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Framework for Supplier Performance Measurement System

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Abstract

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Performance measurement in supply chain provides information on the efficiency and effectiveness of a supply chain. As the performance measures describe the operative performance of a supply chain, the measures can provide additional valuable information to support decision making in companies. The performance evaluation provides fact-based knowledge of supply chain processes which require improvements. Subsequently, the performance of suppliers can be improved in co-operation with suppliers, through appropriate management of the supplier relationships.

The aim of this study is to develop a framework for supplier performance measurement system for the case company. Currently the case company measures the supplier performance with two separate metrics. These metrics, however, do not provide an overall picture of supplier performance, nor do they suggest a fact-based approach to supplier evaluation. In addition to the performance measurement improvements, this study analyzes the improvement opportunities, which can be utilized through supplier relationship management.

The outcome of this study proposes a framework for the performance measurement system in the case company. This framework suggests measuring the performance of the upstream supply chain and aims to help the case company to implement a performance measurement system. To implement the proposed measurement system, some additional metrics need to be developed in the case company. With the developed performance measurements, the case company can focus on improvements to its supply chain, and additionally evaluate the overall performance of its suppliers.

Key words	Performance Measurement, Supply Chain, Supplier Relationship Management

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Toimitusketjun suorituskyvyn mittaukset antavat tietoa tehokkuudesta ja toimivuudesta. Toimitusketjun operatiivisen suorituskyvyn lisäksi, mittaukset tuottavat arvokasta tietoa yritysten päätöksenteon tueksi. Suorituskyvyn arviointi antaa todenmukaista tietoa toimitusketjun prosessien kehittämiseen. Lisäksi toimittajien suorituskykyä voidaan parantaa yhteistyöllä toimittajien kanssa ja asianmukaisella toimittajasuhteiden hallinnalla.

Tämän opinnäytetyön tavoitteena on kehittää viitekehys toimittajien suorituskyvynmittausjärjestelmäksi tutkitulle yritykselle. Tällä hetkellä tutkitussa yrityksessä toimittajien tehokkuutta mitataan kahdella erillisellä mittarilla. Nämä mittarit eivät kuitenkaan anna riittävää tietoa toimittajien kokonaisvaltaisesta suorituskyvystä, eivätkä myöskään tarjoa todenmukaista pohjaa toimittajien arvioinnille. Suorituskykymittausten lisäksi, tässä työssä tarkastellaan millaisia kehitysvaikutuksia toimittajahallinnalla on.

Tutkimuksen tuloksena esitetään viitekehys toimittajien suorituskyvynmittausjärjestelmäksi tutkitulle yritykselle. Tämä viitekehys ehdottaa toimitusketjun yläosan suorituskyvyn mittaamista sekä pyrkii helpottamaan suorituskyvynmittausjärjestelmän käyttöönottoa. Mittausjärjestelmän käyttöönottoa varten, yrityksen on luotava uusia mittareita. Näillä toimenpiteillä yritys voi kohdistaa kehitystoimia toimitusketjuunsa, sekä arvioida kokonaisuutena toimittajien suorituskykyä.

Asiasanat	Suorituskyky mittaukset, toimitusketju, toimittajasuhteiden hallinta

Contents

Acronyms

BSC	Balanced Scorecard
EMS	Electronics manufacturing Service
ERP	Enterprise Resource Planning
FPY	First Pass Yield
JIT	Just In Time
KPI	Key Performance Indicator
OTD	On Time Delivery
PCBA	Printed Circuit Board Assembly
ppm	parts per million
SCM	Supply Chain Management
SCOR	Supply Chain Operations Reference
SRM	Supplier Relationship Management

1 Introduction

This study focuses on the supply chain performance measurement and is devoted to the development of a proposal for the supplier performance measurement system for a medical X-ray company.

1.1 Case Company Background

The case company is a Finnish medium sized company, which is located in the south of Finland. The company designs and manufactures dental X-ray imaging equipment and software for image management. The case company is a part of an international corporation's dental division, which has its headquarters situated in Washington DC in the US. The case company's product development, manufacturing, marketing and sales organization are all located in Finland. The company also has two sales and support offices, one in Germany and one in The United States. Most of the case company products are sold through a global distributor network.

Parts, components and assemblies used in the case company products, are currently purchased from several suppliers distributed over different locations. The purchased parts include, for example, printed circuit board assemblies (PCBAs), sheet metal assemblies, plastic covers, cable assemblies, machined metal parts, sub-assemblies, electronics (such as power supplies, displays, computer accessories, electric motors, electronic components), and other types of parts and accessories.

Once the parts are purchased, the case company uses the parts to assemble its products through five production lines, or mini-factories, which are all responsible for their own daily operations. These mini-factories plan their production, order the parts and manufacture the equipment according to their own schedule and needs. The companywide operations is managed and coordinated by the supply chain management team of the case company. To support the supplying of the needed parts, the case company has a devoted sourcing department, which is responsible of supplier selection and management, as well as price negotiations with suppliers. Later, a more detailed description of the operations of the case company is provided in Section 4 as part of the current state analysis of the case company operations.

