimize supply risk and to achieve the best benefit from the company's buying power. (Kraljic 1983)

As Strategic items have both, high supply risk and high profit impact, these materials are therefore the most critical items for purchasing company to manage effectively and efficiently. Therefore, the main focus should be in these materials in order to manage the purchasing operations and thereby the whole success of the purchasing firm. It will also be required to perform various analyses of the situation, for example market or risk analysis. (Kraljic 1983, 112)

Secondly, as purchasing organization should always focus on the total success of the company it is part of, leverage items are to be focused after strategic materials although materials in this class are not so critical in the terms of supply risk. Kraljic (1983, 112) mentions the strategies for leverage items to be vendor and value analysis, and price forecasting models. He continues that for bottleneck materials specific market analysis and decision models are the strategies to be used. Finally, he states that for non-critical items simple market analysis, decision policies and inventory optimization models will be the management methods to be used. (Kraljic 1983, 112)

Olsen and Ellram (1997a) created the similar two dimensional portfolio model on the basis of Kraljic (1983) and Fiocca (1982). In this model the used dimensions are "strategic importance of the purchase" and "Difficulty of managing the purchase situation". Both of these dimensions are combinations of multiple factors that they base on previous literature on the topic. In Olsen and Ellram –model "strategic importance of the purchase" is a combination of competence, economical and image factors and "Difficulty of managing the purchase situation" includes product, supply market and environmental characteristics. Same naming is used than in Kraljic’s model for the four different categories as seen in figure 2.3 (Olsen & Ellram 1997a).

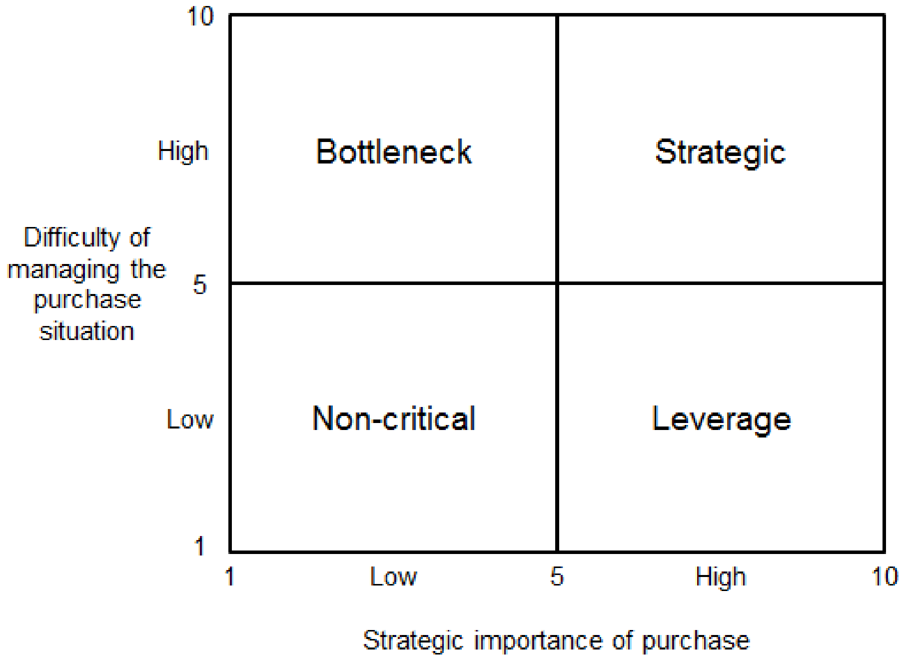


Figure 2.3 Olsen and Ellram (1997a) purchasing portfolio model

As seen, Olsen and Ellram scale the outcome of the factorial analysis to one-to-ten scale before adding the materials to the porfolio models. It is also emphasized by Olsen and Ellram that the choosing of the used factors to calculate the dimension specific number is very subjective and therefore the decision-makers in the company must come to an agreement of the used factors and their relative importance. In their model, Olsen and Ellram (1997a) use the methodology described by Narasimhan (1983) for weighting the factors.

The underlying logic of this factor weighting method introduced by Narasimhan (1983) and used by Olsen and Ellram (1997a) is that it creates hierarchical multi-level structure for the factors chosen to be used. Further on, the idea is to “divide and concure” the dilemma of weighting the multiple factors simultaneusly by grouping the factors to sub-classes.

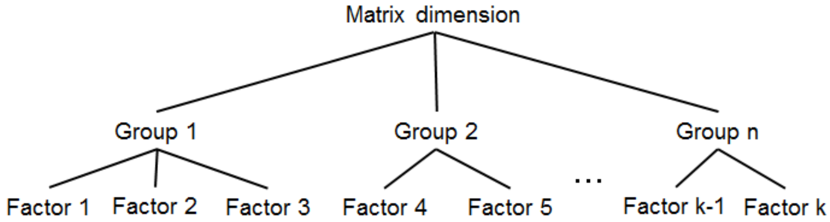


Figure 2.4 Hierarchy for relative weight calculation of analysis factors

To calculate the relational weights for the groups and factors inside the groups, Olsen and Ellram (1997a) introduce the matrix that helps to define the relative strength of each group. The underlying idea is that every two groups or factors are estimated between each other in a predefined scale, for example from 1 to 10. In figure 2.5 x11 to x33 mark these numbers of relative importance.

| | Group 1 | Group 2 | Group 3 | Geometric mean | Weight |
|---|---|---|---|---|---|
| Group 1 | x11 | x12 | x13 | Z1 | W1 |
| Group 2 | x21 | x22 | x23 | Z2 | W2 |
| Group 3 | x31 | x32 | x33 | Z3 | W3 |
| | | | SUM | S | 100 % |

Figure 2.5 Weight calculation table (modified from Narasimhan 1983)

As the matrix design in figure 2.5 show, every group is compared to another group twice. This is, because if there is one factor that is more important than the other, the other should therefore have the multiplicative inverse of the first importance number. This means that for example x21 = 1/(x12). Weight can be now defined by calculating geometrical mean of every line and the then the relative percentage of the sum of the geometrical means. (Olsen & Ellram 1997a; Narasimhan 1983) In matematical presentation this can be defined as:

$$W1 = \frac{Z1}{S} = \frac{Z1}{Z1+Z2+Z3} = \frac{(x11*x12*x13)^{\frac{1}{3}}}{(x11*x12*x13)^{\frac{1}{3}}+(x21*x22*x23)^{\frac{1}{3}}+(x31+x32+x33)^{\frac{1}{3}}} \qquad (2.1)$$

After performing the weighting to groups or upper levels in the hierarchy and in the lower levels of the hierarchy (factors), the weight that one lowest level factor has to the matrix dimension can be calculated by multiplying the lower level weight with higher level group and so on until the highest level is reached. This way the lowest level analysis will get easier to perform as there are fewer factors to be considered against each other. The methodology can be scaled to as many levels as convenient for the analysis. It is also stated that the usage of the complete scale is very important in order to get enough differentiation between groups and factors. As the analysis is subjective to the company, the relative weights and results cannot be generalized so that different companies could be compared to each other. Therefore, the only conclusion that can be made is that this method can be used to allocate the limited resources to the most important purchases and suppliers. (Olsen & Ellram 1997a, 112-113; Narasimhan 1983)

### *2.1.3 Development strategies for material categories*

The classification of purchased materials itself has no importance in supply management if further development plans are not made. Kraljic (1983) used the purchasing portfolio matrix to identify and manage strategic materials, but after this, there have been others, for example Olsen and Ellram (1997a) and Bensaou (1999), to complete this gap in research and purchasing management theory (Caniëls & Gelderman 2007, 220) The underlying statement of Kraljic (1983, 112) was on the other hand that all of the categories require their own purchasing approach. He continued that these approaches should be developed so that the complexity of the analysis and actions is in the correct level when comparing it to the strategic importance of the purchase. Therefore, the effort for the management of a material category should be relative to its importance to the purchasing organization and the company it represents. It is also stated by Kraljic that the management level for these material categorizations should differ as the decisions concerning strategic materials should be done in the top level of the purchasing organization and the others in a lower levels in a decreasing order of importance so that non-critical materials can be managed in the purchaser level. (Kraljic 1983)

The Kraljic's (1983) development orientations are introduced by Caniëls and Gelderman (2005, 142) so that for strategic items partnership relationship should be formed; for leverage items the purchasing power of the company should be exploited; For bottleneck items supply should be simply assured; and in the end non-critical items should only be considered from efficiency perspective. As said, Caniëls and Gelderman (2005) criticize this simplifying and static view that Kraljic (1983) draws about material management level of purchasing and therefore they refer to more detailed development approach to the issue made by Gelderman and Van Weele (2005). As this more advanced strategic direction overview was gathered by performing survey to the purchasing professionals to collect the most used strategies for the categories, it shoud give more holistic and realistic view of actual business development pespectives. The model is illustrated in figure 2.6.

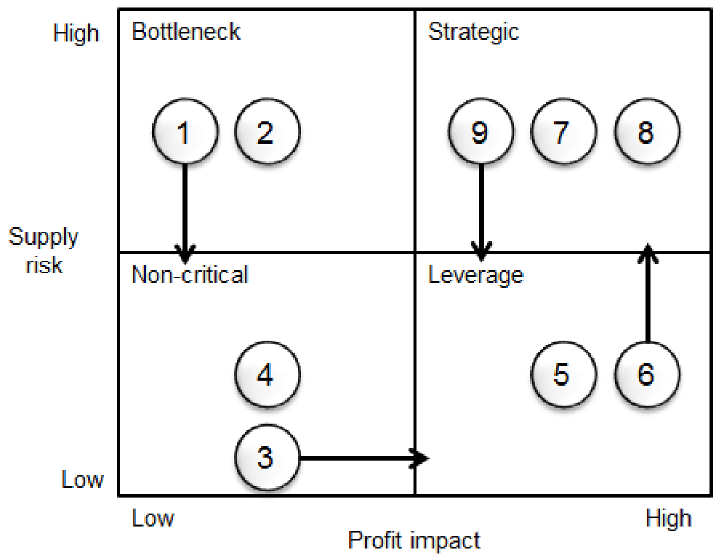


Figure 2.6 Purchasing strategies (modified from Gelderman and Van Weele 2003)

Gelderman and Van Weele (2003) adds more dynamic perspective to the Kraljic's (1983) original purchasing portfolio matrix, but they also keep some of the original strategies in place. As strategy for bottleneck materials were define by Kraljic to be just to assure the suppy which could be seen the same strategy that Gelderman and Van Weele name as (2) "accept dependence". They also also point out that if dependence is only accepted, also negative consequences should be controlled and reduced. This leads to the second strategy they identified in their study, which is to (1) reduce the dependecy and risk. One way of doing this and moving the material towards less supply risk is to try to find alternative solutions that are less risky. For non-critical items, Gelderman and Van Weele found alternative strategy for (4) enhancing to be (3) pooling of requirements and thereby moving the item position in the matrix towards leverage category. As in Kraljic's model, (5) using the buying power is the action for leverage materials if there are no intention to move the material between the mentioned categories. For these materials the need for moving between strategy categories is more likely to come as the need is changed and therefore (6) developing strategic partnership and moving the material towards strategic items category may come to question. Finally, Gelderman and Van Weele found out that there are three strategies to handle the strategic materials group. Two of these, (7) maintain strategic partnership and (8) accept the locked-in 'partnership', are static and the final one (9) terminate partnership and find new supplier is dynamic from the categorization point of view. (Gelderman & Van Weele 2003)

Both of these strategy framworks can be seen as simple lists of options considering: what are the options that could be done when a material is categorized to belong to a group. From the other material classification matrix that was introduced earlier in this chapter, The Olsen and Ellram –model, the authors propose also some ways of managing the materials on the category level. For leverage class materials, they emphasise the importance of supplier relationship and especially the need to identify the value added by these materials, and the possibility to lower costs in the product lines and suppliers to increase the operational efficiency by sharing the future requirements. The low importance and low difficulty category named as "non-critical materials" is stated simply to be managed through standardization and consolidation. The key for material and supply management in these cases is to reduce the amount of suppliers and to develop supplier relationships that need as little attention or maintenance as possible, and thereby the main focus is to reduce the administrative costs. (Olsen & Ellram 1997a)

The bottleneck category receives four approaches from Olsen and Ellram. The first of the solutions is standardizing the purchases and trying to find substitutes for the materials. The other options are to involve supplier into the purchasing organizations' goals by performing joint value analysis and engineering effort to gain cost savings through collaboration. As said the most important materials to be taken into consideration are strategic items. Joint product and service development as well as early supplier involvement strategies should be implemented for strategic items. The way supplier should be seen is stated to be as the extension of the purchasing company, which means that the relationship focus should be long-term and poor performance minimizing in nature. (Olsen & Ellram 1997a) This strategic material category thereby would in many occasions require partnership approach or relationship similar to it.

## *2.2 Supplier segmentation*

Supplier segmentation models are not a new topic in supplier and supply chain management. As Day et al. (2010) point out by referring to Swink and Zsidisin (2006) there is no holistic supplier classification that link the supply management and its strategic side to the value building and risk reduction. They continue that the most popular supplier segmentation model has been portfolio model, especially Kraljic's (1983) model that, despite its popularity, is not the earliest supplier portfolio model (Day et al. 2010, 626). Supplier portfolios or segmentation models are used to divide the supplier management between supply managers in the company by for example the basis of supplier products, location, size or other such feature. Although, suppliers end up to be classified in the same group, they still need to be handled independently as all of the cases are some what different and should be treated differently (Olsen & Ellram, 1997). As segmentation models divide the heterogeneity of supply network into groups, the possibility of creating interorganizational supplier relationhip level governance structures in strategic and tactical levels is made possible (Day et al. 2010).

To consider business relationships and their power balance is a common strategic management issue. It is studied extensively from for example transaction cost economics perspective. From this framework, also segmentation models have been created. For example, Ring and Van de Ven (1992) create a two dimensional segmentation model for business transactions. From the basis of their proposals they end up choosing the matrix dimensions to be “Risk of the deal” and “Reliance of trust among the parties”. As supplier segmentation models are very often built to consider some supplier-buyer relationship in some two dimensional perspective, this general business transaction segmentation model, introduced in figure 2.7, can be used as an introductial example to the topic.

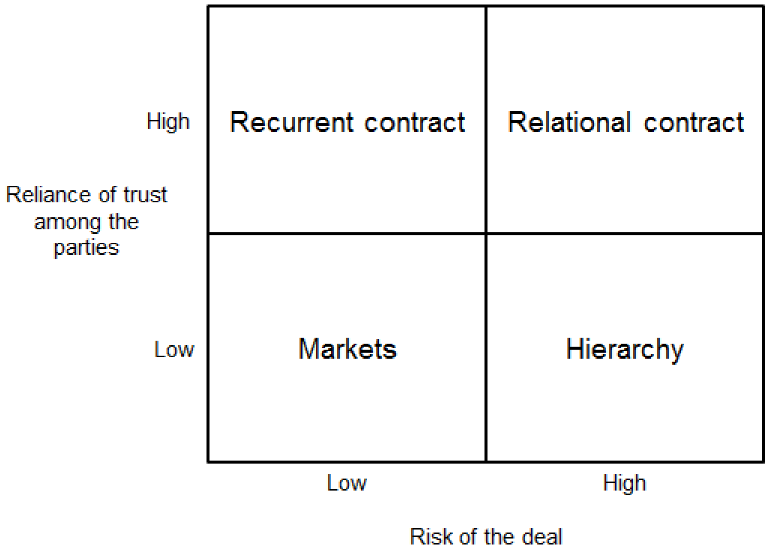


Figure 2.7 Business transaction governance structures (Ring and Van de Ven 1992)

As this example shown in above figure is in very general level, only the studies from supply management perspective are considered in this literature review. In addition to transaction cost economics, the industrial network approach or simply supplier segmentation from production, and research and development perspectives can be taken as the premise to the segmentation model. (Dubois & Nellore 2002; Nellore et al. 2000) For example, Nellore et al. (2000, 253-254) use Kamath and Liker (1994) typology for dividing suppliers into four classes from product development perspective: Partner, Mature, Child and Contractual suppliers. In this sub-chapter, many of the introduced supplier segmentation frameworks are relationship and risk based, and therefore indications of this typology can be seen from the segmentation models and their perspectives to supplier development. At first, the topic of supplier segmentation model is introduced by taking some examples into closer focus. Although, it is not appropriate to collect all of the supplier segmentation models, as it was not appropriate in material level either, the introduction to supplier segmentation models is not complete. This is because the focus of this chapter is only to introduce the possibilities of supplier segmentation in supply management.

### 2.2.1 Supplier segmentation models

Every categorization requires variables that specify the dimensions in which the chosen phenomenon of subjects is studied. Therefore, after 1980's and Kraljic's (1983) purchasing portfolio approach becoming popular among the researchers and practitioners, many supplier categorization methods has been created. (Rezaei & Ortt 2012, p. 4596) Dubois and Pedersen (2012, 37) state that purchasing portfolio models have become widely used because the easiness of understanding and communicating the results as well as the practical guidelines that it gives for different purchaing situations. They also add that Kraljic's model is good tool for visualization of purchasing situations.

Many of the supplier classification methods are suitable for a focused, usually strategic, objective that has been taken as an improvement target (Dubois & Pedersen 2002, 35). Rezaei and Ortt (2012) consider the amount of different supplier segmentation methods to be a problem and therefore they create a model that makes an attempt to combine the previous segmentation models under one umberella. This framework is stated to be multidimensional as the others are seen as two dimensional four-field models. In the end, Rezaei and Ortt (2012) end up creating also the same kind of two dimensional and four-field presentation of supplier segmentation, the difference being that in their model, there are multiple variables under the two dimensions. Some of the segmentation models are collected to table 2.1 (Dubois & Pedersen 2002; Rezaei & Ortt 2012). The list is not complete, but gives a sufficient idea of the two dimensional supplier segmentation matrix models introduced in the different areas of supply management.