1.2 Business Problem

Competition between individual companies has evolved to competition between their respective supply chains and networks. Therefore, collaboration between supply chain partners, their relationships, the alignment of the operations within the supply chain/network, as well as agility and responsiveness to the customers' demands have become a source of competitive advantage for modern companies. To achieve and retain this competitive advantage, a performance measurement system has now become a required necessity for the companies that aim to implement strategies and correctly focus improvements to their activities. (Ip et al. 2011, Lee 2004, Cassivi 2006, Rivera et al. 2007, Giannakis 2007, Gunasekaran et al. 2004)

Supply chain management (SCM) is widely recognized discipline to manage suppliers, logistics, operations and distribution of products and services. Target of a supply chain is to have flexibility, reduce costs, improve quality, and gain a competitive advantage. This is why so many researchers and companies have focused on SCM during the past couple of decades. (Holmberg 2000, Chuah et al. 2010, Lee 2004, Lamming 1996)

Although researchers stress the importance of measurements for supply chain management (Shepherd and Günter 2006), in the case company there is currently no performance measurement system that would enable it to evaluate the overall performance of its suppliers. The performance is measured presently in the case company with separate metrics within the existing supply chain, and they are applied differently to each particular supplier. Moreover, the metrics that have been implemented are not directly connected to each other, that is, they do not create a system, and most of them are only high-level metrics that do not provide any further means for analysis.

Currently, the performance of the suppliers in the case company is measured monthly, for two variables – quality and delivery accuracy. However, this does not give a clear view of the overall performance of the suppliers. Furthermore, there is presently no well-defined method to evaluate the suppliers and manage their performance, although such a method is needed in the case company. Additionally, a set of standards based on benchmarking and existing best practices would be desirable to develop and verify how the objectives of the supply chain are achieved. All these needs create a business problem that is aimed to be addressed in this Thesis.

1.3 Objective of this Study and Research Question

The objective of this study is to improve the supplier performance measurement for the case company by developing a measurement framework, which can be used to evaluate the performance of the suppliers and to identify improvement needs in supplier management.

In this study, the research question can be stated as follows:

How to improve the supplier performance measurement of the case company supply chain?

To answer the research question, this study will analyze supply chain performance measurement frameworks found in the research literature, to find suitable models to develop a performance measurement framework to the case company. The study will also analyze how the suppliers' performance needs to be evaluated and how the supplier performance can be managed. Therefore, this study will focus only in the upstream part of the case company's supply chain. Although developing a performance measurement system for the case company, this study, however does not include the individual metrics for the measurement system. Metrics are discussed only in the general level and used as examples.

1.4 Research Design and Structure of the Thesis

As stated earlier, this study aims to investigate and improve the performance measurement of the supply chain in the case company. The research design shows the organization of the data collection and analysis and the development of the proposal for the case company. The research design is illustrated in Figure 1.

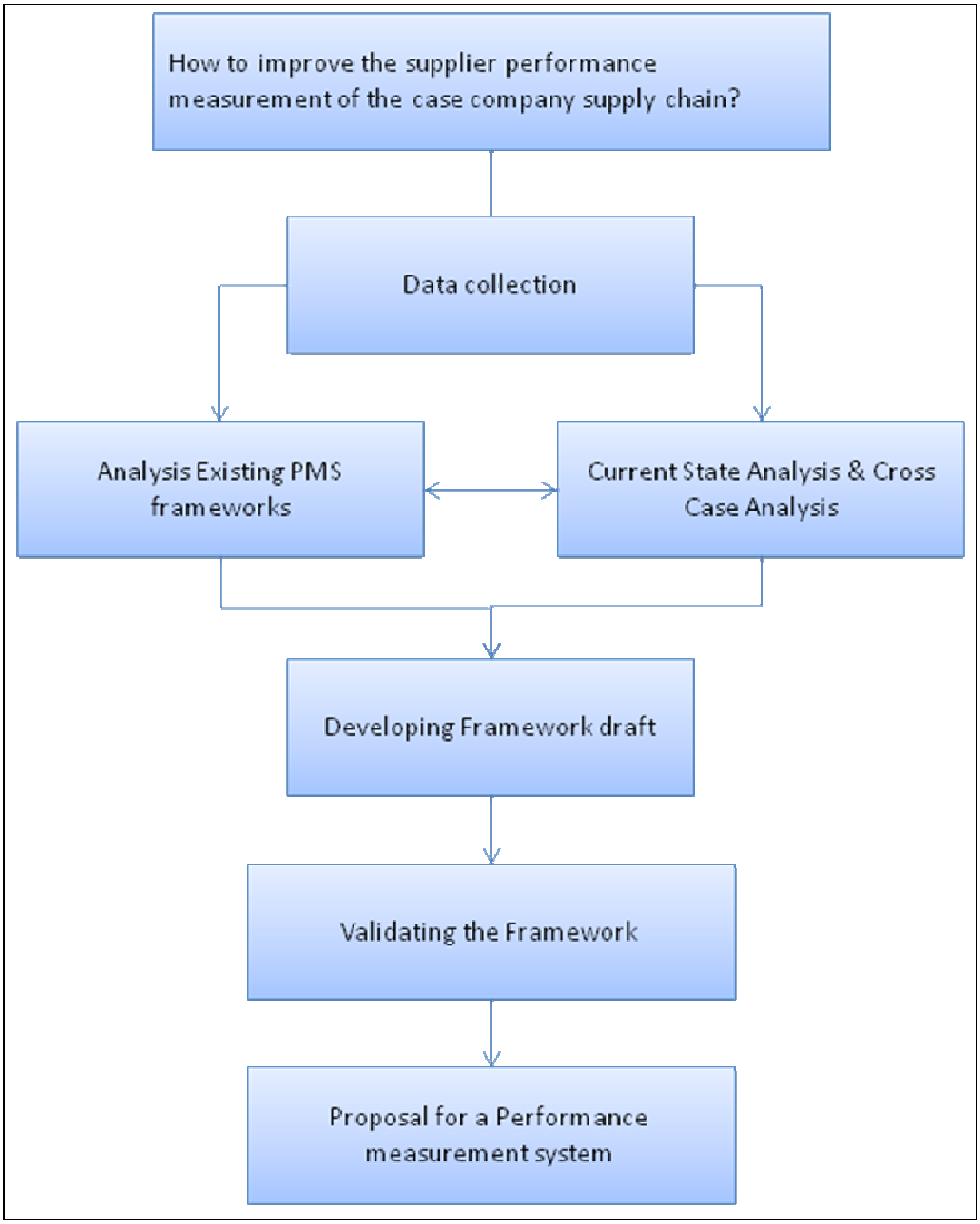

Figure 1. Research design.

As shown in Figure 1, this study draws from two types of material to respond to the research question. First, it reviews best practices found from the research literature, and second, analyzes the current state of performance measurements in the case company and its suppliers. The current state of the supply chain measurements utilized in the case company and in suppliers, is analyzed based on the data collected from interviews and observations by the researcher.

Following the data collection and analysis and backed up by the theoretical search, a draft of the framework is developed, which is then verified with the supply chain management team in the case company. The current data is fitted to the drafted framework to test the validity of the framework. To collect a wider range of opinions for the proposed framework, an internal workshop is conducted to verify and improve the drafted framework. Finally, an improved version of the performance measurement system is developed for the case company.

As for the structure of the Thesis paper, the Thesis is written in seven sections. Section 1 describes the objectives of the study, overviews the design, and outlines the scope of the study. Section 2 introduces the research approach, data collection and data analysis methods applied in this study. Section 3 presents the supply chain performance frameworks and supplier management views found in the literature. Section 4 analyzes the current performance measurements and discusses methods used for supplier evaluation in the case company. Section 5 discusses the models and practices used for supplier performance measurement in case company's supplier organizations. In section 6 the results and analysis of the study is presented, with a framework for an improved performance measurement system for the case company. Section 6 concludes the results of the study and Section 7 presents managerial implications and recommendations for the case company.

2 Method and Material

This section describes the research method applied in this study, and discusses how the data are collected and analyzed.

2.1 Research Approach

This study is constructed as qualitative case study research. As stated by Yin (2003), if the research question is formed, as "how" and "why", the case study approach is feasible research strategy. The case company's supplier performance measurement system is the case studied in this thesis. In addition, to provide more triangulated view on the actual case, additional cases were studied to benchmark, the performance measurements in the case company's suppliers. According to Eisenhardt (1989), the use of cross-case analysis forces the investigator to go beyond initial impressions and improve the analysis of the data to create more accurate and reliable theory.

As stated above, the primary unit of analysis in this study is the case company's supplier performance measurement system. However, the case in question will be revised during the analysis if new issues arise from the data. This will keep the case open and flexible to possible new information and discoveries, if such will be found during the data collection. In addition to the case company's performance measurement system, three other cases concerning performance measurements will help to provide grounding for the conclusions of this study. Because comparing different cases to find a pattern, or a conflict, in the evidence, will generalize results and therefore, will make the findings stronger. (Eisenhardt 1989, Yin 2003)

2.2 Data Collection and Analysis Methods

The data for this study were gathered from a number of sources, including a series of semi-structured interviews, observations by the researcher, and analysis of process descriptions and process instructions of the case company. In addition, interviews and discussions with two suppliers were held to benchmark their performance measurements. At the same time the interviewed suppliers of were also requested to provide information on how they want to be measured. The use of multiple data sources ensures that the problem is explored trough more than one lens and allows multiple facts of the phenomenon to be revealed (Baxter and Jack 2008:544).

2.2.1 Interviews

As already mentioned, interviews were conducted one as method to collect data for this study. Yin (2003:89) argues that interviews are one of the most important sources of data for case studies. Yin (2003:89) adds that the interviews in case studies are more like guided conversations rather than queries whit formal structures. The interviews conducted for this thesis were semi-structured and not recorded, but the data was collected to the researcher's notes.

For the interviews in the case company, a list of questions was prepared and delivered to the interviewees prior to the actual interview. These questions are enclosed in Appendix 1. Interviewees were selected by their position in the case company and their role in the supply chain. Likewise, a set of questions were sent to the suppliers. The questions for the suppliers are displayed in Appendix 2. Totally nine interviews were conducted. Table 1 lists the informants who participated in the interviewees and indicates their position, role in their company and belonging to the case company (C) or a supplier company (S).

Table 1. Informants in the case company's supply chain.

Initials	Position	Role	(C) / (S)	Date
M.K.	VP operations	Leader of SCM team	C	2.2.2012
M.T	Sourcing Director	Director of the sourcing department	C	6.2.2012
J.L.	Sourcing manager	Managing the electronics sourcing and suppliers	C	8.3.2012
J.R.	Supplier Quality Engineer	Responsible of the supplier quality	C	13.3.2012
P.K.	Sourcing manager	Managing the sheet metal sourcing and suppliers	C	15.3.2012
P.R.	Production line buyer/planner	Responsible of production line material planning and procurement	C	15.3.2012

K.K.	Factory Manager	Suppliers factory manager	S	19.3.2012
J.P.	Key Account Manager	Supplier key account manager for case company	S	20.3.2012
T.S.	Production Manager	Suppliers production manager	S	20.3.2012

As shown in Table 1, the informants ranged from top management to operational managers, as for their positions in the organization. Six of them belong to the case company, while three represent the suppliers interviewed for benchmarks. Additionally, informal discussions of the case were held with several other personnel in the case company.