Table 2.1 Supplier segmentation models

| Author | Number of dimensions | Segmentation Dimensions |
|---|---|---|
| Kraljic (1983) | 2 | • Company strength<br>• Supplier strength |
| Olsen and Ellram (1997a) | 2 | • Relative supplier attractiveness<br>• Strength of relationship |
| Bensaou (1999) | 2 | • Supplier’s specific investments<br>• Buyer’s specific investments |
| Kaufman et al. (2000) | 2 | • Technology<br>• Collaboration |
| Masella and Ran-gone (2000) | 2 | • Time frame<br>• Content |
| Svensson (2004) | 2 | • Supplier’s commitment<br>• Commodity’s importance |
| Hallikas et al. (2005) | 2 | • Supplier dependency risk<br>• Buyer dependency risk |
| Rezaei & Ortt (2012) | Multidimensional with 2 major dimensions | • Willingness<br>• Capability |

As the second phase that Kraljic (1983, 112) identifies to be done after material level classification is the market analysis phase. In this phase Kraljic takes the discussion further to supplier level by comparing the strength, or on the other words replationship power, between purchasing organization and supplier. This is illustrated in figure 2.8, in which purchasing power situation toward purchasing organization is colored green. On the other hand, red squares mark the situation in which supplier possesses more relationhip power. Through this framework, strategic positioning can be mapped and the Willingness criteria, specified by Rezaei and Ortt (2013), quantified.

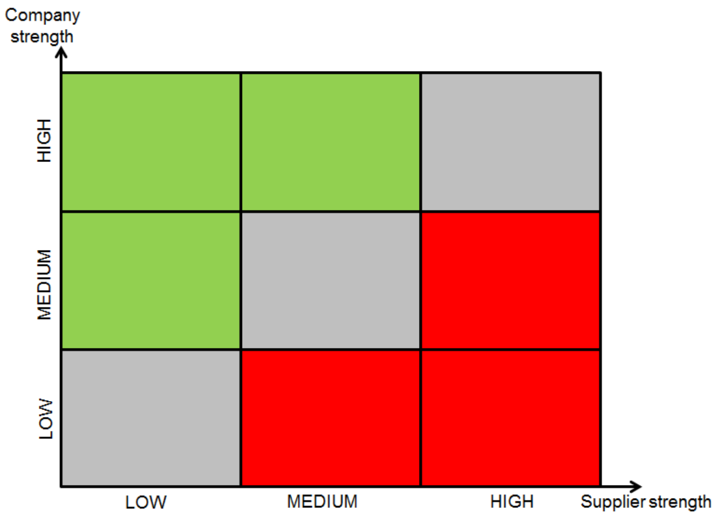


Figure 2.8 The Purchasing Portfolio Matrix (Kraljic 1983)

The criteria from Razei and Ortt (2013) framework perspective would be that capability criteria would include Kraljic's Supply Risk perspective, shown in figure 2.8, including profit impact. On the other hand, Willingness criteria can be identified from The Purchasing Portfolio Matrix as a combination of the axis of the matrix and the strategies specified from the positions in which the purchasing business relationship is part of.

For portfolio approach to supplier relationships management, Olsen and Ellram (1997a) propose three step process, which is very similar to Kraljic's model. The first phase, "Analysis of the Company's Purchases", follows the framework of previously published Kraljic's model. This portfolio model divides the purchased items to similar groups as Kraljic's model, but names the dimensions to "difficulty of managing the purchase situation" and "Importance of the Purchase". The second phase, "Analyze the Supplier Relationship", considers two factors named "Relative Supplier Attractiveness" and "Strength of Relationship", and therefore takes a slightly different view than Kraljic's model which can also be seen from the figure 2.9.

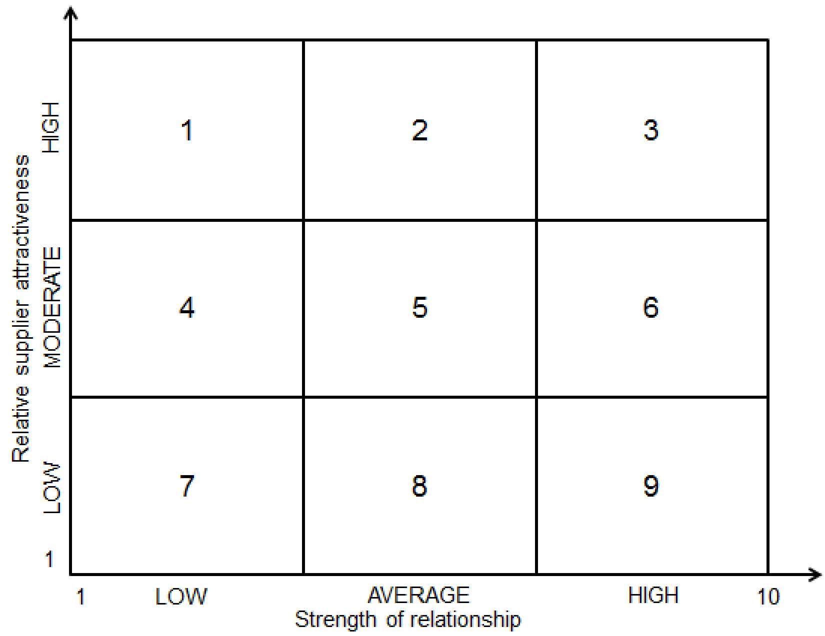


Figure 2.9 Olsen and Ellram (1997a) supplier segmentation model

Both dimensions in Olsen and Ellram –model were divided into groups and factors in the same way than was done in material categorization model. Relative supplier attractive was divided into six groups: Financial and economic; performance; technological; organizational, cultural and strategic; and other factors. For all of these goups of factors, they present two to eight different factors to be considered. The other dimension in Olsen and Ellram –model, "Strength of Relationship", Economic factors, exchange relationship characteristics related issues, cooperation and distance are considered. Economic factor in this context can be emphisized to be the mutual interest to the business relationship and easiness of exit related questions. For these groups three to five factors were identified to belong in the groups. The final step in supplier relationship portfolio approach, for which the supplier segment numeration was applied, specified by Olsen and Ellram is "Develop Action Plans" -phase that is very similar to the last step in Kraljic's model and will be focused more in detail in the following sub-chapters. (Olsen & Ellram 1997a)

As Rezaei and Ortt (2013) point out in their introduction to the topic, supplier segmentation is supplier management phase that comes right after supplier selection and is needed for dealing with suppliers in a systematic way. They also argue that as there has been several proposals for two-dimensional supplier segmentation models after the introduction of first supplier segmentation models in the early 1980's, these dimensions should be combined to under more common framework to be able to move from "one-fits-all" strategies toward more flexible multi-dimensional approach. Therefore, their proposal for the division is to group these previously identified classification criterias under two perspectives, capability and willingness criterias that form the basis for segmentation. (Rezaei & Ortt 2013)

This means that both of the criteria include more sophisticated calculation with prioritization between factors. In addition to this, Rezaei and Ortt combine in their model previously presented two of the first steps of purchasing portfolio management introduced by Kraljic. In this so called multi-dimensional presentation introduced by Rezaei and Ortt, capabilities include many of the factors and viewpoints previously presented in the first item level approach that was presented in figure 2.1. As willingness includes the mutual strength perspective presented in figure 2.2, the Rezaei and Ortt –model, shown in figure 2.10, can be seen as more sophisticated way of performing purchasing portfolio management. (Rezaei & Ortt 2013)

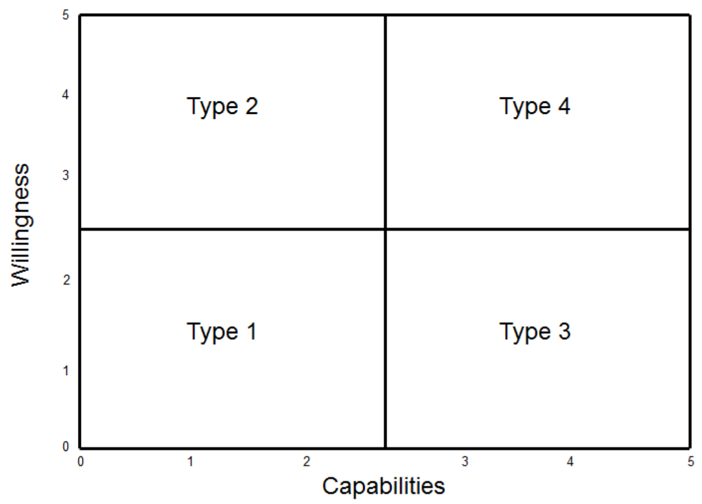


Figure 2.10 Multi-criteria supplier segmentation model (Rezaei & Ortt 2013)

The viewpoint that this multi-criteria supplier segmentation presents is the segmentation of supplier according to their potential. As seen from above figure, Rezaei and Ortt (2013) name the segments to types. Type 1 suppliers are specified to be the worst suppliers as the capabilities and willingness to cooperate with the purchasing organization are both low. The obvious strategy for these kinds of suppliers is replacing them. The only reason to keep this kind of suppliers in supplier base is to use them in high demand peak situations to ensure the material availability. As Type 2 suppliers are willing to work with buyer, the supplier may benefit more than the purchasing company of the relationship, but this might also have an effect to the power balance between the companies. (Rezaei & Ortt 2013)

Type 3 suppliers are on the contrary suppliers that should be kept in supplier base if possible. The reason for the lack of willingness should be therefore investigated and removed, if possible. Rezaei and Ortt (2013) mention partnership as one of the cures for this kind of situation. One criticism for this view is that if the willingness gap is caused by the size difference between supplier and purchasing organization or purchasing organizations' size compared to other customers of the supplier, from the supplier point of view the benefit of partnership approach might not be rational option. (Rezaei & Ortt 2013)

For type 4 suppliers, the partnership approach is almost self-evident as both of the partners benefit from the mutual cooperation. As a consequence, the benefit for purchasing organization would be to decreased prices, improved deliveries, high quality products and services, and other similar business objectives that build up lasting strategic advantage compared to competing business value nets. (Rezaei & Ortt 2013)

In addition to previously introduced supplier segmentation models, also Bensaou (1999), Hallikas et al. (2005), and Mansella and Rangone (2000) constructs their supplier segmentation from supplier relationship point of view. Bensaou (1999) takes the point of captivity and considers the investments the parties have made to the business transactions. In a nutshell the point is that investments made to enable the business transaction by either company creates power inbalance as the party that has invested more to the business partnership has more to loose. Therefore, this company is less willing to withdraw from the business relationship.

Hallikas et al. (2005) takes another very important point of view to the supplier segmentation from relationship perspective, risk. More accurately, the dependency balance is considered. Mansella and Rangone (2000) do, on the contrary, not consider only already selected suppliers, but also supplier selection and relationship perspective. The two perspectives are time horizon and the content of relationship. The former means the anticipated length of time period the business relationship is planned to last. The level of integration between supplier and customer is considered in the other dimension.

Kaufman et al. (2000) take also relationship perspective, but they form it in technology context. Their dimensions, that are collaboration and technology, include relationship balance, power and importance perspectives. It also specifies the possibilities of supplier and customer organizations to contribute to the business relationship from technology perspective. Finally, the last of the supplier segmentation models is segmentation model that combines many perspectives considered in the other segmentation models as well as material and supplier segmentation models. In this segmentation model created by Svensson (2004), the level of analysis is done in rather material level than supplier level and therefore it is not completely comparable to the other models. The dimensions of segmentation are "Supplier's commitment" and "Commodity's importance" to the purchasing organization. Although Svensson's model considers also the supplier-customer relationship it can be seen to be more operational than the other models.

Additionally to supplier segmentation models introduced in table 2.1, more operational ways of managing the purchasing operations can be taken. For example, buyclass framework can be considered while building the understanding on supplier management. Anderson et al. (1987) consider buyclass framework by using buying decision grid introduced by Robinson et al. (1967, 24). This approach is shown in figure 2.11.

| TYPE OF BUYING SITUATION | NEWNESS OF THE PROBLEM | INFORMATION REQUIREMENTS | CONSIDERATION OF NEW ALTERNATIVES |
|---|---|---|---|
| NEW TASK | HIGH | MAXIMUM | IMPORTANT |
| MODIFIED REBUY | MEDIUM | MODERATE | LIMITED |
| STRAIGHT REBUY | LOW | MINIMAL | NONE |

Figure 2.11 Buying decision grid (Robinson et al. 1967, 24)

Buyclass framework takes yet a different perspective of purchasing situation. The purpose of this framework is to consider the purchasing situation, not suppliers or materials as was seen on the previously introduced supplier and material segmentation models. The buyclass framework is nonetheless one perspective to be taken into account when sourcing and purchasing functions are planned. The frequency of purchases, problem newness or information requirements are not so much considered on the supplier selection or segmentation models, but consideration of alternatives is one of the key solutions while developing and managing supplier base. For example, Kraljic (1983) purchasing material classification considers the alternatives for making the decision about risk of purchasing, but takes it from another perspective than buyclass framework.

As seen, there are numerous supplier classifications with different factors, or in other words dimensions, and perspectives. It seems that most of the bi- or multi-dimensional models are constructed from strategic and relationship perspectives and as Day et al. (2010) point out that the key task for buyer in portfolio modelling is to manage supplier base by understanding the nature of these business ties, and use this knowledge to make an assesment and plan how the supplier relationship should be managed by using different supplier management tactics and strategies.

### *2.2.2 Basic processes related to supplier segmentation models*

To simply divide supplier into segments is not enough as seen in the material context. Therefore, many of the authors who have contributed to the creation of the purchase portfolio frameworks or supplier segmentation models have specified framework steps or phases to be taken while performing their analysis. As purchasing portfolio framework and supplier segmentation models have been broadly used, there are extensive amount of approaches to the issue. Therefore, table 2.2 includes only the methods previously introduced and the approaches that were found to have significant additions to the process view.

Table 2.2 Development steps and phases

| Author | Supply strategy related development process steps or phases |
|---|---|
| Kraljic (1983) | 1. Classification<br>2. Market analysis<br>3. Strategic positioning<br>4. Action Plans |
| Olsen and Ellram (1997a) | 1. Analysis of the Company's Purchases<br>2. Analyze the Supplier Relationships<br>3. Develop Action Plans |
| Bensaou (1999) | 1. Classify relationships<br>2. Identify contextual profiles<br>3. Design management profiles |
| Masella and Rangone (2000) | 1. Segmenting of customer/supplier co-operative relationships<br>2. Define selection criteria<br>3. Integrate selection criteria |
| Svensson (2004) | 1. Analysis of business environment<br>2. Analysis of relationship criteria<br>3. Selection of relationship strategy<br>4. Managerial decision of relationship strategy |
| Rezaei & Ortt (2012) | 1. Determine functions and activities that the buyer tends to carry out either internally or externally<br>2. Relative weight for the chosen functions<br>3. Supplier selection<br>4. Categorise suppliers based on functions (step 1)<br>5. Supplier segmentation<br>6. Supplier management<br>7. Supplier development<br>8. Supplier evaluation |

The above table shows that there are plenty of processes from which to choose the approach to supplier segmentation usage. It is obvious that these processes adapt to the context they are used in a way that the process is suitable for the case on hand.

Therefore, the three step approach also used in this thesis to review the purchasing portfolio (step 1) and supplier segmentation (step 2). The third step in Olsen and Ellram -model, development action plans, is divided between the sub-chapters considering the first two steps in order to clarify the material and supplier level approaches to development actions.

For portfolio approach to supplier relationships management, Olsen and Ellram (1997a) propose three step process, which is very similar to Kraljic's model. The first phase, "Analysis of the Company's Purchases", follows the framework of previously published Kraljic's model. This portfolio model divides the purchased items to similar groups as Kraljic's model, but names the dimensions to "difficulty of managing the purchase situation" and "Importance of the Purchase". The second phase, "Analyze the Supplier Relationship", considers two factors named "Relative Supplier Attractiveness" and "Strength of Relationship", and therefore takes a slightly different view than Kraljic's model.

In the Olsen and Ellram –model, the final step, Supplier Attractiveness, consists of financial and economical; performance; technological; organizational, cultural, and strategic; and other factors. Financial factors include sub-factors such as supplier's financial stability and supplier experience related issues. In performance factor, delivery, quality and price are considered. Technological factors include supplier's ability to perform in changing technological environment and patent related issues. Organizational, cultural, and strategic factors include managerial and trust related issues. Finally, in other factors supplier safety and responsiveness to environmental changes are taken into account.

### *2.2.3 Development strategies in supplier segmentation models*

The development process phases work as a guideline to the development projects, but do not disclose any information about how to operate with different supplier segments. Therefore, as seen with material categorization phase of these development strategies, the segmentation should prioritize as well as give guidelines to the development directions of a particular segment. The development efforts can be divided in two classes from the level of perspective. These levels are named to be segment and matrix levels. In segment level, the decision is focused on how to operate with the certain kind of suppliers. In matrix level on the contrary, the development directions are specified between the levels.

As before, the analysis is begun from Kraljic's purchasing portfolio model. In figure 2.8 colours were used to mark the different situations. These three colours are named to be Exploit (green), Balance (gray) and Diversify (red). This model focuses on only the strategic items and creates development plans to only this material segment. Exploit is a group in which the company has more power and therefore it can spread purchases over several suppliers, exploit price advantages, increase spot purchases, and reduce inventory levels. On the opposite side of the matrix, the strategy includes consolidating supply position for fragmented purchase volumes under one supplier, accept higher prices and to cover the full volume requirements through supply contracts. The "balance" category does not require any special ways of management. After positioning the suppliers to the matrix, the company should create long-term plans on the basis of this short-term plan made by using purchasing portfolio matrix. Kraljic introduces also policy issues or perspectives that can be applied to the three groups of suppliers. For example one of the issues is volume that was already mentioned. The other policy issues that Kraljic introduce are price, contractual coverage, new suppliers, inventories, own production, substitution, value engineering and logistics. As seen, this is one example of segment level development plans although the groups actually include several segments of the matrix. (Kraljic 1983, p. 114)

Gelderman and Van Weele (2003) have collected these two development levels into one picture that was already shown in figure 2.9. Segment level of the matrix development case is represented by strategic development plans 2,4,5,7 and 8 that are in some cases the same as in the original model introduced by Kraljic (1983). Development strategies 1, 3, 6 and 9 focus on the directions in which the supplier relationship would in some cases be beneficial to move. (Gelderman & Van Weele 2003)

Although supplier segmentation models are rather young compared to for example marketing related models, multiple different approaches have been taken as an analysis perspective. The main criticism presented against the supplier segmentation models consider the modles to be too static and include less factors that would be needed in order to get holistic understanding of supplier management possibilities and strategies to be followed. It can be therefore concluded that there are as many possibilities to the supplier and material segmentation models as there are possible focus areas. The level of analysis may also vary from generic to highly focused analysis perspective. Therefore, the analysis should be always done so that the outcome suits best to the set objectives.