2.2.2 Observations and Documentation

Another data collection method was direct observations by the researcher. The researcher participated in the monthly meetings with suppliers, supplier audit and, made observation is in the production lines, as well as suppliers' facilities. The evidence collected from these observations was also discussed with the previously listed informants in the case company as well as other personnel. The observations were documented in the researcher's field notes. According to Yin (2003:86) the strengths on direct observations are that the events can be covered in real-time and that direct observations are contextual. In addition, for weaknesses Yin (2003:86) lists the costs of human resources, reflexivity, selectivity, and time-consumption of the observations. Documentation of these observations became also somewhat challenging, as the researcher was not always prepared to gather notes.

The researcher also reviewed process descriptions and instructions, meeting minutes, and supplier performance data from different databases, documented by the case company. The value of this kind of documentation as a source of evidence is great, according to Yin (2003:86-87), because the data is stable, unobtrusive, exact and, the documentation covers a long time span, lot of events, and many settings. The researchers access to some financial data was however limited.

2.2.3 Analysis of the Data

After the data collection, an analysis of the data was conducted to provide grounded solution for the business problem. The data was reviewed and as Yin (2003) suggests, pattern-matching, cross-case syntheses, logic models and explanation building were applied. The analysis was done in two phases. First a preliminary analysis was conducted after all data was collected to find out is all aspects covered. Then a further analysis was done to thoroughly investigate whether the business problem could be solved based on the evidence.

2.3 Reliability and Validity

According to Yin (2003), the goal of reliability in a case study is to minimize errors and biases. This can be achieved, when the research is designed, and conducted so, that someone else can repeat the study and reach the same conclusions using the same data. Yin compares case study reliability to accounting and bookkeeping, where an auditor performs a reliability check to the numbers and figures accounted and calculated. In the same sense a case study results should be repeatable by an auditor, using the procedures as the original researcher. For the research procedure and data, which were mentioned before, Baxter and Jack (2008) point out that, trustworthiness can be achieved once the researcher ensures that, the research question is clear, the case study is appropriate for the question, appropriate sampling is used, systematical data collection and management is used, that the data is analyzed correctly. (Yin 2003:38-39, Baxter and Jack 2008:556)

Validity and reliability of a research are is an important issue to be considered. As stated by Yin (2003), the validity in case studies can be assessed by testing the construct validity, internal validity and external validity. According to Yin (2003), these tests can be applied at different points of the research process. Construct validity can be achieved when the data is collected from multiple sources, chain of evidence is established and having the research report draft reviewed by key informants. Multiple data sources forces the researcher to triangulate the problem from different perspectives, thus also increasing the validity to the study. Likewise, establishing a clear chain of evidence provides not only validity, but also clear logic to the structure if the cases study, which allows an external observer easily to be able to follow the research from initial research question to conclusions. As the third mean to improve construct validity of a study Yin (2003:159) proposes that, the research report is reviewed by the key informants. This way any disagreement or misunderstandings about the facts of the case can be further investigated. In addition, some new evidence or data may be prevailed, which was ignored at the actual time of data collection. (Yin 2003)

To obtain internal validity, the researcher must do pattern matching, build explanations, address rival explanations, and use logic models when analyzing the case evidence (Yin 2003:36). Eisenhardt (1989:545) states that, tying the results of the study to existing literature is a way to enhance the internal validity of the study. This supported by Yin (2003), as existing literature can provide rival explanations and other patterns to review. External validity is attained when the findings of a study can be generalized in another context. This test will show, weather the results of the study support the theory of single-case study or provide same results in multiple case studies. According to Yin (2003), this requires similar replication logic as a scientific experiment, meaning that a theory must be tested in different, but similar surroundings. (Yin 2003:37)

To increase the reliability and validity in this study, different data sources were used and the business problem was approached both form the case company's and suppliers perspective. Furthermore, reviews and discussion with the key informants were held during the whole research process. And finally, once the drafted framework was created, it was presented in the case company for the key informants. Based on the discussions and comments from the informants a finalized version of the performance measurement framework was developed. This framework is introduced in the Results section of this thesis.

3 Supply Chain Performance Measurement

This section introduces brief overview of supply chain management and focuses on describing common supply chain performance measurement frameworks found in research literature. Different frameworks are introduced and later analyzed to find suitable elements to implement in the case company. Additionally, to include in the analysis, supplier relationship management (SRM) is reviewed and finally, an initial framework is developed, based on the research literature. This framework is then further developed as for potential implementation within the case company, in Section 6.

3.1 Supply Chain Management Overview

As stated in the introduction, supply chain management is a business discipline to manage suppliers, logistics, operations and distribution. Lamming (1996) states that, although supply chain management originates from theories and practices from the field of logistics, it has evolved during the past decades to include whole value chain of a product or service. Janvier-James (2012) has analyzed some of the various definitions of supply chain management, and all of them share the basic idea that, supply chain management is aimed at examining, managing, and developing networks of organizations, which construct the supply chain. Additionally, Janvier-James (2012) mentions that the main activities of supply chain management thrive for optimizing and controlling the various processes within the supply chain.

Companies are concentration more and more on improving whole supply chains to create competitive advantage (Holmberg 2000). That is also a reason, why supply chains is studied and analyzed, not only researches but also companies themselves. Different supply chain models have evolved as a result from this research and from companies own needs. Bilsback (2011) argues that lean supply chains are strongest; Christopher and Towill (2001) state on the other hand that, agility is prerequisite for successful supply chain. Lee (2004) describes a "Triple-A"supply chain that is Agile, Adaptive, and Aligned, to be the best model for a supply chain. Also several hybrids and combinations of lean supply chain and agile supply chain have been developed and studied (Goldsby et al. 2006, Agarwar et al. 2006, Banihashemi 2011). Regardless of the supply chain model, performance measurements need to identify the core processes, which drive the performance.

Even supply chain configurations may be different, the main goal remain same to all supply chains: optimizing time, cost and quality. Likewise, the challenges that currents business environment poses to supply chains need to addressed despite the supply chains configuration. These challenges include the rapid changes in demand, shortened lifecycle of products and services, fast development of new technology, global competition and advances in information technology, just to mention few. To mitigate the risks and continuously improve the supply chain and its performance, companies need to focus their improvement efforts to right parts and processes within their supply chain. To support these efforts, performance assessment of supply chains has become a key research area (Ip et al. 2011). Cuthbertson and Piotrowicz (2011), point out that, many factors, such as: supply chain model, industry, strategic goals, supply chain scope, are important to understand, in order to develop a performance measurement system.

3.2 Supply Chain Performance Measurement

The following sub-sections will introduce the performance measurement systems (PMSs) found in the research literary. Finally, the presented frameworks are summarized and analyzed to find suitable parts to develop a framework to the case company.

3.2.1 Supply Chain Operations Reference Model (SCOR)

The Supply Chain Operations Reference (SCOR) model is a framework developed by the Supply Chain Council. SCOR was first introduced in 1996 and since then has been updated and revised several times. It is a framework that includes processes, metrics, best practices, and technology features, which can be applied to any industry. The framework was developed to be used as a standardized way of describing a supply chain. (Li et al. 2011, Huan et al. 2004, Theeranuphattana and Tang 2008)

The SCOR model contains five basic components of planning, sourcing, making, delivering and returning. These components, or processes, are the as building blocks of the framework. These five basic processes of a supply chain in SCOR model are shown in Figure 2. In the SCOR framework, performance metrics are also categorized within five classes, namely reliability, responsiveness, flexibility, cost, and assets. Theeranuphattana and Tang note that quality is not included in this list. According to them, the quality management is separated from supply chain management. (Theeranuphattana and Tang 2008:127)

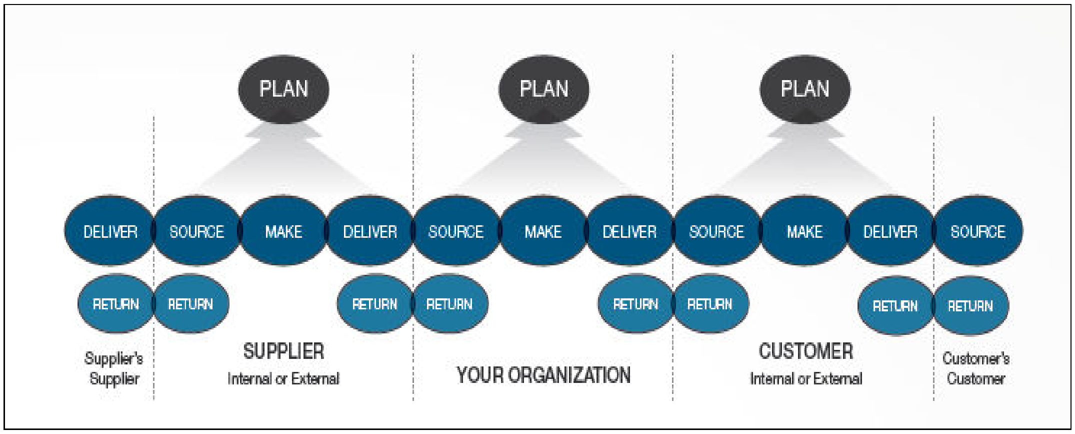

Figure 2. SCOR model basic processes for a supply chain (Supply Chain Council 2011:6).

The performance metrics within the five blocks, shown in Figure 2, are divided into three levels of process details. On the top, there is Level 1, which combines strategic metrics and key performance indicators (KPIs). Level 1 is used to define the scope of the supply chain and holds the KPIs for the five block of the model. Then, Level 2 contains the metrics for decomposing each of the top level KPIs into more detailed metrics. Level 2 metrics can be configured to accommodate the specific operations of the supply chain, such as make-to-stock, make-to-order or engineer-to-order. Finally, Level 3 is then used to decompose Level 2 metrics. Level 3 metrics can be used to describe an individual process element or task, for example, produce and test, or package tasks. There also is a Level 4, but this level is industry specific and lies beyond the scope of the generic SCOR framework. (Supply Chain Council 2011, Li et al. 2011, Huan et al. 2004, Theeranuphattana and Tang 2008)

As stated previously, the SCOR model does not include the quality parameter (Theeranuphattana and Tang 2008, Li et al. 2011). However, Li et al. (2011:35) point out that reliability and responsiveness, included in the framework, can also be considered as quality indicators. The lack of direct quality metrics does not diminish the applicability of the SCOR model, as quality is measured and evaluated along the products and services lifecycle several times by everyone involved in the supply chain.