# 3 MATERIAL FLOW OPTIMIZATION IN SUPPLY CHAIN

Supply chains and networks consist of several consecutive companies or business units. A component or product for one party is usually the product for the predecessor tier. As the supply chain has been widely studied, Chen and Paulraj (2004) introduce the topic by dividing the inspiration for supply chain concept research into five sources including quality, material management, logistics, industrial markets, and increased business focus. They continue that the concept has been named in a multiple ways in the past. In the early 1980's these perspectives were gathered under one umberella that was called supply chain management (SCM). After the birth of this branch of research, there have been many perspectives from multiple levels of business specificity. Usually these perspectives are in some way linked to the performance management systems of a company or network of businesses. As Flapper et al. (1996, 27) states "The success and continuity of an organization depend on its performance". They continue this by defining performance as "the way organization carries its objectives into effect". This requires that the whole organization turn its focus into the same direction.

Usually "looking the same direction" is evident, but as can be derived from the list that was introduced, there are many perspectives to the issue. From a broad perspective, value chain and network can be taken into focus as was done by Kähkönen and Lintukangas (2012). One of the main concepts in supply chain or supply network research is the quality perspective. For example Chin et al. (2006), Taylor and Wright (2003), and Batson (2008) considers the issue in their research articles. Both of these broad level perspectives end up pointing out the point Flapper et al. (1996, 26) was making. The analysis of this kind of broad topics is never simple. Therefore, as Miemczyk et al. (2012) point out by dividing supply network research into three levels, the analysis has been made easier by the researchers and practisioners by taking suitable size topics under the domain of value and performance perspectives.

## 3.1 Definitions in supply network

Supply chain as a concept is usually seen as “a network of materials, information, and service processing links with the characteristics of supply, transformation, and demand”. This perspective consists of three consecutive parts: suppliers, internal supply chain of company, and customers. All of these three parts can be divided into more specific parts. (Chen & Paulraj 2004) For example, the simplified representation of supply chain of centralized purchasing unit of a company can be illustrated as done in figure 3.1. The internal supply chain can differ, because the internal operations of the particular company or business unit usually vary. Additionally, company internal parts of the specified supply chain can in some occasions be a part of make-or-buy decisions as for example services such as warehousing and distribution logistics can be purchased from external supplier.

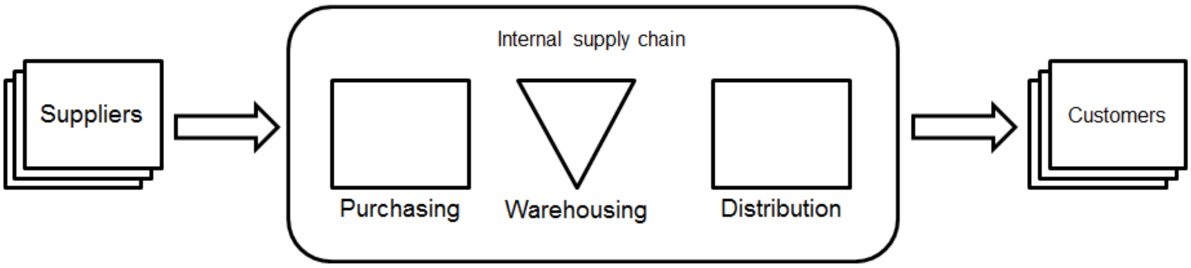


Figure 3.1 Supply chain of centralized purchasing unit

Furthermore, the structure of a network is a combination of companies, business units and functions as all of the external parts of supply chain from a company’s point of view consist of same kind of structures. As end customer product is manufactored in this kind of chains that are combined together in order to get the required functionality to the product, the final operational view is appear more like a network than a single chain. Therefore, in next sub-chapter the structure of supply network is presented.

### 3.1.1 Hierarchical levels of supply operations

Miemczyk et al. (2012) divide the perspectives to supply operations into three levels: dyad, chain and network. These levels are hierarchical so that latter can also be divided into former as can be seen from figure 3.2. For example, supply network consists of chains and chains consist of dyads. Dyad is the simplest structure that can be found from supply network in company level and as production of items and services always demand division of labour, the network model is the most realistic.

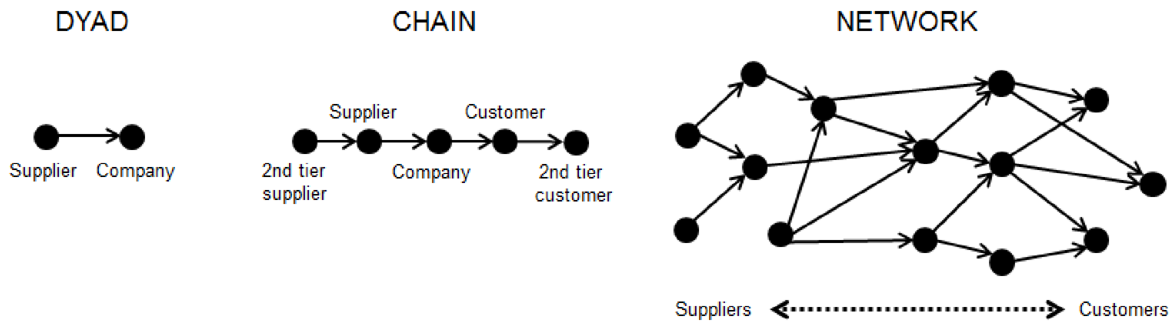


Figure 3.2 Supply chain levels

The network approach brings up the fact that buyer-supplier relationship is not, as in dyad perspective, independent from the other nodes or network entities and therefore Dubois and Pedersen (2002) states that purchasing portfolio approach is not, as such, suitable from industrial network approach perspective. They also point out that the relationships in the network are usually continuous by nature in the industrial environment and therefore the future purchasing situations should also be considered in the SCM practices and in purchasing operations as the relationship evolves over time. Additionally, Dubois and Pedersen (2002) state that as products are formed in the network of companies rather than in one firm, produts can be seen also as "network entities" that reflect the performance of particular network. This is evident because of specialization. Furthermore, the network and chain perspectives have increased focus on tiers further than just one step away from the company in focus.

In many studies, dyad perspective has been the dominant as seen in the previous chapter. Furthermore, supplier-purchaser dyads are usually studied rather from relationship perspective than more operational perspectives such as quality or other performance, such as material flow points of view. On the contrary to supplier management, the focus of SCM has been rather in quality and process research than in relationsips. These focus areas have been for example Just-in-time (JIT) (De Toni & Nassimbeni 2000; Kannan & Tan 2005; Kaneko & Nojiri 2008; Jina 1996; Gunasekaran 1999; Green et al. 2014), Total quality management (TQM) (Flynn et al. 1995; Kannan & Tan 2005), process (McGinnis & Vallopra 1999), purchasing (Karpak et al. 2001), and supplier performance (Hald & Ellegaard 2011; Vonderembse & Tracey 1999). Additionally, the flow of products as "network entities" have been considered more in depth in SCM literature in dyad level than in supplier management (Kannan & Tan 2005). As the dyad level approaches can be extended to chain and further on to network levels, the same approaches are studied also in chain level as done by for example Aigbedo (2004), Delbufalo (2012), and Green & Inman 2006, but there are also additional perspectives to be considered such as value perspective that is used by for example Kähkönen & Lintukangas (2012) and Ahtonen & Virolainen (2009).

### *3.1.2 Performance management systems*

In a wide context, performance in supply chain can be thought to be constructed from relationship and process related measurement objectives. Narasimhan and Nair (2005) for example take quality expectations and information sharing into focus from relationship perspective, and supply chain proximity as well as physical performance of supply chain. Giannakis (2007) point out by referring to Slack et al. (2004) as a part of the introduction to the issue that benchmarks should be taken as a basis for measurements. He also divides these performance benchmarks or standards into four classes: Historical standards, target performance standards, competitor performance standards, and absolute performance standards. This division of the origins of standard levels to the performance management creates therefore a good basis for performance indicator development. As Flapper et al. (1996) states, “the success and continuity of an organization depend on its performance” they also continue by defining performance as “the way the organization carries its objectives into effect”.

As organizational performance is the basis for performance management system creation, there should be consistent method for performance indicator (PI) creation. Therefore, according to Wang et al. (2004) three dimensions of PI’s should be thought at first: the type of decision that PI is ment to support, aggregation level of decision, and the measurement unit or its type for PI. Decision type can be divided for example to strategic, tactical and operational decisions that PI is supporting. Aggregation level is on the other hand showing the level in which the PI is considering the performance. These levels can be for example overall and partial. Furthermore, measurement unit can be decided to be monetary, physical and dimensionless (Flapper et al. 1996). For example, if Six Sigma is taken as a quality improvement methodology and supplier development as a context of measurement, the PI can be chosen to measure defects per million opportunities and additionally the cost savings induced by the changes made (Wang et al. 2004).

Furthermore, PI creation process can be thought as three step process that consist of PI definition phase, reciprocal PI relationship consideration, and target value setting. PI relationships should also be modeled as hierarchical illustration in order to get the main and sub-level PI’s identified and the structure behind PI management system decided. These levels can be called, as Flapper et al. (1996) do, as parent and child levels. (Flapper et al. 1996)

## *3.2 Material requirements planning fundamentals*

Future is always unknown, but in order to be able to give the best possible customer service via material availability, many predictions must be made in order to ensure material availability in warehouse or distribution center. In material requirements planning (MRP) there is always constant debate between having enough materials in storage when needed and the costs related to higher stock levels than needed. As costs related to warehousing of materials and decrease in purchase prices as lot size increases affects to the viability of different solutions to average storage levels. In this sub-chapter fundamentals of inventory management and stockout situations are introduced.

### *3.2.1 Inventory management*

In supply chain management, one of the key components to succesfull operations is related to management of inventories. Inventories are formed in basically every part of supply chain as well as in production environment to maximize the efficiency of production and gather the materials to groups that can be managed in best way also from economical perspective. For example, moving products independently is usually significally more costly than moving a pallet of products. Also in production environment, the lot manufacturing is more economically efficient than single product manufacturing. One reason for this is that production settings need not be re-configured between manufactured products of a lot. The reason for lot manufacturing can also be derived from demand side, because in many occasions materials are purchased in different batch sizes. Therefore, inventories give the possibility to optimize manufacturing or purchasing lot sizes at the same time that lead time to customer is kept as short as possible. This is usually one of the main presumptions in service business. Therefore distribution centers are required to act as a supply buffer.

According to Tersine (1988, 8) inventory problems can be classified by using four variables: Repetitiveness, supply source, knowledge of demand and knowledge of lead time. To futher classify the inventory related cases the first classification criteria, repetitiveness, is further divided to one time orders and repeating orders. Supply type can be also thought as internal and external supply sources. Furthermore, the knowledge about future demand can be constant or variable, and related to this also independent or dependent. Also lead time can get the same kind of approach about constant and variable approaches. (Tersine 1988, 8)

When lead time is considered further, it can be also divided into parts. For example Tersine (1988, 12) introduce five parts of lead time to be considered. These steps are order preparation, order transit, manufacture and assembly, transit, and uncrating, inspection and transport. This perspective is mainly considering manufacturing environment, but in order to enlarge the perspective to retail or other business environment, manufacturing can also be thought to be the warehousing part of the chain. Furthermore, the inventory costs are specified by Tersine (1988, 13) to consist of purchase costs, order or setup costs, holding costs and stockout costs. The cost perspective leads up to conflicting organizational objectives for example from marketing, purchasing, production, finance or warehousing perspectives. These objectives should be balanced in order to get the best possible operational efficiency.

In figure 3.3, an inventory cycle of a product is drawn in order to illustrate the basic concepts of inventory management. In the figure, y-axis represents material quantity and in x-axis represents time. As seen, every sales order (SO, marked with middle length dashed line) diminished the amount of materials in stock (drawn with continuous line). Sales orders are sold and there are no actions to be done until stock quantity goes below re-order point (ROP, the upper long dashed line). When storage quantity passes the ROP level (point 1), new purchase order (PO) is made with the current re-order quantity (ROQ). ROP and ROQ as well as safety level (SL) change according to demand and supply parameters and therefore, it should be noticed that ROQ, ROP and SL are not static and are reviewed every time the analysis of inventory parameters is made. In ideal situation, additional materials (point 2) are received in warehouse when only SL quantity is in storage. After this, the cycle begins again. (Tersine 1988)

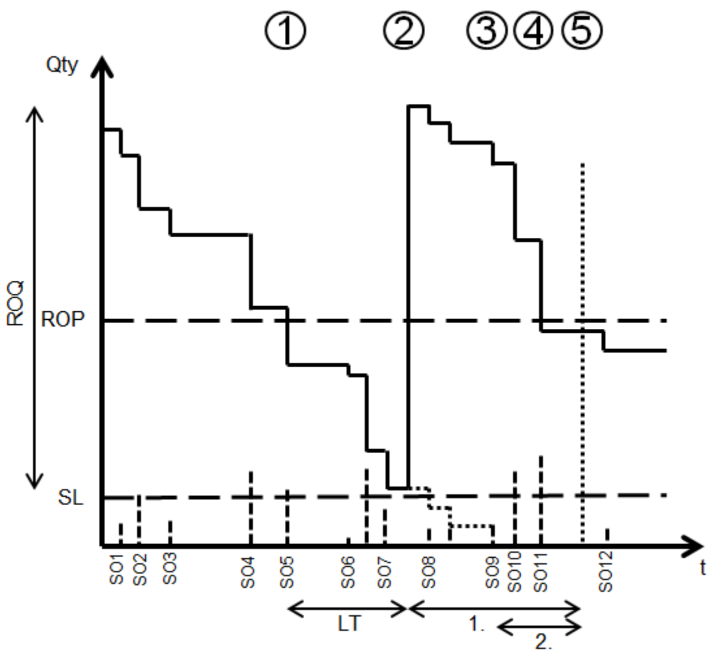


Figure 3.3 Inventory cycle for a material (Modified from Tersine 1988)

The process introduced is idealistic and therefore not so realistic model about the inventory management process as in many occasions there are variations in demand side or in purchase order lead times in supply side. ROP is measured so that the quantity left in stock can cover the demand for the lead time (LT) as well. As it is not usually possible to predict accurately the future demand, supply operations should be designed to be flexible and accurate so that changes in demand can be handled in the best possible level (Al Kattan & Adi 2008).

### *3.2.2 Stockout situations*

In previous sub-chapter, ideal process for inventory cycle was introduced. As the world never works in the ideal way, the ways of deviations in the process should be known and response strategies created. In figure 3.3 late PO shipments has been drawn with small dotted line. After SO9 the storage quantity is zero (point 3) and it is also possible that prior to this SO there have been potential sales, but as the amount in stock has been too low from customer perspective, the sales have been lost to competitor. In this presentation, SO10 and SO11 could not have been met, because of stockout situation. (point 4) Overall, in the presentation (cannot be generalized) when the first PO arrives (point 5) stock quantity might already be lower than ROP.

In figure 3.3, lead time for the late shipment is the original LT plus the time outlined by arrow 1. The time of stockout situation is marked with arrow number 2. The time when the SL buffer can still provide materials to be sold (points 2 and 3) is the time in which the backup for deviation in both demand and supply side still works in most of the cases. As safety stock is placed to compensate the deviation in supply and demand, the correct size of it should be decided in order to get to the desired service level in demand side. In figure 3.4, the basic model of connection between safety stock and service level is presented.

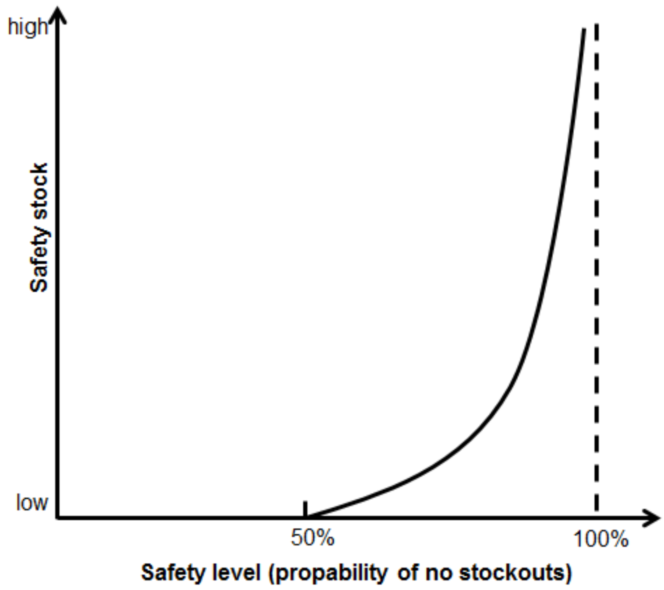


Figure 3.4 The effect of safety stock to service performance (Tersine 1988, 188)

In general, stockout situations can be generated by variations in both supply and demand side of operations. As figure 3.4 point out, increasing service level will increase the safety level size in an accelerated manner and still there is some propability of stockout situation.  In supply side, longer lead time than used in MRP or quality problems in received materials can lead to stockout situations. In demand side, the deviation of demand is the main reason for the demand caused stockout situation. As warehouse is a buffer that should prevent the demand caused stockout situations, deviations in demand are included in ROP and SL and therefore the normal variation in demand and supply is covered with safety level and it is not obvious that late PO shipments will automatically cause a stockout situation. (Tersine 1988, 188)

## *3.3 Delivery accuracy*

It is important for the company and its customers that material availability, which is one of the premises of supply chain management, is secured. This leads to the point that it needs to be under control if the company plans to meet the customer requirements so that all of the required inputs are in place in order to enable successful deliveries to the customer so that supply chain can in the end meet the requirements made by its end customer successfully and with the best possible service level. As from this perspective, Basnet et al. (2003) by the basis of the survey they directed to the companies operating in New Zeland, conclude that companies are largely interested especially in the timeliness of deliveries. Even though they also remind that their results cannot be generalized, because of the far-out location and with the low response rate, delivery accuracy from the suppliers as well as to the customers have been much researched topic. For example Sánchez-Rodríguez (2009) and Krause and Ellram (1997) consider the topic in their articles.

Just-in-time (JIT) and improvement of the internal response time in supply chain are also in the top of their survey results in which the most important dimensions of supply chain management are ranked. This seems to be applicaple both, in local and global scale. Additionally, they mention one inventory management related issue, that is bad possibility to plan and manage inventory levels supply chain wide, to be also one of the main problems or disruption causing issues in supply chain management. The effect of this can be seen to be overpowered in the survey, because of the remote location of New Zeland. On the other hand, JIT ideology in purchasing and inventory management can be seen to stress this perspective. (Basnet et al. 2003)

It is also stated that quality certificate, for example ISO 9000 certificate, has an effect on the supply chain by affecting to the supplier selection so that the certificate holder is more likely to choose supplier that has the same quality certification. Although Romano (2002) concludes that suppliers' quality certificate seems not to have an effect on general quality performance or quality cost decrease, he noticed that choosing suppliers that are quality certificate holders had an effect from the delivery perspective. (Romano 2002)

### *3.3.1 Delivery accuracy engagement to the business of buying firm*

In companies that have centralized their supply operations to one single purchasing organization that provides service to the internal customers such as installation and service departments, it can be said that these internal customers are particularly important also for the supplier to provide best possible service. From this perspective, the performance of purchasing organization can be stated to include the physical material quality of the purchased items, material price, timeliness of the deliveries, inventory management performance and internal customer satisfaction. (Sánchez-Rodríguez 2009)

Primo et al. (2007) sums the affecting issues to the purchasing organizations' business by supplier caused errors to be increasing transaction costs (Forker 1997), searching the alternative supplier as the trust decreases (Ellram 1991), decreased sales caused by stockout situations (Dion & Banting 1995), and brand image decrease because of the withdrawal from the supplier collaboration. Although these effects to the business are specified in the articles to be in the production company context, the mentioned outcomes can be seen to be in very general level and therefore could be applied to wholesaling, material supply for service business as well as grocery.