To summarize the strengths of the SCOR model, it can be identified that its biggest strength is the global implementation and adaption of the model. The Supply Chain Council that has developed the SCOR model has close to 1000 members, which include some of the biggest corporations (SCC 2011). The model provides a standardized method to evaluate the processes of a supply chain with enormous database of benchmarks from the member organizations. As a weakness of the model, it needs to be mentioned, that the model consists of hundreds of metrics. For effective implementation of the SCOR model, all of these metrics should be scrutinized to find the suitable ones, which capture essence of the performance in the supply chain in question. The abundance of metrics also requires a huge amount of data, which in some cases does not exist. Despite mentioned shortcomings, the SCOR model is a desirable framework, as it includes all the processes within a supply chain.

3.2.2 Balanced Scorecard

Balanced Scorecard (BSC) is a widely used management tool that tracks all the important elements of a company's strategy (Kaplan and Norton 1992). Kaplan and Norton (1992) compare the BSC with the dashboard of an airplane, which gives the pilot all the vital information with a quick glance. The BSC links performance measures under four important perspectives of business, which are: financial perspective, internal business perspective, innovation and learning perspective, and finally customer perspective (Kaplan and Norton 1992). Brewer and Speh (2000) introduced a framework to measure supply chain performance with the Balanced Scorecard ideology. Figure 3 below illustrates how Brewer and Speh's framework on supply chain performance is linked to BSC perspectives.

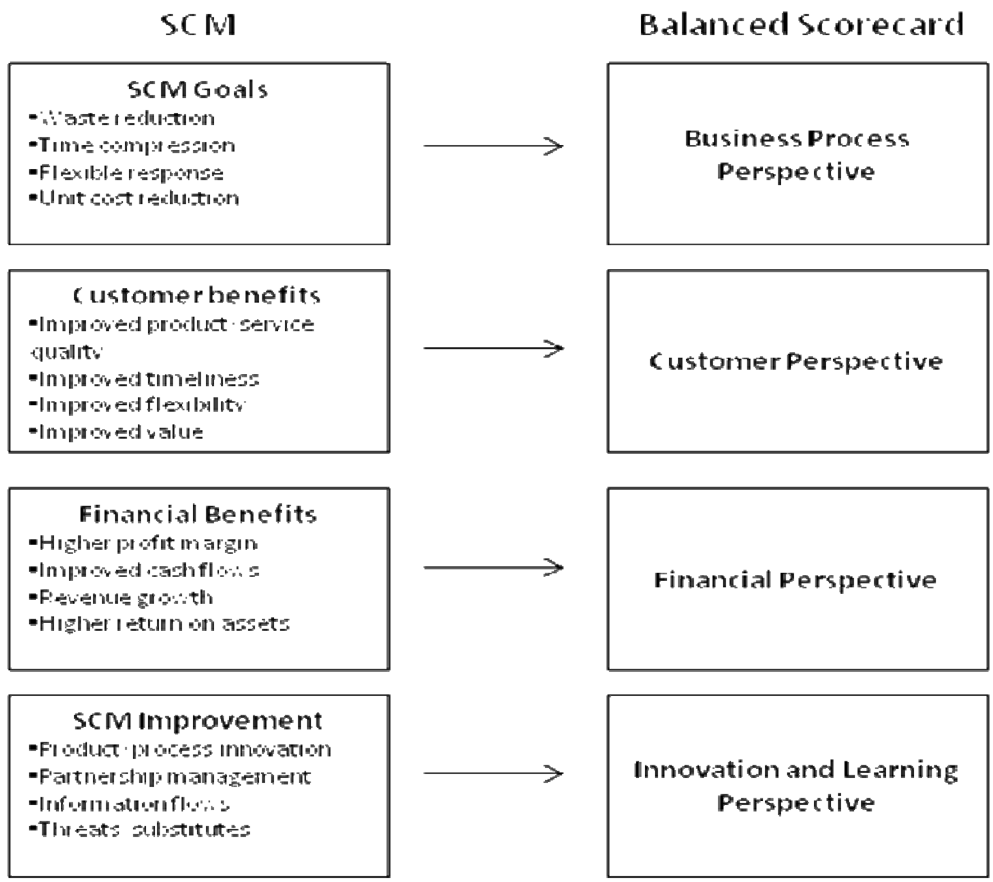

Figure 3. Linking the SCM to BSC (Brewer and Speh 2000:85).

As can be seen in Figure 3, the Brewer and Speh's framework suggests a link between the BSC and supply chain management (SCM) frameworks. On the left side, there are the four elements introduced by Brewer and Speh (2000) as a framework of SCM , and on the right side, the construct has the four BSC perspectives developed by Kaplan and Norton (1992). Brewer and Speh (2000) argue that, this linkage can reveal the performance aspect of a supply chain more accurately and effectively than traditional logistics metrics.

In their framework, Brewer and Speh (2000) list four major goals for SCM. These are waste reduction, time compression, flexible response and unit cost reduction. These goals are then transferred into the goals of the BSC's business process perspective, and then further developed into metrics of supply chain performance. Similarly, the customer benefits, financial benefits and SCM improvement goals are transferred into BSC measures. (Brewer and Speh 2000)

As stated by Brewer and Speh (2000), to provide support for supply chain strategies, the identified performance measures should fit in the balances scorecard framework. They give examples of measures to each category and stress that strange or unconventional metrics should be reviewed from the scheme, as it will help to assess the processes and result differently. This framework is meant to help companies to identify improvement opportunities within their processes.

Brewer and Speh conclude that use of the balanced scorecard framework has four primary benefits. First, the approach emphasizes supply chains interfunctional and interfirm nature, and recognizes co-operative and integrative relations that companies share in the supply chain. Second, the balanced approach in management is more likely to be used in decision making among the partners in the supply chain. Third, the examples provided by Brewer and Speh help to create unique and appropriate measures and metrics for a company's particular needs. And finally, Brewer and Speh argue that, by using this framework, companies would be able to focus their attention on going beyond typical performance measures and achieve the wider goals set for the supply chain. (Brewer and Speh 2000:91)

It is obvious, that the performance measurement framework developed by Brewer and Speh (2000) is directed to companies the already have implemented the use of the Balanced Scorecard as management practice. However, the idea of directly linking the supply chain performance measures to the company strategy is a significant notion by Brewer and Speh.

3.2.3 Chan and Qi's Framework

Chan and Qi (2003) developed a performance measurement method that can be used to develop and improve supply chains. The model suggested by Chan and Qi (2003) is, by nature, a cross-organizational method, which concentrates on the six core processes of the supply chain. According to Chan and Qi (2003), these six core processes comprise supplier, inbound logistics, manufacturing, outbound logistics, marketing and sales and end customers. These processes are linked together by the supply chain, and they describe the general flow of the supply chain as well. Chan and Qi (2003) claim, that their presented framework for performance measurement provides support for strategy development, decision-making, and performance improvement. (Chan and Qi 2003, Chan et al. 2003, Theeranuphattana and Tang 2008)

To clarify the performance measurements, Chan and Qi (2003) divide the measures into three main categories, which are input measures, output measures and composite measures. According Chan and Qi (2003), the input measures are most often related to time and cost, while output measured also include some intangible measures, such as value added, flexibility and customer responsiveness. In contrast, composite measures, such as productivity, efficiency and utilization, are measures, which involve both inputs and outputs compared against each other. Chan and Qi (2003) state that these composite measured need to be well defined and normalized in order to clearly and precisely describe the supply chain performance. They also recommend forming a performance measurement team, which would be responsible for the measurements. This team should consist of the representatives from various different parts of the supply chain. The performance measurement team would then also act as evaluators of the measurement system. (Chan and Qi 2003, Chan et al. 2003)

As illustrated in Figure 4, the measures for each process and sub-process are identified and grouped to form a hierarchal model. The model consists of different levels of measurements, from individual performance measures, which are combined trough the hierarchy into measures of processes and sub processes. (Chan and Qi 2003)

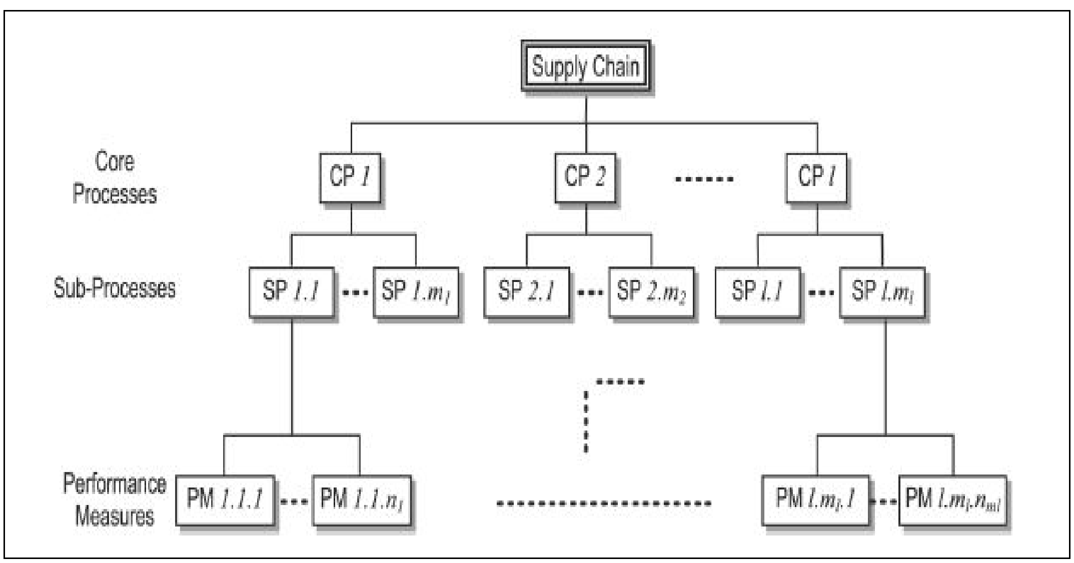

Figure 4. The hierarchical model of the measurement system (Chan and Qi 2003:214).

In this model, illustrated in Figure 4, measures and metrics for each processes is calculated separately and then aggregated according to the suggested framework to facilitate decision making in the supply chain. As for some examples on metrics Chan and Qi (2003) list the following: delivery cost, delivery flexibility, transport cost, transport productivity, product quality, efficiency, inventory accuracy, stock capacity, response time, and order to fill rate. The metrics are combined with a mathematical model that includes the scaling and weighting factors decided by the performance measurement team, to create a single performance index of the supply chain. (Chan and Qi 2003)

Like the SCOR model, presented previously, Chan and Qi's model requires an efficient data collection system, which enables a company fully to be able utilize the metrics. The performance measurement team, proposed by Chan and Qi, can then evaluate, asses, and develop the measurement system to support the improvement needs of the company. The major advantages on Chan and Qi's model are the cross-functional involvement of participants within the supply chain, which provides visibility throughout the processes. And as a second major advantage is the notion, that a single performance index can be calculated from the various metrics of the supply chain.