Primo et al. (2007) divides the effects of inquiry process of the delivery failures and directions of the effects to six main results. They list as negative impact increasing effects to be linkage of delivery error to the next tier of supply chain, responsibility denial by supplier, and continuity of errors. On the other hand, they bring out as the negative effect decreasing things to be the slack in the operations of purchasing organization, high cost of changing the supplier, and the proof that supplier is commited to the cooperation by taking actions to the errors.

From supplier perspective the logistic performance of deliveries can be divided to on-time deliveries, delivery time and delivery reliability (Fawcett & Closs 1993). As time factor in deliveries is crusial for customer, its effect to delivery performance can be encapsulated into the term time-based performance (Dröge et al. 2004). Additionally, when this perspective is broadened to include delivery performance of the customer company the integration via real time communication and information changing in supply chain becomes very important (Daugherty et al. 1999).

The results of Boon-Itt and Wong (2011) suggest that it is especially important to pay attention to internal integration inside the company as well as integration in supply chain level, not solely to customer integration, in order to maximize the delivery service level towards customers. In addition to this, they found out that as technological uncertainty decreases, also the benefits of the supplier integration efforts decrease as well. By combining these results, it can be therefore stated that collaboration with suppliers should be performed only when the materials that are purchased have this feature of technological development uncertainty, but on the other hand they found out that the positive effects to delivery service performance created through company internal integration decreased when technological uncertainty increased. Furthermore, demand uncertainty had negative effect on the results of both of these integration situations. It can be thereby concluded that both the source of uncertainty and the integration focus have significant effect to the possibilities of a company to adapt to the changes in the business environment and therefore also to manage the success of delivery timeliness in customer interface. (Boon-Itt & Wong 2011)

### *3.3.2 Quality perspective to the timeliness of deliveries*

Time-based Competition (TBC) is stated by Jayaram et al. (1999) to have a significant role in modern business world and therefore they conclude that time related performance requirement from the supply chain management perspective are found very important.They take a five factor approach to the topic. These factors are lead time, time taken to develop new product, delivery reliability, time taken to bring new product to the market and production lead time. Furthermore, they concluded also by referring to previuos studies that supplier development projects and just-in-time purchasing have even higher critical effect to the TBC in company level. (Jayaram et al. 1999)

Similar perspectives to supply chain improvement have been brought up by Basnet et al. (2003) as they took three delivery accuracy perspectives to their survey. These perspectives were on-time deliveries, just-in-time (JIT) and location. In their studies they approached the issue in addition to supplier perspective, also from purchasing company perspective. Their approach is therefore quite similar to Boon-Itt and Wong (2011) approach. The difference between JIT approach and on-time deliveries is that as the latter considers only the late shipments, the former sees also early shipments as a development objective. JIT approach is therefore also considering the unnecessary storage from inventory management point of view. Location related issues refer to the question of logistic distance and the uncertainty caused by the distance.

As stated earlier, delivery accuracy is a part of quality in supply chain and supplier relationship management. When delivery accuracy is considered, the definition as mentioned by Handfield and Nichols (2004, 33), should be made clear as different parties in supply chain might define the words like “arrived” and “delivery accuracy” differently. In this thesis, the definition of on-time delivery is delivery that has arrived to predefined and jointly agreed location inside the predefined time of delivery after purchase order was made. Additionally, it should be noted that the point at which the liability is not always the same. On the basis of research results from Matson and Matson (2007), it can be said that delivery accuracy is a clear challenge for companies’ right after production and physical quality of the purchased items. They also noticed that frequency of occurance for challenges in delivery accuracy is larger and therefore more difficult to eliminate. In addition to this, Grout (1998) point out that the importance of delivery accuracy increases as company changes its supply chain management to follow JIT purchasing as inventory levels are to be decreased.

As purchasing organization applies JIT policies, one of the main ideas is not to decrease the inventories only in the purchasing company, but in the supplier as well. This is because if JIT purcasing is not applied in all of the supply chain tiers, the reduced inventory levels in other companies will end up accumulating into not JIT companies and therefore the total efficiency and inventory levels in the supply chain will not decrease as planned and the inventory cost will remain. This will only end up changing the share of value in supply chain and not increasing the total productivity in the chain. Therefore, on-time delivery can be defined also in the framework of JIT ideology so that deliveries are on-time, but at the same time inventory levels should not increase. This will end up to conversation and measurements considering management of deviation in delivery times. (Grout 1998) As Kumar et al. (2012) continue, it is especially important to share demand information towards the previous tiers in supply chain in order to, at the same time maximize the service performance to end customers, and to meet the previously set requirements for supply chain or network. In an important role in this work are supply chain improvement methods such as JIT and material resources planning (MRP). (Kumar et al 2012)

Also critics can be presented towards JIT purchasing. Gupta and Kini (1995) collect the main points well by stating that it is rare that company can reach to the ideal JIT model. They continue that this allows the suppliers to use quantity based discounts to make it more economical for purchasing company to increase the lot sizes. At the same time, supplier can enlarge its production lot sizes and gain decreased unit price because of the benefits gained from the increased volume of production. In the end, the JIT ideology of getting rid of inventories and thereby maximizing the economical productivity can be therefore declared to be somewhat inapplicape for many supply chains or networks.

### *3.3.3 Measurements of delivery accuracy*

To develop any process or organization, there should always be a basis in measurements. From supplier management perspective, Handfield and Nichols (2004) specify the reasons for this to be the point that supplier performance should be monitored and developed in order to decrease costs and risks as well as to ensure continuity of increase in value addition. Through the assistance of general and consistent performance indicators, it is possible to determine the level of operational performance in the context of purchased materials, suppliers as well as in the larger context of the whole supply chain. This will apply also to the supply performance disruptions, as well as to the development of supply chain improvement strategies and to the total cost approach. (Handfield & Nichols 2004) In addition to this perspective, the approach should also be to point out the improvement needs and development objectives as well as actions taken with the suppliers by using analyses made out of measured data. Furthermore, it is also a point of reliability in the analyses and management.

The general level of supply chain performance can be thought as a combination of cost effectiveness and reliability based performance. The former includes inbound and outbound operations, inventory costs and improved monetary turnovers. The latter on the other hand includes for example order fulfillment rate, inventory turnover, safety stocks, obsolete inventory and product warranty claims. (Lee et al. 2007) From the previous list, delivery accuracy can be seen to affect at least to inventory turnover and safety levels that will lead to changes in inventory costs.

Delivery accuracy can be measured by using completely on time (COT) or as Chapman et al. (2011) did and take sample of deliveries and study the deviation in a certain level of accuracy. The delivery deviation can be for example measured in hours or days. This will give the possibility to study delivery timeliness by using histogram and to compare it to the expected value. (Chapman et al. 2011) By using this measurement approach, delivery time predictability, or in other words delivery time related quality, can be derived.

## *3.4 Development of supply chain*

Supply chain or network development is a key part of business performance improvement. As Krause and Ellram (1997, p. 51) state, supplier development actions are used as the cost for changing supplier may be very high and therefore it can be seen as the main motivation that is preventing the supplier change to be used for “not well enough performing” supplier situations. The result of their study indicate that significant performance improvement can be reached through supplier development projects when this development is done so that the expectations are high enough and well communicated to the supplier, and when purchasing firm is actively participating in the improvement efforts. Therefore, it can be said that the collaboration perspective should be taken as a basis for the improvement actions.

Although Krause and Ellram are considering only a dyadic perspective to the improvement Wang et al. (2004) expand the efforts to be taken in every business or interface when the supply chain improvement is considered. They see the Six Sigma improvements as a collective effort of supply chain and illustrate this in their framework so that every connection between supply chain and network should be taken as an improvement objective. (Wang et al. 2004)

The development efforts can be taken in many fields of business as stated by Chen and Paulraj (2004) when introducing their research framework. As a prerequisite they identify key elements, such as environmental uncertainty, strategic purchasing and information technology, to support the SCM development. Furthermore, they divide strategic purchasing to consist of three additional issues: customer focus, top management support and competitive priorities. Additionally, they divide SCM to three parts that are supply network structure, buyer-supplier relationships and logistics integration. (Chen and Paulraj 2004)

Li et al. (2006) takes a bit different perspective to SCM and identify five sub-constructs for SCM practices. These sub-constructs are strategic supplier partnership, customer relationship, level of information sharing, quality of information sharing and postponement. Additionally, Jalalvand et al. (2011) introduce five step method for supply chain comparison: determining business stages, decomposing these business stages into processes, calculating process efficiency scores, specifying business stage grades and determining supply chain ranks.

As continuous improvement of supply chain practices and therefore performance improvement is the key aspect in supply chain development, performance should also be defined. Narasimhan and Nair (2005) use six performance indicators in their study. These key indicators are market share, return on assets, average selling price, product quality, competitive position, and customer service. On the contrary to this, Jalalvand et al. (2011) define five, more operational supply chain (SC) attributes to measure: SC reliability, SC responsiveness, SC agility, SC costs, and SC asset management. Furthermore, Kannan and Tan (2005) take four measurement perspectives into their focus: Just-in time (JIT), total quality management (TQM), supply chain management, and performance. In their research, JIT includes material flow, commitment to JIT and supply management; TQM includes product design, strategic commitment to quality and supplier capability; supply chain management includes SCM integration, SCM coordination, SC development and information sharing. Performance measures they use are market share, return on assets, product quality, competitiveness and customer service. As seen, this perspective combines the two previous points of view and therefore creates basis for larger study framework. It also points out that SCM development is about material flow as well as product quality and even the integration perspective of SCM.

### 3.4.1 Operational improvements in inventory systems

Before the perspective is enlarged to consider the whole supply chain, inventory management related development actions should be introduced. From this narrower perspective, cost and risk reduction efforts can be reviewed in many fields of operations. From supplier interface, the improvement actions can be for example sharing expected demand information with suppliers or making contracts for minimum annual order amounts. Also lead time reduction efforts and decreasing the amount of used suppliers are viable options for improvement actions. (Tersine 1988, 519-521)

In inventory management and manufacturing side, additional actions are introduced by Tersine (1988, 520). These actions are for example minimizing setup times, improving capacity planning, disposing inactive stock, adopting cycle counting, standardizing stock items, improving forecasting, controlling access to storage areas and other such improvement efforts. Also buying to consignment stock, considering transportation costs in inventory planning and offering customers discounts on preordered items are ways of getting cost savings and decreasing inventory related risks. As a conclusion, it can be thereby said that inventory management related improvement actions in cost and risk perspectives can be taken internally and by the means of improving the communication between supply chain tiers.  (Tersine 1988)

### 3.4.2 Development of supply chain from delivery accuracy perspective

Internal performance of a company as well as external, supplier related, performance has a strong relationship to the whole supply chain performance, as mentioned previously. Furthermore, the possibility to affect firms own effectiveness by using development actions and integration actions was noticed to be affected by technological uncertainty as well as from other reasons. The basis of supply chain development can be divided to multi-step process.For example Chapman et al. (2011) introduce the issue by presenting  the five step process for quality management techniques in supply chain development. This model includes stages that are: develop strategies, identify key processes, analyse the existing processes, redesign processes and implement new processes. They comment on this by stating that the first step has already been made, because delivery accuracy has been chosen to be the focus area for the development actions. The following two steps consider then the measurement steps and the analysis of existing processes, and the last two steps are about the changes to the processes. The idea of continuous development can be thereby applied to this five-step process as after implementing novel processes, the analysis phase should be re-applied, and therefore the circle can be seen as an endless loop. (Chapman et al. 2011)

As this five-step process does not consider the issue of analysing and making the actual change, and more in detail, what kind of tools should be chosen in order to take the measurements. Additionally, identification and prioritization of development areas or objectives are not considered. To respond to this critic, Chapman et al. (2011) introduce three quality improvement tools for delivery accuracy improvement that are: process and flow charts, histograms and cause and effects analysis. In addition to these three improvement tools, for error identification and severity investigation as well as for the priortitization of development action Failure Mode and Effects Analysis (FMEA) can be used. As a basis for FMEA analysis, there are three factors to be evaluated: risk severity, risk propability and detectability. Simultaneusly, the process and its steps and the share of these steps to the failures in delivery accuracy are evaluated by using the FMEA framework. (Chapman er al. 2011)

After this the question is how to make the necessary change. As Grout (1998) points out, the most common actions that are suspected to have late deliveries decreasing effect are extension of specified delivery time and reduction of deviation in delivery times. The latter is seen as a better solution as the former would accept the bad quality in deliveries, decrease the purchasing organizations flexibility in delivery planning as well as would increase lot sizes and thereby increase inventory levels. Grout (1998) continues by taking JIT perspective to the improvement and points out that supplier incentives can be used to enhance the development, but his results indicate that all of the three objectives that were introduced previously (increased share of on-time deliveries, decrease of deviation in delivery time, and the two previous objectives should not be achieved by increasing the inventory levels) cannot be always met at the same time and therefore the usage of supplier incentives does not always have direct and working impact to these delivery accuracy objectives. (Grout 1998)

### 3.4.3 Six Sigma in supply chain improvement

In supply chain context, the improvement project can be performed for example by using Six Sigma methodology. The name of Six Sigma methodology comes from the objective it has: to reduce the process mean amount of defets under 3,4 defects per million opportunities. As one sigma level represents standard deviation of a process, the sigma levels can be defined as illustrated in table 3.1. (Wang et al. 2004)

Table 3.1Six Sigma levels (modified from Wang et al. 2004)

| **Specification limit** | **Inside specification** | **Defects per million opportunities** |
|---|---|---|
| ±σ | 30,23% | 697 700 |
| ±2σ | 69,13% | 608 700 |
| ±3σ | 93,32% | 66 810 |
| ±4σ | 99,379% | 6 210 |
| ±5σ | 99,9767% | 233 |
| ±6σ | 99,99966% | 3,4 |

Wang et al. (2004) collect the Six Sigma framework to supply chain improvement points and the process that is used in Six Sigma to organize the improvement project. They point out that the usage of Six sigma process is motivated by the fact that these projects “can be considered as a driving force for cost reduction and service improvement in SCM”. Although Six Sigma is intended for product and process quality improvement projects, it can be applied to supply chain context as performance management objectives can be taken in hierarchical way as Flapper et al. (1996) performance management framework suggests. This way, the improvement objectives can be defined in correct level and Six Sigma Define, Measure, Analyze, Improve and Control (DMAIC) -process that is illustrated in figure 3.4 used for organizing the improvement efforts. (Wang et al. 2004)

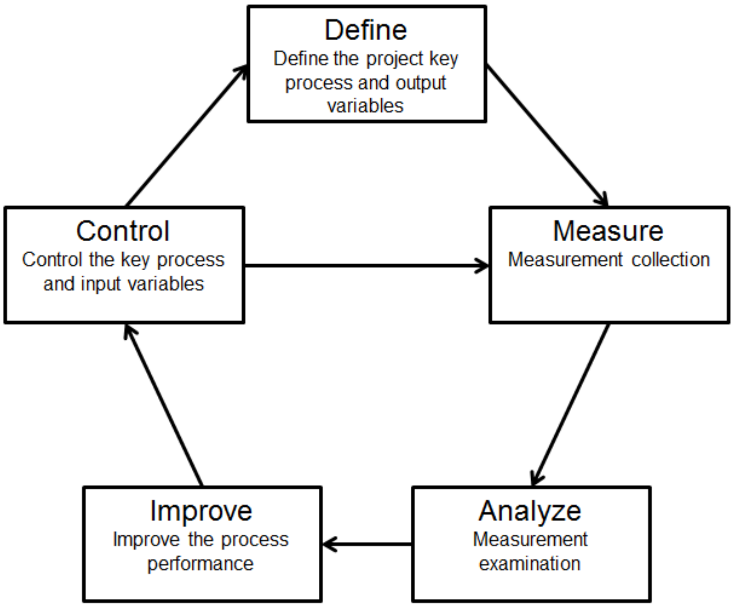


Figure 3.5 Six Sigma DMAIC process (Modified from Wang et al. 2004)

Wang et al. (2004) call the DMAIC process steps as modules so that the module one that begins the process is the Define phase. In this first module, processes are prioritized and the focus is placed to processes that have most impact to the improvement objective. The main activity is therefore to find out the key output variables that should be improved and to calculate the cost of poor quality they represent. The second module identifies and measures the capability of the process by using performance measures such as cost, productivity, and service level. In third phase the analyses about when and where the defects occur is performed. It is also investigated that the process is in control. In improve –phase Six Sigma improvement actions are taken. The purpose of this module is therefore to identify and implement the improvement actions and changes that should be made in order to improve the process performance. Usually this is done by using process variance reduction as an objective. In the last module, control, the plan is created to respond to the question of how the new process should be controlled in order to maintain the achieved level of process and gained benefits. (Wang et al. 2004)

# 4 CASE: SPARE PART SUPPLY BUSINESS UNIT

Centralized procurement business unit that supports the service operartions' material requirements can be seen to have similarities with brokers and retailing businesses. As all of these businesses or business units are purchasing materials to warehouses or distribution centers to gain from economics of scale in sourcing operations, there is also always some considerations about the balance between the price of keeping the materials in warehouse shelf and stockout risk. Stockout risk can be seen as a combination of demand and supply risk. Both of these risks will be compensated by keeping increased amount of materials in warehouse shelf as a buffer. But as said, increased material levels in stock cause increased warehouse costs and increased level of capital costs from the materials in storage. To free capital for more profitable business purposes, this buffer should be minimized.

The objective of this case study is to create process for continuous improvement of material shelf availability by controlling the supply risk. At first the connection between inbound and outbound service performance of a distribution center is studied by using quantitative research methods. After this, supplier segmentation methdod from material availability perspective is created and improvement process for the most critical supplier class is proposed.

In this study, customer demand fluctuations are considered only as a part of total risk for stockout situations. This is done by using Six Sigma based DMAIC framework. The case study is primarily focused on the first three steps of this framework, but in the results, improvement and control phases are considered by creating and documenting processes also for these steps. As the actions taken in the improvement phase can be divided to short term corrections and long term process studies, also the short term actions are performed and considered in the results. At first, before moving to performing DMAIC framework based improvement project, case business unit and its business environment are introduced.

### 4.1 Introduction to business unit and case business environment

This case study is part of material availability improvement project of one business unit of corporation providing equipment and services globally. The field of business is to provide equipment repair services to equipment owners that are not usually the end users of the devices. Furthermore, service is provided to such equipment that cannot be completely changed in the case of breakdown and therefore repairing is done on site. The business unit in question is material support unit in the service business operations and it could also be described as centralized sourcing and procurement unit. Because of this, new equipment business is excluded from the scope of this case study, as well as maverick buying done by the internal customers of the business unit. Mainly customers are internal country organizations providing maintenance service for customers that are the owners of the equipment, but also external customers are served.

In this global organizational environment, distribution centers are the hubs for the materials and as so, the location decisions to optimize the sales lead times to customers are very important. Additionally, distribution centers should have enough customer demand from inventory management point of view. In this case study, the location related decisions of distribution center as well as the amount of distribution centers are excluded from the scope as this study is focused on issues related to managing material availability in delivery chain by analysing and controlling material flow through the distribution centers. This includes also material movements between distribution centers that are caused by the demand changes or supplier location related considerations.

### 4.2 Definition of the case study

Material availability in the storage is the main focus of this case study. This study tests the correlation and regression between inbound and outbound delivery service performance of the distribution center. Tests are peformed to three groups of data. In the first group, 50 suppliers with the most sales lines from the distribution center are investigated. The second group consists of supplier data of every 10$^{th}$ supplier when suppliers are sorted to diminishing order of sales lines sent from distribution center for their materials. The third group was chosen to be single supplier test approach, which in this case was chosen to be the supplier with the most outbound sales lines sent from the distribution center.

The purpose of these tests is to find out if it would be beneficial for outbound service performance improvement efforts to follow up and control inbound delivery lead times and their failure rate. If the correlation and regression can be found, inbound delivery lead time accuracy would be chosen as key performance indicator to be followed up on weekly basis. Standard deviation of the inbound delivery accuracy will also be tested as an alternative.

After process and key performance indicator testing, suppliers are divided to four classes from material availability risk and material sales line point of view. In literature, supplier classification has been done from strategic perspective. In this case study, more operational approach is used. After creation of the classification, material availability improvement processes for the most critical supplier class is proposed. The perspective of this classification is chosen to be build so that it would overlap with the strategic supplier classification as little as possible. This is done in order to gain knowledge of supplier performance from alternative perspective than has been previously considered.

As materials that are not kept in storage, the service level should be the same for inbound and outbound operations, this case study has its focus only on the materials that are kept in storage facilities of distribution centers. Additionally, materials that are not actively forecasted and purchased are not included in the scope. Furthermore, purchase order deliveries that were ordered, but not received during the year 2013 are not taken into account while performing the case study and its analysis. With these limitations, the analysis is based on the purchase and sales data from the year 2013.

The outputs of this analysis are the answer to the question about the connection between inbound and outbound service performance of a distribution center, supplier classification from material availability perspective, and specification of improvement process for the most critical supplier class. To limit the scope of the case study and the thesis, these strategies and processes are not tested in practice. Therefore it can be stated that define, measure and analysis phases of Six Sigma DMAIC process are performed, and only suggestions for improve and control phases are given.

## *4.3 Measurements*

The required data is acquired from Enterprise Resource Planning -system and the other material requirements planning systems in use in the case company, and therefore any specific measurement techniquest were not required to perform this study. This also limits the measurements so that any control methods for measurement practices are not available. Despite the fact that it is not possible to control the information gathering procedure, it is assumed that the extensive amount of used data will reduce the effect of the measurement errors so that analysis can be performed and results are accurate enough to be used to take improvement actions.

Measurements and calculations include two types of data: binary data to indicate on-time delivery and interval scale that indicates the lead time accuracy. Measurement scale for lead time accuracy is stated in days. Service level for both sides of operations of the distribution center is calculated from the other available data and presented in relative scale.

### *4.3.1 Key performance indicator for delivery accuracy of purchase orders*

As stated previously, the analysis will be based on the data gathered during year 2013. This is emhasized to be the present state of the operations and is used to test the analysis methods. It is assumed that time frame of 12 months is satisfactory in order to achieve reliable results. The data used in this analysis is gathered from the ERP system and other material requirement planning system currently in use in particular business unit. Statistical analysis is conducted by using statistical analysis software Minitab and other parts of the analysis are performed in Microsoft Excel.

Key performance indicator –testing, that included correlation analysis and linear regression analysis is tested in order to find out the answer for research question 1. As this case study mainly focus on current state of operations, future corrective and improve actions are emphasized as outputs of the analysis. In addition to this, improvement plan is created on the basis of the performed analysis and its results. After key performance indicator analysis, supplier classification from material flow point of view is created to find the most urgent and effective improvement objectives. In this case study, improvement objectives are searched both in supplier and material level. After building up this supplier classification process, analysis about similarities and features of these supplier groups is performed. This supplier classification and analysis will serve as a basis for supplier improvement process creation in the subsequent subchapter.

In process management, it is important to follow up the progress in time. Follow up should begin before any changes are made to find out the actual effects of the improvement efforts. For this purpose it is necessary to measure and choose performance indicator carefully. This is done by testing that performance indicator has an effect to the final objective of the improvement project. In this case, the objective is to maximize outbound service performance by improving inbound operations capability. In the present case study, this is done by measuring the lead time accuracy of purchase order lines. In this case study, lead time accuracy is defined as the difference between purchase process lead time specified in the material management system and the realized purchase process lead time. This measurement can be used to measure both data and supplier quality. Division of the effect to the outbound service level between these two quality viewpoints is excluded from the scope of this thesis, but should be kept in mind when performing the analysis and during the process to seek improvement actions to the delivery chain.

Three sets of sample data is used to study the effect of inbound service performance to outbound service level as stated previously. As the objective of this thesis is to investigate the connection between the success of inbound and outbound operations of a distribution center, at first the coverage of each of the sample sets need to be specified. This is shown below in table 4.1.

Table 4.1 Sample coverage of sales lines

| Sample type | Coverage of total purchase order lines |
|---|---|
| 50 suppliers that corresponds to most sales lines | 70,1% |
| Every 10th supplier in most sales lines | 13,7 % |
| Supplier corresponding to most sales lines | 6,5 % |

As seen from the table, the first set has most coverage of the population and was chosen as test sample especially for the coverage point of view. This amount of suppliers was chosen as the 70% was noticed to be a point, after which the share of additional vendor had to the total impact of service level was decreasing significantly. The second set, every tenth suppliers according to arranged list of suppliers by sales lines corresponding to the supplier materials, includes significantly lower proportion of the volume of outbound operations, but gives wider spectrum of the supplier base. The third set is based on the biggest supplier according to the service level impact of the materials it provides and was included to the analysis in order to study the individual supplier perspective. To further describe the sample sets, table 4.2 shows the amount of samples in the group (N) as well as mean and standard deviation.

Table 4.2 Description of sample sets

| Sample type | N | Mean | St.dev |
|---|---|---|---|
| **50 suppliers that corresponds to most sales lines** | 29698 | -15,02 | 22,24 |
| **Every 10th supplier in most sales lines** | 6696 | -13,54 | 18,21 |
| **Supplier corresponding to most sales lines** | 2364 | -15,43 | 20,33 |

The mean for the sample sets is negative for all of the sample sets which indicate that most of the inbound deliveries have been received earlier than expected. Standard deviation of approximately 20 can be seen to be quite large and therefore actions to decrease the standard deviation are needed.

To study the influence of inbound lead time accuracy to outbound service level, correlation and linear regression are tested. These tests are performed on weekly basis thereby considering all 52 weeks of test data. This amount of input samples is large enough to give satisfactory estimate of the relationship and its strength. P-level limit for all of the linear regression analysis is 0,05 which means that if p-level obtained from the analysis is below this limit, statistical significance occur.

### *4.3.2 Suppliers with most sales lines*

The first set of samples consists of data for materials that are sourced from 50 suppliers with most sales lines. Therefore, the impact of these suppliers to the outbound service performance is largest. At first, weekly based data was gathered to the materials purchased from chosen suppliers and service performance as well as inbound service performance was calculated. Scatter diagram of this data and regression line are illustrated in the below figure 4.1.

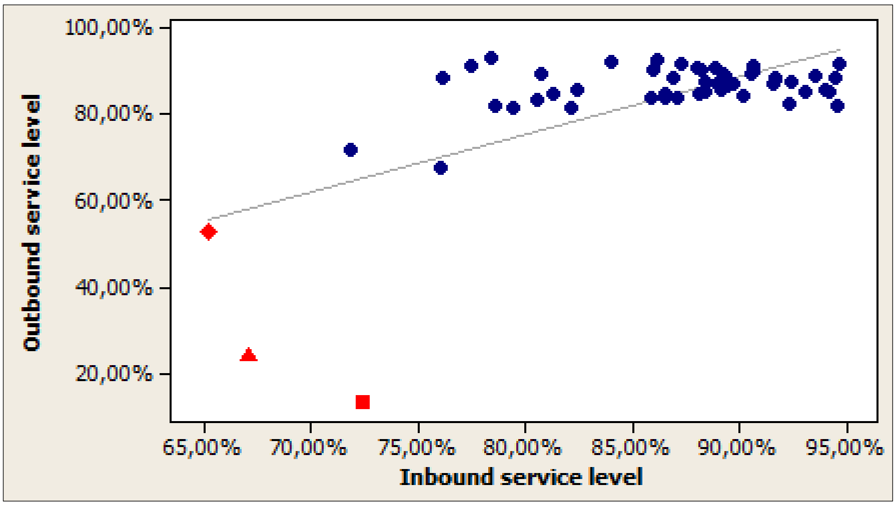


Figure 4.1 Correlation and regression analysis for 50 most sales lines suppliers

According to the above figure, there is statistical significance between the two variables as P is near 0,000 and the amount of samples (n=52) is stated to be large enough. Additionally, positive correlation with r = 0,64 indicates that when Inbound lead time accuracy increases, also service level tends to increase according to the findings. Linear regression can be illustrated with fitted line presented in equation 4.1.

$$Y = -0{,}3 + 1{,}3X \tag{4.1}$$

In the equation Y is the outbound service level and X is inbound service level. It is also stated that approximately 39,7 % of variation in service level can be seen to be caused by this linear regression model according to adjusted R-squared indicator for linear regression model. As seen in the above figure, there are three data points that are significantly different than the majority of sample data points. These points are marked with red dots. To improve the process, the reason for these unusual occurances should be investigated and corrected. It can also be tested if these unusual occurances that bend the regression model have an effect to the correlation or statistical significance by excluding these sample points from the analysis. Regression analysis was repeated after excluding these three red sample points from the regression and correlation analysis. This regression analysis is shown in below figure 4.2.

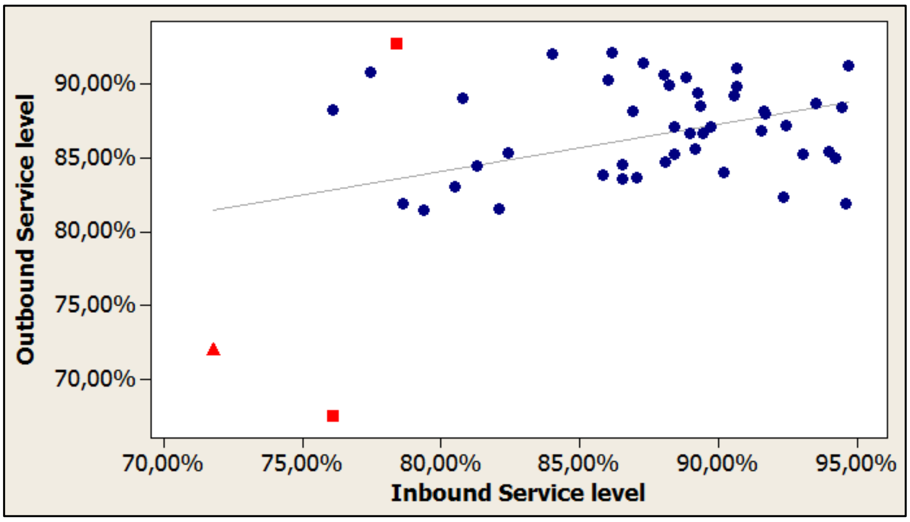


Figure 4.2 Correlation and regression analysis without significant outliers

The eclusion of the three outlier data points bend the statistical analysis to be more significant. After excluding these data points, the statistical relationship between the variables was still found to be significant, but with much weaker correlation (r = 0,38) As a result of this analysis, it can be stated that by investigating and making required corrections in order to avoid the lower performance in inbound service level, the linear regression and correlation between inbound and outbound service levels can be decreased.

In order to further study the connection between inbound and outbound service levels, other regression models can be also considered. Because of the effect that safety level have to the service peformance through material availability, more realistic regression model for the phenomenon was identified. In figure 4.1 it was seen that with lower inbound service performance the effect to the outbound service level was larger. Therefore, quadratic regression model was also tested. In figure 4.4, this regression model is shown.

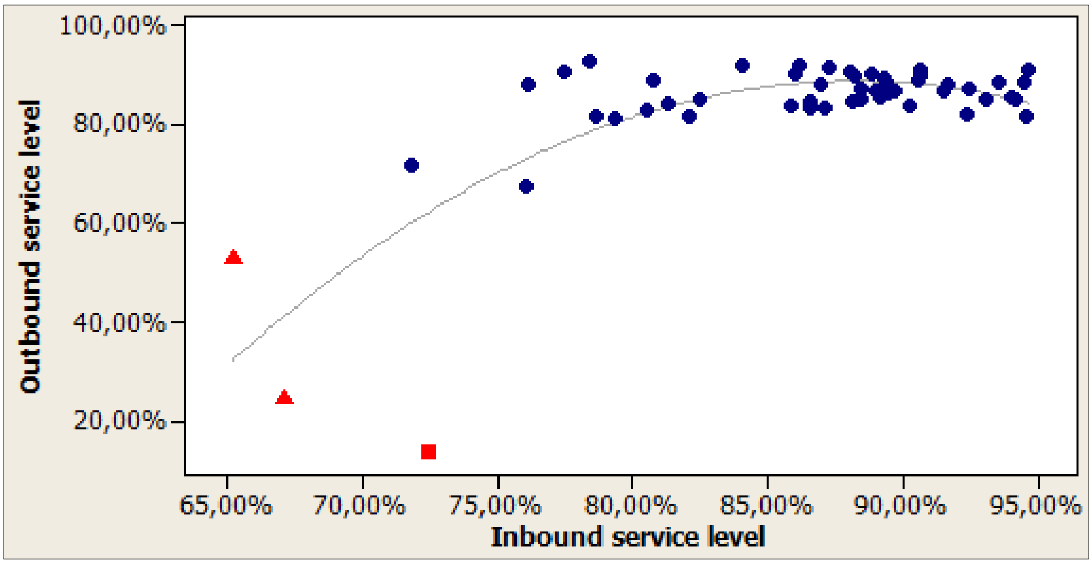


Figure 4.3 Quadratic regression model for the sample set 1

By using the quadratic regression model 58,9 percent of the service level was identified to be caused by inbound service level according to R-squared analysis. This is in line with the theory considering stockout situations and safety stock. The regression model can be now modeled with fitted curve presented in equation 4.2.

$$Y = -7{,}4 + 18{,}8X - 10{,}7X^2 \qquad (4.2)$$

This regression model displays the connection of the two service levels more clearly. Therefore, the result to first research question and the hypothesis derived from it can be given so that according of this first sample set the hypothesis is confirmed.

After analysing the statistical significance, other perspectives can be taken to the analysis of the inbound lead time accuracy. One of these other analysis methods is to consider the frequency of occurrence of the absolute values of lead time accuracy. By performing the simple classification between on time and late shipments, it is possible to calculate the sigma level for the process. According to this sample data, 15,40 percent of inbound delivery lines were received later than expected when counting re-order points, order lot sizes and safety stocks. This can be seen as very poor result and therefore rapid actions to increse the amount of on time deliveries shouls be performed. This is also illustrated below by using histogram.

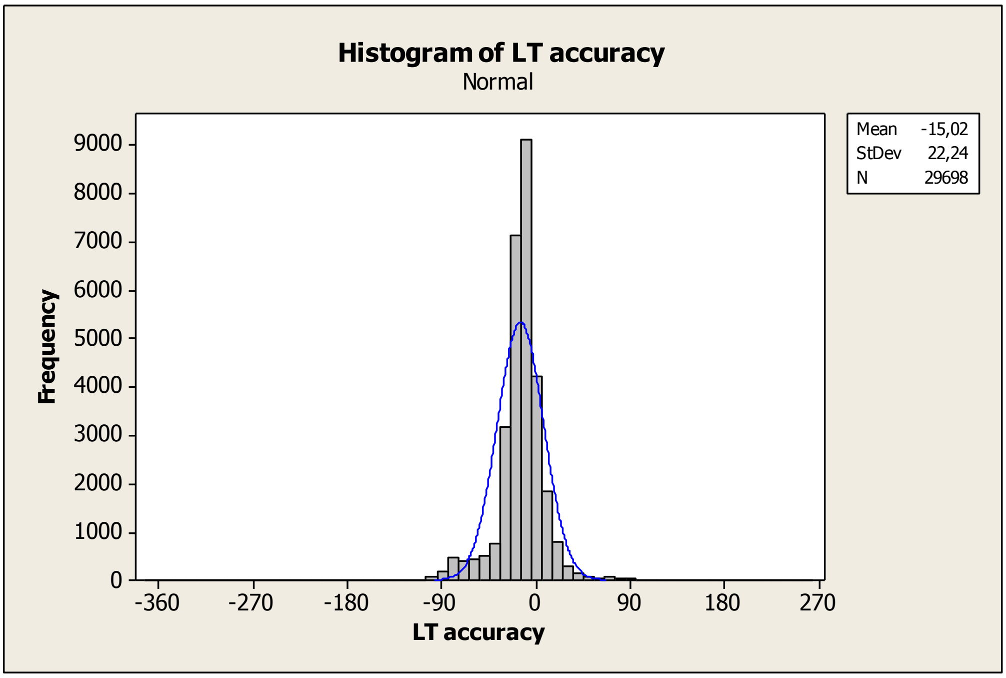


Figure 4.4 Histogram for lead time accuracy in 50 most sales lines suppliers

Second of the most significant findings is that trigger for late deliveries or in other words the point in which lead time accuracy is zero, is very close to the highest peak of distribution chart. Therefore, one of the findings can be stated that the center of this distribution chart should be moved to avoid late shipments. To move the zero-point lead times should be moved to correspond to the realized lead times, but as stated before in this thesis, this should not be the only corrective action and therefore additional steps should be taken in order to improve the actual process performance. It can be done by ensuring the lead times with suppliers by adding the lead time as more significant part of contract with larger sanction clause if these time limits are not met. This is one of the quick fixes to be done to improve the availability, but as it might accept longer lead times than before and therefore causes the safety level and average storage levels to increase which should be avoided as much as possible as it increases the process costs. Furthermore, this contract based lead time should be used only as minimum performance limit for suppliers.

Third strategy for improvement is to seek ways to decrease the standard deviation with supplier. As is stated in the supplier classification part of this case study, this would also decrease the risk level of the supplier and thereby can be seen as one of the most important development objectives. It is also the Six Sigma way of thinking the process improvement. As first and second findings were considering the moving of normal distribution curve, this third improvement action is focused to narrow down the curve and by doing this decreasing the costs of safety stock. As stated in regression analysis, significantly different points of data should be excluded in order to find the improvement points for process capability. Propably the easiest way of finding these outlier points is to use boxplot diagram. In below figure, the outlier points are marked with asterisks.

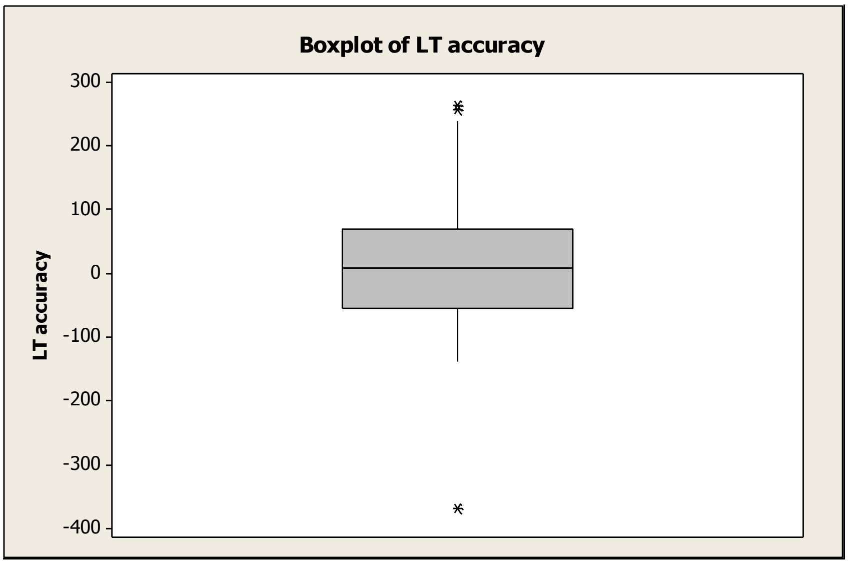


Figure 4.5 Boxplot of lead time accuracy for 50 suppliers with the most sales lines

As seen from the diagram, there are points that are unrealistic that should be investigated one by one and the reasons fixed. For example, it is not realistic to receive the delivery over one year beforehand and therefore there is problem with the delivery data in system. There are also result points that indicate over half a year late deliveries. These datapoints are usually caused by problems in suppliers' production and should be thereby investigated to create risk assessment and reaction plan for similar cases in order to decrease the risk in inbound operations of a distribution center.

### *4.3.3 Sample with every tenth supplier as per most sales lines*

The same linear regression and correlation tests were applied to the second set of tests, which included the data considering the materials that are provided by suppliers that were chosen by taking every tenth suppliers' data into account when suppliers were arranged by the amount of sales order lines. By using this sample data, it was again found out that when all 52 weeks' data were taken into account in the regression and correlation analysis, statistical significance occurred. The linear regression estimation model is shown in equation 4.3.

$$Y = 0{,}05 + 0{,}9X \quad (4.3)$$

Additionally, approximately 18 % of service level variation was accounted to be caused by inbound lead time accuracy and positive correlation was found as r was found to be 0,44. The illustration of the regression model is shown below.

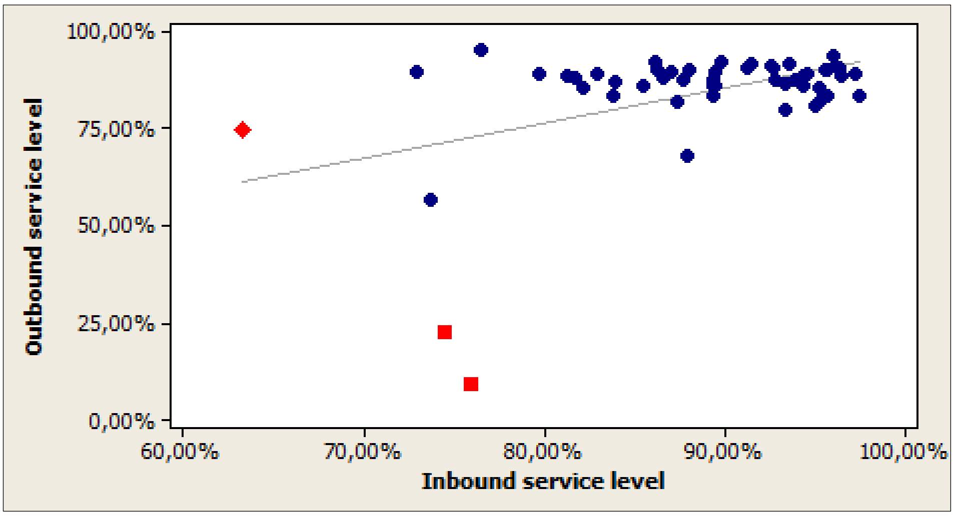


Figure 4.6 Correlation and regression analysis for second sample set

Once again, as seen from the figure, three unusual points could be identified. To perform the same kind of test than with the previous sample data, these three points were excluded and second analysis was performed. For this set of samples, the statistical significance disappeared. Therefore, the result is the same than with the first sample set and confirms the first hypothesis. Furthermore, as the statistical significance disappears when the three most significant outliers are excluded, the improvement objective should be to study the causes of these outliers and to make improvements in order to avoid the same kind of oulier causing events in the future. For this set of samples, the linear regression model was the most suitable as R-squared fot the quadratic model was only 17,4 percent. This results in not unambiguous for the second subordinate research question for the main research question as the most appropriate regression model was different between the sample sets.

With this second set of data samples, also histogram was drawn and is shown in figure 4.8. As before, also in this case, it was found out that zero point for on-time delivery was remarkably near to the center of the normal distribution curve. Therefore, the results of previous analysis are confirmed and the same observations and correction actions apply also to analysis performed with this data set.

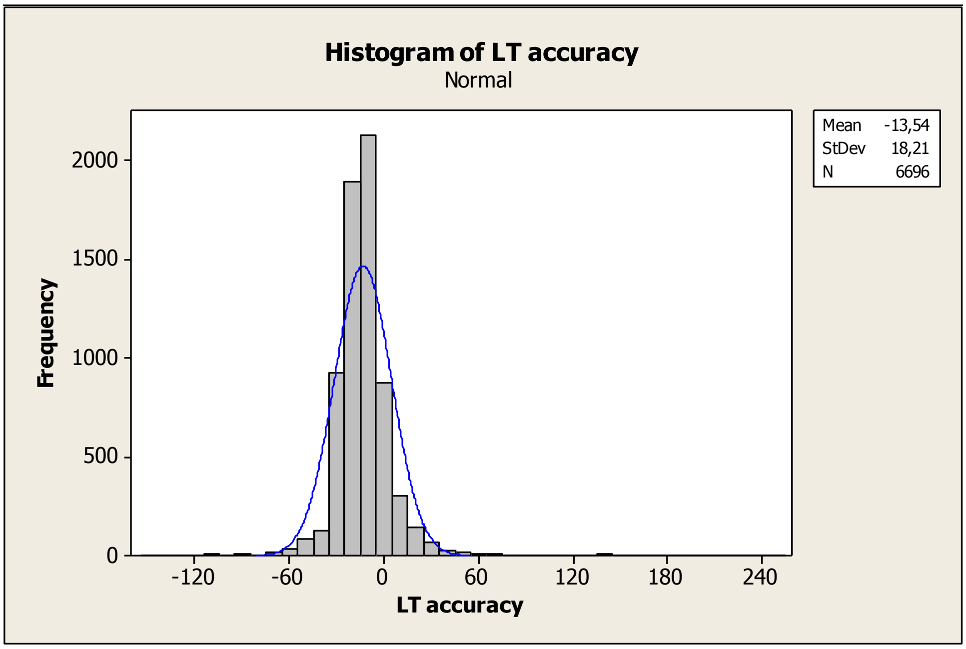


Figure 4.7 Histogram for second sample set

One difference in histograms between the first and second set of samples is that the width of the normal distribution curve is narrower for the second set of samples with standard deviation of 18,21 compared to the standard deviation of the first set that was 22,24. Therefore, it seems that lead time accuracy is better for this set than the first one and might indicate that lead time is more accurate for the suppliers delivering smaller amound of deliveries annually. Because N is significantly different for these sets of samples, to make this kind of conclusion would need additional study to be performed. To analyse the differences between the sample sets, boxplot diagram shown in below figure, was drawn also for the second set.

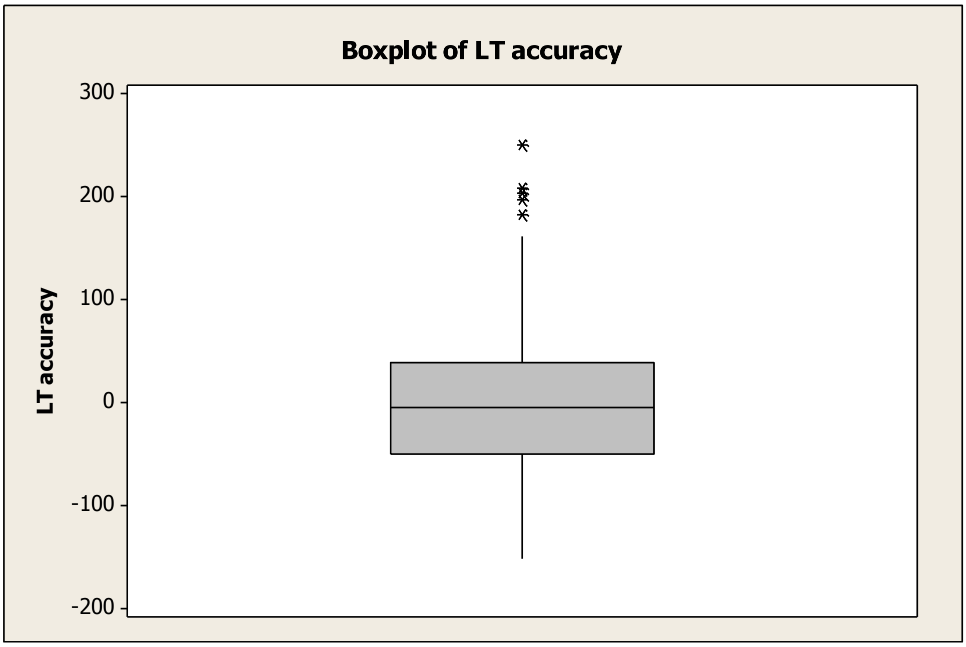


Figure 4.8 Box plot for second sample set

The absence of outlier points in negative side of the boxplot diagram show that, on the contrary to the first sample set, for this second set of samples data points that are significantly too early do not exist. As these points can be concluded to be incorrect information in the system the significance of this observation can be said to be small. When comparing the positive side of the diagram in which the realized lead time is longer than lead time in system, the sample sets seem to be similar.

As stated before, boxplot diagram can be used to identify outlier points in data. The reasons for found outliers should be investigated in order to find out if the exceptional points in data are only symptoms of a larger problem. Therefore, root cause analysis should be done to every outlier found from boxplot diagram.

### *4.3.4 Supplier level analysis*

The third statistical analysis is performed in supplier level. The purpose for this analysis is to find out if the previously introduced analyses could be used to identify supplier performance and to be used as a part of the improvement process. On the contrary to previous tests, linkage between operational performance between inbound and outbound operations is not in the main focus as such, but the analysis and its outcomes are. Therefore, in order to understand the key points for improvement, meaning of the analysis results, is considered. At first, linear regression and correlation is analysed. Result of regression analysis is illustrated in below figure.

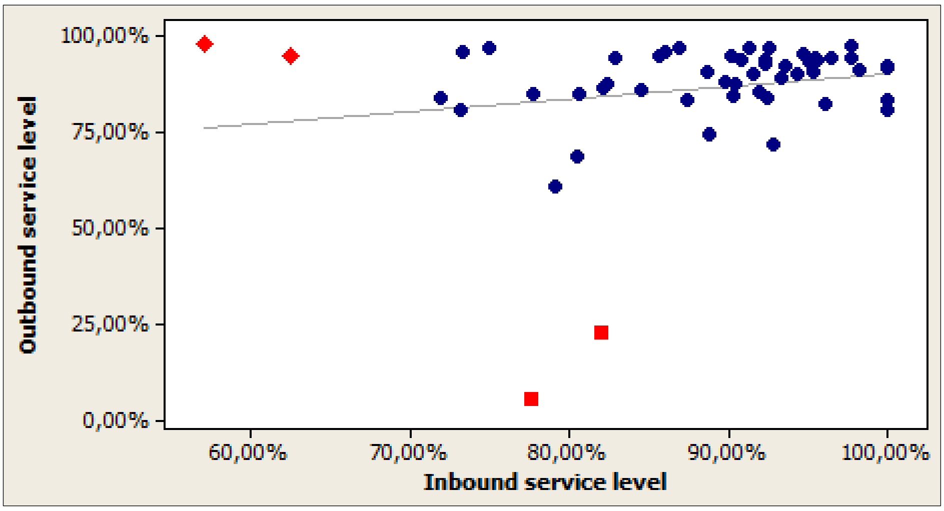


Figure 4.9 Correlation and regression analysis for supplier level analysis

For the supplier in question, statistical significance for linear regression or correlation analysis were not found. This result indicates that for this particular supplier inbound operations are at good level and safety levels that cover the sales fluctuation are also at satisfactory level. Despite the fact that overall performance can be stated to be in satisfactory level, there are still some points in which outbound service level is very poor for the materials provided by particular supplier. This might indicate a problem considering only a small amount of materials, because overall inbound service performance has been in relatively normal level for the weeks in question, and therefore it can be concluded that with a high propability the outbound service level for these weeks are poor because of some other factor than inbound service level. One possibility for the inbound service level to have an effect to outbound service performance is that materials that are purchased in large baches and sold in significantly smaller batches have arrived late to the distribution center and this event has had the effect to the outbound operations. Because the large amount of overall delivery lines, this is very unlikely, but should be investigated in order to gain certainty. As statistical significance between service levels was not detected, supplier level inbound actions are not needed and focus should be turned to material level analysis which would investigate the possibility of some few materials to affect the outbound service level significantly.

If correlation and regression analysis would indicate statistical significance between inbound and outbound service levels, supplier lead time accuracy would need to be taken as a special objective in material availability improvement part of operations development. And, as stated, even if this analysis does not indicate statistical significance, material level investigation should be performed to find out the improvement objectives. By using material level analysis, it would be possiple to find out improvements to be performed when supplier performance as a whole is in a good level. One way to find out the materials to be improved is thereby to use box plot diagram to seek single exceptional points from the supplier lead time accuracy data. Box plot analysis considering lead time accuracy for the supplier level analysis is illustrated in the below figure 4.12.

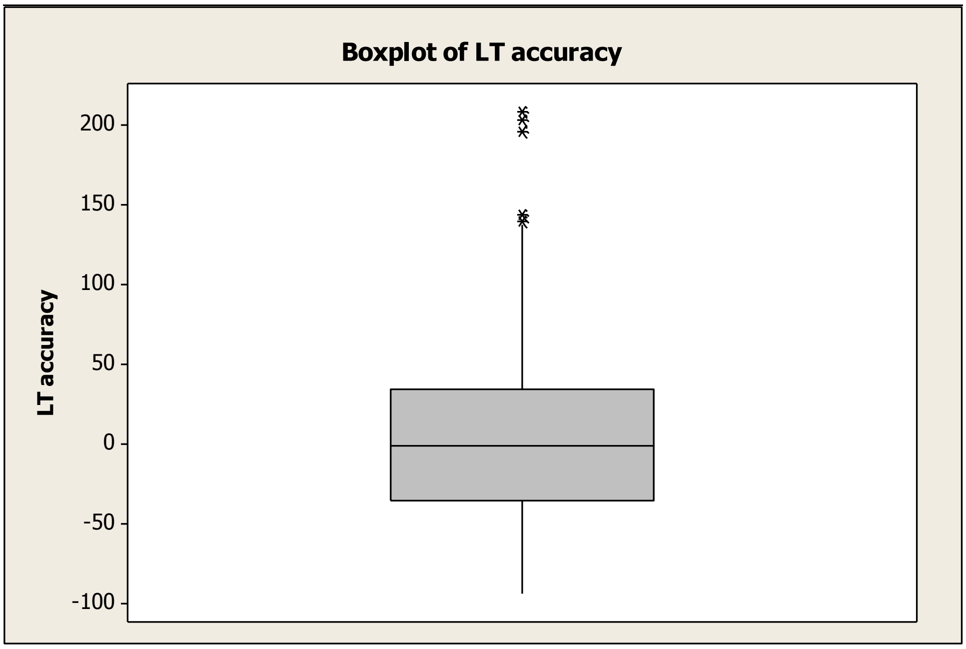


Figure 4.10 Box plot diagram for supplier level analysis

As can be seen from the above figure, although correlation and regression analysis found no connection between inbound lead time accuracy and service level some additional conclusions can be made by investigating boxplot diagram. As many of the outliers for positive lead time accuracy and the tail of the normal data points are significantly over the zero point, in besides the preivious analysis objectives, more Just-in-time approach or in other words variation diminishing actions should be applied in order to improve the cost effectiveness of the operations.

To strengthen the the previous results, histogram was used. The objective in this analysis is to diminish variation in lead time accuracy as well as to change the center point of the curve so that the part of tail of the curve that includes late deliveries would be under desired level that can be defined for example by using sigma levels.  Additionally, as stated already in this chapter, all the outliers should be inventigated one by one to find out the extremes of the process in order to eliminate the future occurance of these unorthodox pieces of process.

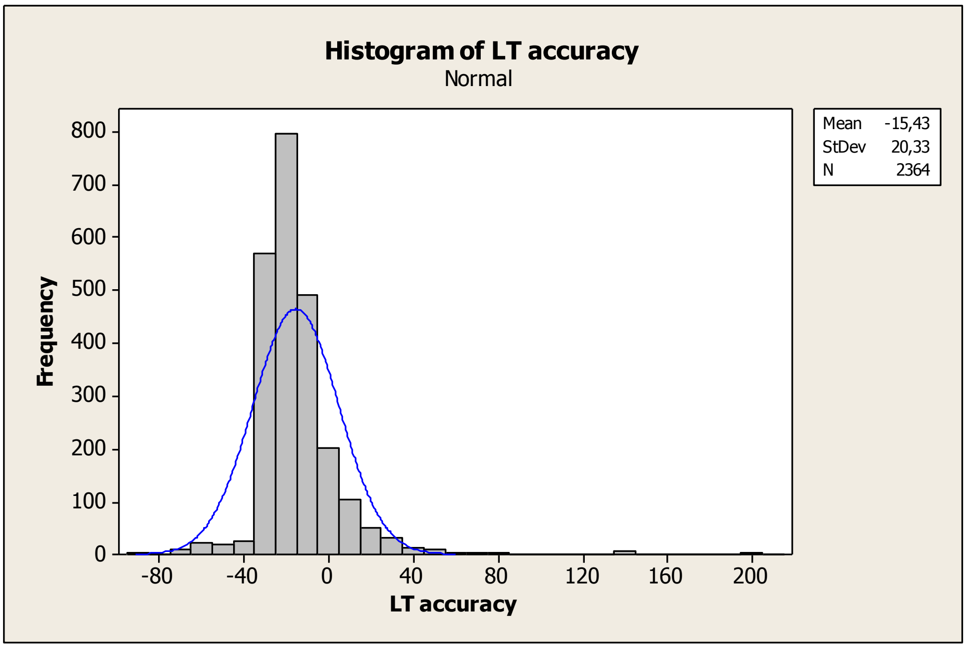


Figure 4.11 Histogram of supplier level sample set

In the above figure, it can be seen that major part of inbound delivery lines are on time and as there still are some purchase order lines that have been received after expected arrival date, these inbound delivery lines and corresponding materials should be thereby investigated. Despite the fact that too early deliveries cannot be thought to possess any risk to outbound operations, also these points should be investigated to decrease the standard deviation and thereby to shrink the safety stock and furthermore to reduce the warehousing costs.

### 4.3.5 The results of statistical analysis

First two sets of samples were used to test hypotheses related to the first main research question and its sub-questions. As correlation was found in both of the analyses, the first hypothesis is confirmed and the answer to the first research question is positive. However, the second hypothesis could not be conirmed as the results between got from the sample sets were not in line with each other. Therefore, the second hypothesis could not be confirmed. Furthermore, it was seen that only a few outlier sample points had an effect that made the correlation and regression analyses statistically significant. It can be therefore stated that these occurences should be taken as a key improvement objectives.

As most of the data points were found out to be affected by the system data, lead time corrections should be the first action to be taken. Also investigation for the reasons of exceptional weeks should be performed to find out corrective actions. In order to follow up the inbound service performance, stockout situations could be taken into closer investigation. Therefore, key performance indicator (KPI) to follow up the trend of stockout situations should be created and monitored. Equation 4.4 represents the proposal for this KPI.

$$Stockout\ KPI = \frac{N_{stockout}}{N_{deliveries}} \tag{4.4}$$

In above calculation N is used to denote quantity of situations. Therefore, the equation states that KPI is measuring the percentage of stockout situations caused by late shipments compared to the whole amount of deliveries. A stockout situation can be therefore defined to be in question when supplier delivery time exceedes lead time that have been used for inventory planning and the time that it takes to empty also the safety stock.

It is obvious that by measuring the number of situations in which safety level is not sufficient to protect from inbound and outbound variations, process stability is also considered and indirectly measured. This can be stated as significant process instabilities appear as an outlier in the process. Furthermore, as poor process performance is seen in increased calculated lead time, without close follow-up of either safety level changes or stockout KPI, there is considerable possibility that safety level and therefore the warehouse costs will continue increasing as process is allowed to deteriorate.

As stated by Grout (1998) lead time increases in system are only a short term solution to the lead time accuracy problem and would only decrease flexibility in the purchasing organizations' material management as well as increase the material stock levels and thereby warehouse costs. The real improvement should be therefore done together with the supplier by having three goals for the improvement project: increased amount of on-time deliveries, decreased variation in lead times and this should not be done in supplier side by increasing stock levels. (Grout, 1998) Therefore actions to stabilize the process in long term should also be taken. These supplier development projects include lead time review, contractual agreement review and actions to be taken to improve the accuracy of the supplier shipments. By creating an agreement with the supplier about lead times and improvement actions, the problems with rather reactive action done in short term can be avoided. One of these problems is that if suppliers are not taken into the improvement process, the actions remain to be done only in system level and there is still no certainty of improvements in the process level.

In histogram analysis, it was noted that the zero-point in which the deliveries are in time was very close to the highest peak of standard curve. This was noticed for all of the sample sets. From Six Sigma point of view, this is not problematic, but as the deviation of the curve is too wide to keep the deliveries in time to fulfill Six Sigma level, moving the standard curve might be appropriate to perform as a short term action. As stated, there are two ways of performing the change: changing lead times in the system to correspond the realized values and taking further actions with suppliers to agree for improvement activities in practical and contractual level. Histogram and box plot analyses also pointed out several significant outlier points, and suggested that these points should be investigated to improve the process. This should be done also to manage the supply risk in material and supplier level.

## *4.4 Supplier classification from material availability perspective*

The second part of this case study is to build a classification framework for suppliers from the material availability perspective. In contrast to the traditional strategic classification framework, the availability is now thought from strictly operational perspective as the framework layout stays relatively same. In this case study supply risk is kept as y-axis same way as is done in the previous strategic supplier classification, but x-axis is changed to be number of sales lines for the items supplied by the particularsupplier. As x-axis is relatively straight forward to get from the sales data, risk number calculation is considered more in detail.

As seen in previous sub-chapter, operational quality in the inbound material flow is one of the affecting parameter for the succesful outbound operations of the distribution center. Therefore, supplier classification should take into account operational performance both in inbound and outbound side of operations. This performance can be measured by considering the accuracy of deliveries to the expected level and by taking the variance as an additional variable. In this case study, standard deviation of purchase order lead time accuracy is considered as well as service performance of outbound deliveries in the risk level calculations. In addition to the measured variables, also some material parameters should be considered. In the present calculation, suppliers' portion of all materials and share of X and Y materials are taken also as a part of risk level calculations. This is done, because stockout risk is higher for materials with shorter cycle time. The factors chosen for material availability risk calcualtions are shown in table 4.3.

Table 4.3 Availability risk Factor parameters, emphasis and classification limits

| **Emphasis of the parameters to risk factor** | | | **Classification limits** | | | | | **Orientation** |
|---|---|---|---|---|---|---|---|---|
| Parameter | Sub-parameter | Emphasis (%) | 1 | 2 | 3 | 4 | 5 | |
| Sales | | **S** | | | | | | |
| | Average of service level | xs | xs1 | xs2 | xs3 | xs4 | xs5 | Upper |
| | Demand standard deviation | σs | σs1 | σs2 | σs3 | σs4 | σs5 | Lower |
| Purchasing | | **P** | | | | | | |
| | Lead time standard deviation | σp | σp1 | σp2 | σp3 | σp4 | σp5 | Lower |
| Material | | **M** | | | | | | |
| | Percentage of all materials | Ma | a1 | a2 | a3 | a4 | a5 | Lower |
| | Percentage of x-materials | Mb | x1 | x2 | x3 | x4 | x5 | Upper |
| | Percentage of y-materials | Mc | y1 | y2 | y3 | y4 | y5 | Upper |

Calculation settings were prepared so that control table presented in table 4.3 could be used to test and make adjustments to the risk level. Parameters and their sub-parameters were set as previously specified and seen convenient in this context, but on top of that, emphasis of parameters and sub-parameters as well as classification limits are available for fine tuning in the table. Emphasis of parameters can be defined so that their sum is 100 percent and on top of this, emphasis is divided also in sub-parameter level. Risk that derives from one parameter can get integer value from one to five. Mathematical representation of risk number calculation is:

$$Risk = S(S_{\bar{x}}\overline{x_s} + S_{\sigma}\sigma_s) + P\sigma_p + M(M_a a + M_x x + M_y y) \tag{4.4}$$

After this calculation is done, there is still doubt if the risk is large or small, because it is not stated in any reference scale. Therefore, risk numbers should be scaled. This can be done by using the following formula.

$$Scaled\ risk\ number = n\frac{Risk}{\max\{Risk\}} \tag{4.5}$$

In this equation, n is the maximum number that scaled risk number can have, which is the risk number given to supplier with maximum unscaled risk number. After the scaling, all suppliers have risk number between zero and ten. It is also relatively simple to get impression of relative risk level compared to other suppliers by just investigating the scaled risk number. For now on, risk number is referring to the scaled risk number.

The same classification framework that divides the supplier into four groups that is used in strategic supplier classification is used in this built framework as well. Now risk factor of 5 is used to divide suppliers in y-axis and some convenient proportion of total sales lines that suppliers’ materials represents is used as dividing parameter value for the x-axis.

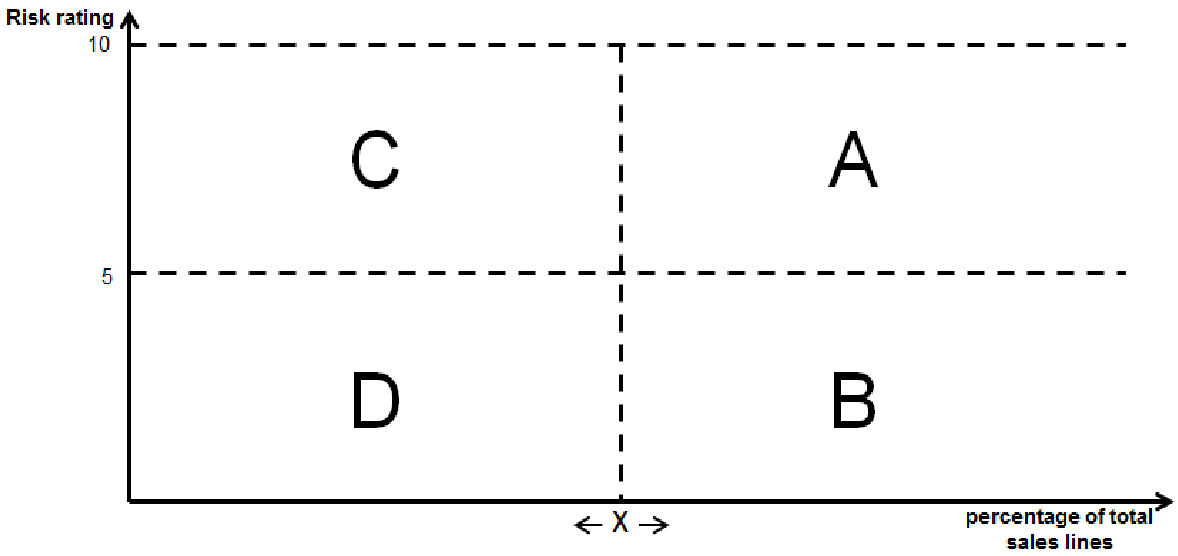


Figure 4.12 Supplier classification framework

This dividing proportion of sales hits is marked in the figure below as x. By increasing or decresing x, limit between A and C as well as B and D classes can be moved and by doing this, amount of suppliers in classes can be controlled. The other way of controlling the division of suppliers to the classes can be done by adjusting emphasis percentages or classification limits in the risk number control table, but changing values in risk number control table is more difficult to perceive. Additionally, because of risk number scaling, if improvement has been achieved for the supplier with the largest risk number, re-scaling will increase the scaled risk number for all of the suppliers and thereby bring new suppliers to A and C classes. This will ensure that prioritization and improvement prosesses and strategies can be used repetitively. Classification limits are illustrated in below table.

Table 4.4Supplier classification limits

| **Classification criteria** | Limit | A | B | C | D |
|---|---|---|---|---|---|
| Percentage of total sales hits | x | x ≤ | x ≤ | < x | < x |
| Risk number | 5 | 5 ≤ | < 5 | 5 ≤ | < 5 |
| **Amount of materials in class** | n | nA | nB | nC | nD |

By adding value to x in above table, it is possible to move the horizontal classification limit and, as mentioned earlier, also affect to the division of suppliers between classes. To help the decision making, the count of suppliers in classes can be seen as x is adjusted. By doing this, it is possible to control resources put to supplier development efforts by deciding the count of suppliers that should be included in class A and thereby finding out the parameter x.

In this case study, number of A class suppliers were set to be between 20 and 30. Therefore, x was chosen to be 0,6 % of total sales lines. Scaled risk factor limit was kept as 5. With these parameters, count of class A suppliers was 27. The results for 50 suppliers with the most sales lines in year 2013 are illustrated in below picture.

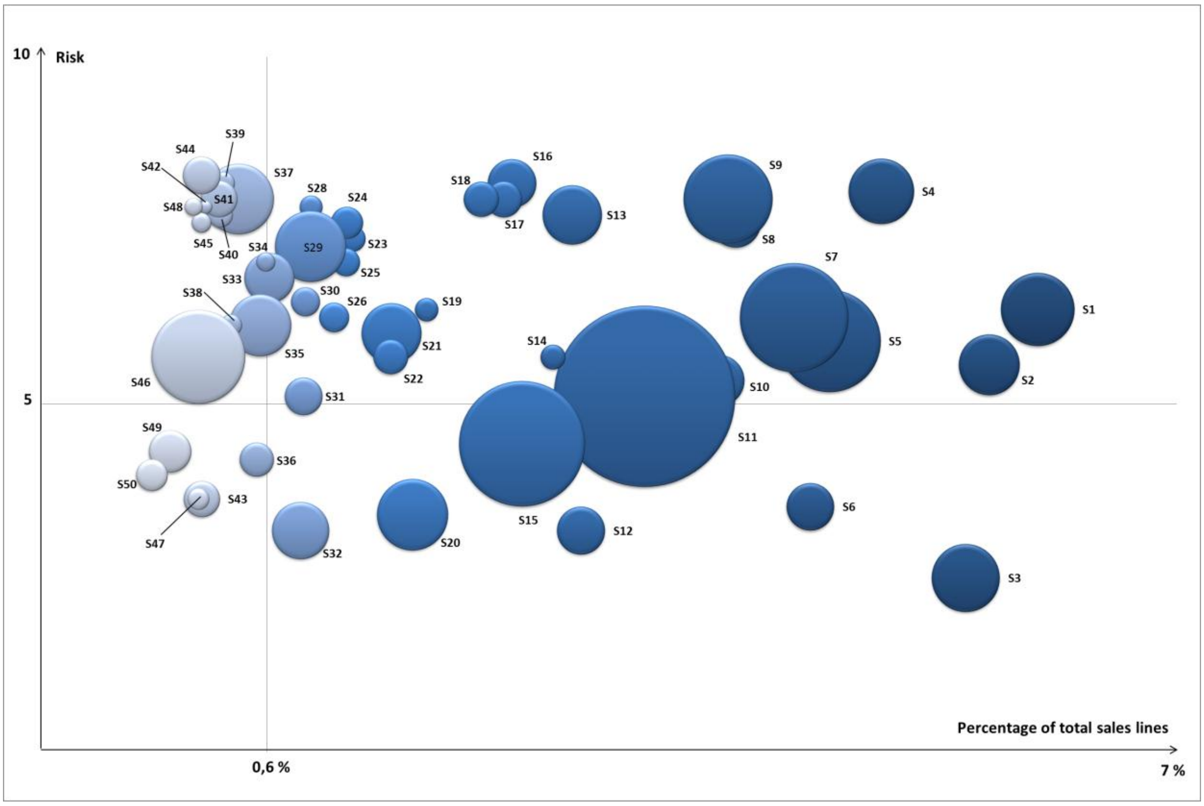


Figure 4.13 Supplier classification for case study

In the above figure, bubble size is illustrating the annual purchase value of the supplier. This makes the purchasing volume based negotiation possibilities visible, but as it neglects the supplier size, conclusions are not this straight forward. More useful perspective is that, by illustrating the purchasing value per supplier it is possible to make conclusions about the average value of the purchased materials and the corresponding effect on the sales side of operations. This is one of the most important perspectives when urgency and the managerial involvement to the improvement projects are considered.

## 4.5 Improvement strategies for supplier classes

As supplier classes divide suppliers by using chosen material management level performance or risk level related indicators, the way these supplier classes should be managed will have their own characteristics. These material management processes are considered in this chapter. In order to perform the improvement actions in the most efficient manner, supplier level is considered first to improve the structural defects of supplier-purchaser interaction. After this, improvement efforts should be made in material level to intervene to the material level supply process defects. Before moving to the category level processes, certain common procedures and considerations should be stated. These questions should identify the framework for process so that details such as division of labor, gathered data characteristics, and time as well as frequency of the analysis are specified.

Division of labor related questions consider at least four points of view: project supervision and sponsorship, data collection and compiling responsibilities, analyses responsibilities and improvement action responsibilities. These tasks and responsibilities may vary between processes as the magnitude of the analysis and improvement processes are not the same between supplier classification categories. For one category and supplier belonging to it, some process steps are needed and others may not be necessarily needed every time.

The second question stated before included the data point of view. As classification is done to categorize the suppliers to four groups in order to manage distribution center outbound delivery risk, all the analyses are performed in supplier level. Therefore, in many cases specified framework might not be adequate and case specific measurements should be developed and used. Category specific analysis process framework presented in this thesis is therefore not fully comprehensive and database for used and needed additional analyses should be gathered in time.

The third perspective that was stated is the time and frequency of the analyses. As the normal fiscal year is calendar year; weekly, monthly and annual reporting is convenient. Therefore, management of the amount of ongoing supplier development projects and other improvement actions should be specified as well as the length of the projects and actions. For example, it could be defined that certain supplier development project will endure half a year and the best timing for the initiation of the project will be in the beginning of second quarter of the year. As this point of view is substantially related to general management issues, it will not be considered further in this thesis and the point of view is therefore directed to the category based processes.

As categorization is based on effectiveness perspective, the prioritization of the supplier categories is obvious; the most focus should be given to the class A suppliers that provide materials that correspond to large amount of outbound lines, but the risk for service performance is also relatively large. As service performance can be defined to be calculated by comparing on-time delivered sales lines to total sales lines, as was done in this thesis, class B should be the second priority to be considered. Despite the fact that category B suppliers have lower risk level than average, there are still improvement actions that could be done to achieve larger effect to the service level than by performing category C supplier improvement process related actions. The supplier category specific process for the most critical suppliers belonging to class A is considered next.

### *4.5.1 Supplier category A*

This category can be seen as the most urgent, but also the most effective improvement objective and therefore it is considered further in this thesis. By making improvement actions in this category, the coverage in material level is the largest and as so, the development of the material flow with the chosen suppliers is the most critical development area. In the case business unit, category A suppliers represent 2,6 percent of the materials and 48,5 percent of outbound lines of the chosen distribution center. Therefore, by focusing to these under 3 percent of total amount of materials in offering, it is possible to make improvements that focus on almost the half of the outbound lines and therefore nearly half of the service level.

As stated previously in key performance indicator testing section of this thesis, the beginning of the supplier level improvement process should be to test the statistical significance of the relation between inbound and outbound operational performance. Therefore, all of the statistical analyses introduced in the previous section should also be done to perform the first phase of supplier improvement project. In the below process chart, this is called as “Supplier level process analysis” and is followed by the beginning of the process that is obvious to be the point in which the supplier is chosen to be the object in the larger, general management level, scale of operational improvement in the purchasing organization.

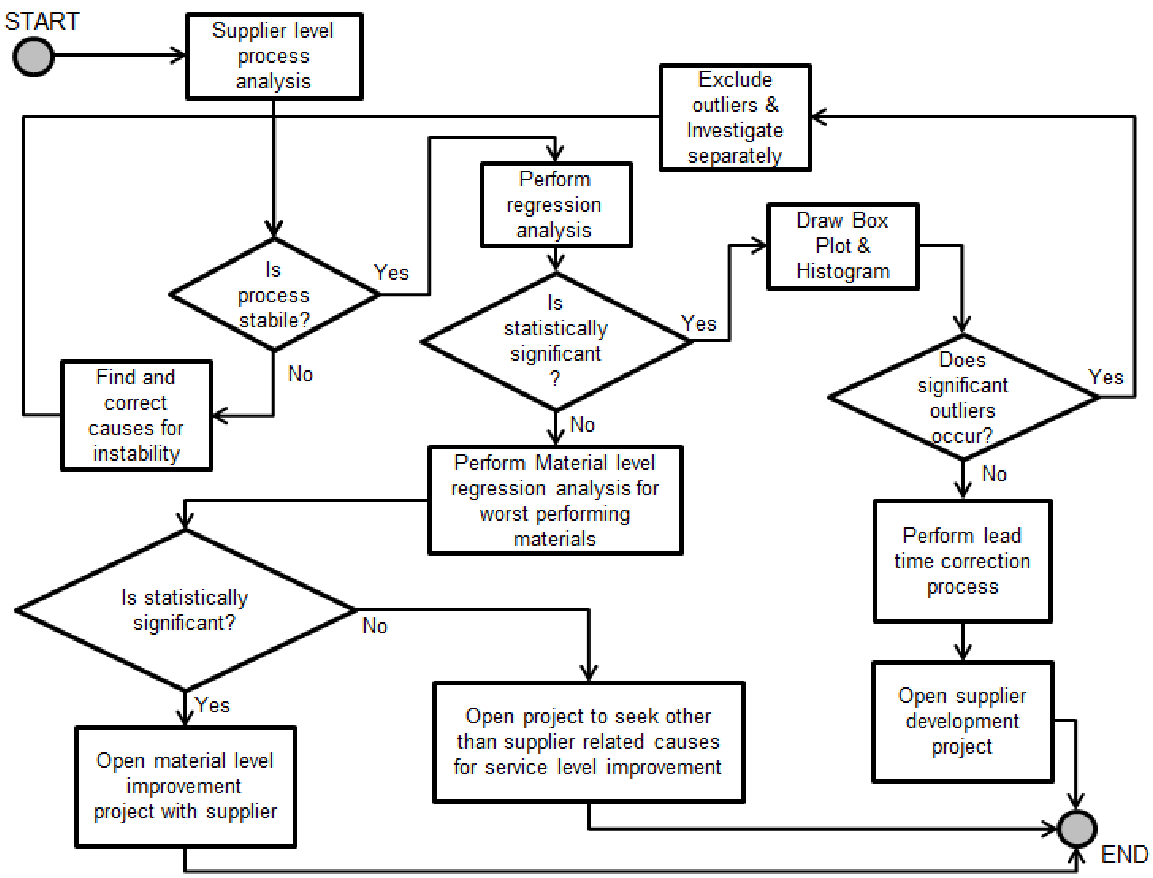


Figure 4.14 General process for category A supplier improvement project decisions

Process chart shown above can be divided to two parts, the first being the supplier level analysis and the second being performed on the material level. As this process chart is presenting the flow of preliminary, general level analysis, it will not seek or pinpoint any specific improvement actions to be done, but can only be used to seek answers to the questions such as the level of the analysis that should be performed, should the improvement project be performed together with the supplier or as an internal improvement project in the purchasing department, or should the analysis be performed on supplier or material level. It is also important to perform preliminary analysis to back up the claims during the negotiations to set up the improvement project with the supplier.

With any of the result got from the preliminary analysis, short and long term improvement actions should be identified by using for example Six Sigma related process improvement methods such as root-cause and FMEA analyses. Also improvement action identifying and prioritization should be considered during the project. These are for example QFD and XY analyses. (Wang et al. 2004)

### *4.5.2 Overview of supplier improvement strategies*

In the previous sub-chapter the proposal for improvement process for most critical suppliers was introduced. Although the criticality of improvements can be noticed from the created classification, it is also relevent to specify main improvement guidelines also for other supplier classes. These different strategies can be collected to one chart which is seen in below figure.

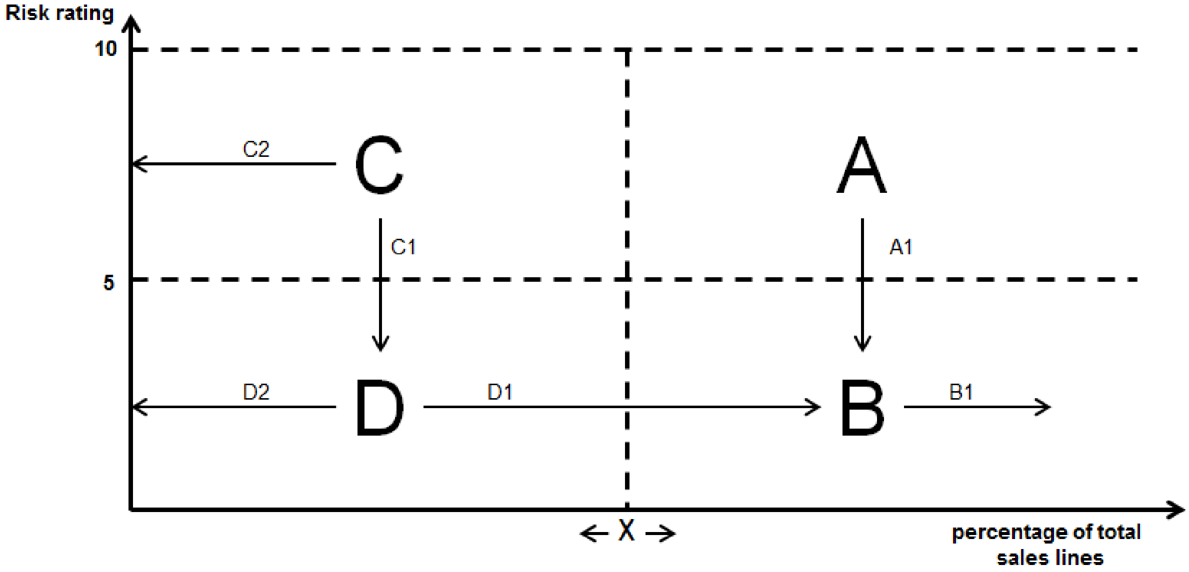


Figure 4.15 Supplier class related development paths

As stated in the supplier category related strategy considerations there is only one strategy to be taken for class A suppliers which is to reduce the risk level. This is shown in figure as A1. Additionally to the risk reduction strategy, class C suppliers have alternative strategy of reduction of materials purchased from them as shown in figure with C2. This could be done if materials can be sourced from larger supplier with lower risk level and if there are no strategic reason to keep them in supplier base. The same applies to class D supplier reduction strategy maked with D2 arrow. For low risk supplier classes B and D the best strategy would be to centralize the supply operations for these suppliers as much as possible as is stated by arrows marked D1 and B1.

As this view to supplier management does not draw the complete picture of strategies and actions to be taken, it should be used in parallel with the strategic supplier management. One obvious reason for this is that the specified operational perspective to supplier classification does not include material cost or cost of quality perspectives. Therefore, the basis for strategy selection should be carefully considered, before making any drastic actions.

## 4.6 Results

The case study was divided into to distinct parts deductive and inductive approaches. In the first part, quantitative analysis was used to perform a correlation test for inbound and outbound operations service performance of a distribution center. Linear regression and correlation was found and therefore hypothesis 1 is confirmed and inbound service level can be seen to affect to outbound service performance. This result leads to the conclusion that the answer of the research question 1.1 is positive.

When the model was tested by excluding three data points that were furthest from the linear regression line, the statistical significance decreased and therefore the linear regression model and correlation model was stated to correspond to improvement actions. Furthermore, the second hypothesis was not confirmed as the best regression model for the tested two sample sets was not the same. This was because the excluded data points in the first sample set were located in the lower part of scale and the best regression model was discovered to be quadratic. From theory perspective this can be seen to be caused by stockout situations, and therefore it is the logic outcome from theoretical perspective.

The second hypothesis was tested with regression analysis and as a result it was noticed that this hypothesis could not be confirmed as quadratic model gave better result for the first set of samples. This can be concluded to correspond with the previously introduced theories. The cause for quadratic regression model to correspond better to the results was deduced to be cause by the safety stock and its effect to the material availability. As quadratic model was not the best model for all tested sample sets, this statement cannot be completely confirmed either.

The second part of the case study built up a model for supplier development framework from material availability perspective in a distribution center environment. The goal of this part was to create and test with data the material availability risk perspective in order to create the supplier and material management framework for improving the material availability. From literature, portfolio models were taken as a basis for this model creation. After testing the model that was created, the dynamics and supplier positions were agreed. The result was used to focus only to the most critical suppliers from the material availability perspective and therefore process for class A was only created. Overall view of main strategies for the classes was also illustrated in order to create holistic view to the case through applying features from previous literature.

Other findings of the case study indicate that supplier level lead time analysis should be made in order to find out more accurate lead times for the materials. Also the contractual lead time management should be paid more attention to. This was seen from histogram analysis that was applied for lead time accuracy related data. As this perspective was not included in the main framwork of this thesis, further study of this perspective should be conducted.

# 5 DISCUSSION

The first deductive research question was to test the correlation and regressions between inbound and outbound service performance of a distribution center. As the result, it was seen that statistically significant correlation and regression exist in case situation. Therefore, the first hypothesis was confirmed. The sample data was noticed to have some considerations as major outliers were found. As the second hypothesis was rejected because the best regression model for the first set of samples was found to be quadratic. Therefore, in these cases it can be concluded that if the outlier points are in line with the regression analysis, these points should be the primary focus for the improvement effects. If the occurred outlier points do not correspond with the regression analysis, other influencial factors to outbound service level should be investicated. In order to further study the impact of inbound lead time accuracy and service level to outbound service performance, these other failure mechanisms should be identified. This could be done through data analysis and by collecting the findings to cause-and-effects diagram.

In addition to correlation analysis, also regression was used to test the mutual interaction of the two sides of distribution center operations. It was seen that linear regression is not unambiguous regression model for the connection. As safety stocks are used in inventory management, the buffer that these extra storage levels cause reduces also significantly the connection between inbound and outbound operations. In order to take the time that safety stock covers the demand into account in the analysis of stockout situations, there would be some obstacles. One of these is that as inventory planning normally uses automatical and floating safety stock determination system, also the safety stock coverage changes over time. This will lead to difficulties in reporting systems.

As the statistical significance was found between inbound and outbound service performances, it can be said that the performance of outbound operations can be improved through developing the inbound operations from material flow perspective. Additionally, the regression models can be used to define the desired inbound service level that would fulfill the goals that are set to outbound operations. The contractual perspecive can also be seen to be important in order to motivate the suppliers to implement the agreed improvement actions. One of the actions to be taken in the purchasing organization that could be implemented quickly was identified to be the changing of the lead times to correspond the realized lead times from previous purchasing orders. The improvement efforts related to this point of view should be performed together with the supplier and as a part of the development actions contractual dimension should also be taken into account. One of the actions that could be taken would be to add more effective contract clauses considering lead times, if possible. This action could be done only when the purchasing organization has enough bargaining power towards the supplier. If not, other methods should be used, for example seeking alternative suppliers and simply changing the lead time in the system to follow the actual realized lead time, could be considered. If development project is created with the supplier, the main goal should be to decrease the standard deviation of supplier lead times. Also root cause analysis should be performed to both, inbound and outbound processes for the most significant outliers.

This study included only materials that are in storage and so called non-stock materials were excluded from the focus. As non-stock materials are planned to be sent out within the lead time specified in the system, this should also be considered while taking improvement efforts for outbound operations. Furthermore, in addition to supplier level analysis also material level should be considered in order to find the most significant development areas. In this level, reaction plan should be created to ensure the material availability in both, long and short timeframe. In short term, for example lead time could be extended in order to get the lead time in system to correspond with the reality. In long term, this example would require actions to be taken with supplier to define the correct and realistic lead time as well as reducing the deviation. This might result to additional development efforts such as sharing of demand forecasts to suppliers or introduction of vendor managed inventories to the supply process.

In the second part of the case study, models represented in literature were used to create a model for operational supplier development frame work. Although the supplier categorization model was tested only in one case company, the model was developed so that it would be applicape also to other business environments and therefore it can be seen as a relatively generalized approach. This framework was decided to be constructed the similar way than its predecessors, as portfolio model. Although the previous portfolio models for supplier classifications had been criticized to be too static, the created model was developed to bring more dynamic perspective to the supplier segmentation as the results and classifications were designed to change in time. Operational performance should be dynamic at least in a situation in which supplier development actions are applied in supplier level. Therefore, the changes that have been achieved should be visible in the matrix classification. As the analysis was made by using solely operational, concrete and measureable data, there are additional considerations that could be taken into account when the created model is further developed. One of the additional future development and research focus areas related to this study would be adding material price considerations and material quality related approach to the model. Also, as was already stated, the relationship perspective could be added to the classification. On the other hand, this would move the model towards strategic supplier segmentation and would therefore duplicate the consideration already made in the strategic sourcing. Therefore, further development of this supplier classification method should also in the future focus only to the operational and measurable data.

# 6 CONCLUSIONS

The results of this study, that there is positive correlation between inbound and outbound service performances. It was also seen that the regression model is not linear. This was concluded to be caused by safety stock and its respond to the variance. It was also seen that when the supplier is working in a good level from the delivery timeliness perspective, statistical significance does not occur. The result was used in the process created in the improvement process creation as it was chosen to measure the need for supplier or material level improvements from material availability perspective. As the logistics operators and distribution internal operation were excluded from the analysis, the results are not completely generalizable. Further research would be required in order to get the more holistic model of the material availability phenomenon and the structures and factors affecting it. Furthermore, as the result of regression model test was not unambiguous further testing of the most suitable model should be performed.

Additional research of supplier delivery lead time accuracy should be performed to test the accuracy in the outbound side of distribution center operations as it was shown in this study that there is a connection between the inbound and outbound service performances. This would provide more in depth view of the background phenomenons and might bring up more sophisticated improvement actions. Also the extension of this perspective further in supply chain level would be beneficial, although the perspective resembles closely to bullwhip effect.

Supplier segmentation model from material flow perspective was constructed solely from operational perspective and therefore there is need for creating holistic supplier management system that would take both operational and strategic perspectives into account. Additionally, it would be appropriate to compare the results between different supplier segmentation models in particular between strategic and operational models to seek an answer to the question of need for both analyses. If the results would be similar in great extent, the need for two analyses cannot be seen appropriate and beneficial. Additionally testing of the effect that emphasis in the availability risk factor should be further performed in order to optimize the risk factor.

# 7 SUMMARY

Connection between inbound and outbound service levels of a distribution center was studied in this thesis. Additionally, the improvement efforts to maximise material availability from inbound delivery timeliness perspective and thereby the outbound service level were the main scopes. At first, connection between service levels was studied by testing hypothesis that stated that there is correlation between the inbound and outbound delivery service performance. This first hypothesis was confirmed as the results from both of the sample sets were positive. After this, second hypothesis was tested. In the second test, regression analyses were performed to the two sample sets. The purpose of the test was to test if linear regression model best suits to describe the connection between inbound and outbound service performances. This hypothesis was rejected as the result from the first sample set was that quadratic regression model was the more suitable that linear regression model.

The second part of the case study was to build a model for supplier development process to improve the material availability of a distribution center. This second research question was answered by performing literature review and combining the previous models, observations and theories, in order to create supplier segmentation model that would point out the most critical suppliers from material availability perspective. This model was formed to resemble portfolio models. After most critical suppliers had been identified improvement process was created for the most critical supplier class and coarse improvement directions were suggested for all of the four supplier classes. These processes were not tested in practice as the testing part of this model was excluded from the scope of this thesis.

As statistically significant regression models were found as a part of the first main research question, these models could be used to point out the target for the inbound service level so that the outbound service level could be improved to the target level. As there are other factors that are influencing to the outbound service level, these should be further investigated in order to further develop the improvement process. Furthermore, one of the influencial factors for delivery timeliness was identified to be the control and sanctions presented towards supplier in contractual level. It was stated that the improvement efforts should be linked to the contract. As that would be one of the long term solutions, in short term lead times should be changed to correspond better the realized lead times. This would improve the inventory planning momentarily before the long term process improvement actions could be implemented.

In the supplier segmentation model, additional perspectives should be considered in the future. As business is about the money, the price perspective should be included to the risk analysis. Additionally, method of including the material quality to the availability risk should be developed. As the strategic supplier classification and the segmentation model presented in this thesis have complementary scopes, the comparison between these analyse methods can be stated to be a very good future approach to continue the research considering supplier segmentation models.

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