3.2.4 Gunasekaran, Patel and McGaunhey's Framework

Another framework for supply chain performance measurement was developed by Gunasekaran et al. (2001). According to Gunasekaran et al. (2004:334), an operating system must meet the strategic and competitive objectives of quality, speed, dependability, flexibility and cost. To meet these objectives, the processes of the supply chain need to be measured and compared with the given set of standards. Gunasekaran et al. (2001), stress the importance of assessing the performance throughout the supply chain. An important notion by Gunasekaran et al. (2001) is, that performance measurements and metrics should not be dictated by one single party of the supply chain, but rather developed and planned by all members of the supply chain. Gunasekaran et al. (2004)

The framework presented by Gunasekaran et al. (2004), is arranged around the four high level processes of the supply chain. These processes include: plan, source, make/assemble and deliver. As it can be noticed, the processes repeat a similar set of processes suggested in the SCOR model presented previously. To further development of the SCOR model, Gunasekaran et al. (2001) classify the metrics of the processes into three different categories, namely: strategic, tactical and operational. According to Gunasekaran et al. (2004), this classification is suggested to clarify the management authority and responsibility for the performance. Gunasekaran et al. (2004)

According to Gunasekaran et al. (2001), the classification of the metrics into these four categories signifies which particular metric to use in each process. Figure 5 illustrates how Gunasekaran et al. (2001) link the processes and metrics that they propose. Additionally, the customer perspective is added as the final process/link of the framework. Gunasekaran et al. (2001)

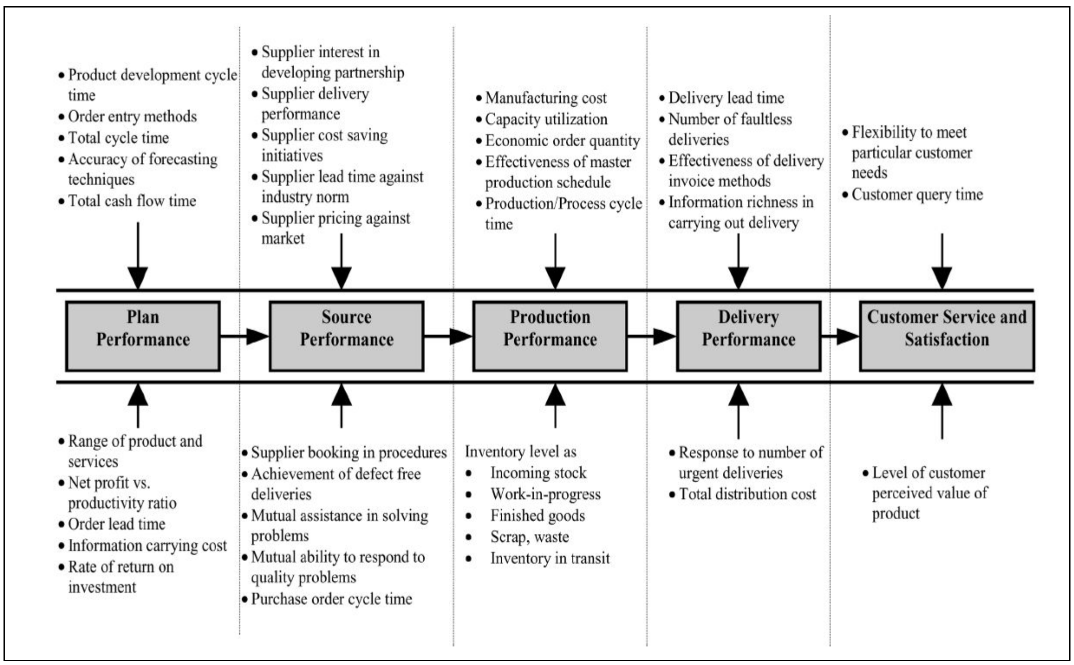

Figure 5. Measures and metrics in the framework (Gunasekaran et al. 2001:85).

As demonstrated in Figure 5, various different types of metrics, both financial and non-financial, are applicable to the processes. Additionally the metrics include intangible issues, such as interest in partnership development and information richness. All the processes, displayed in the Figure 5, include metrics in the three mentioned categories, strategic, tactical and operational. For example, strategic metrics for planning process include total cash flow time and variances against budget, which clearly are guided by strategic decisions of top management. The operational measures for planning process on the other hand are more functional by nature and measure variables such as order entry methods and the productivity of human resources. (Gunasekaran et al. 2001, Gunasekaran et al. 2004)

Like the three frameworks already presented previously, also this framework by Gunasekaran et al. (2001) emphasizes the importance of cross-functional evaluation of the supply chain. Additionally Gunasekaran et al. (2004) point out that performance improvement can be achieved through strong supply chain partnerships and cooperation. Their recommendation is that the all members of the supply chain are involved in the development and the use of the performance measurement system. (Gunasekaran et al. 2001, Gunasekaran et al. 2004)

3.2.5 Beamons Framework

Beamon (1999) argues that a supply chain measurement system must emphasize three types of measures: resource, output and flexibility. Although the goals for each of these three measures are different, all of them are important to the overall performance of the supply chain. According to Beamon (1999), complexity of supply chains make it difficult to choose the appropriate measures. (Beamon 1999)

In the resource measures, Beamon (1999) includes the following variables: inventory levels, personnel requirements, equipment utilization, energy usage and cost. All these are general types of measures, which are measured by minimum requirements. The notion of minimum requirements is one of the central for Beamons (1999) framework. As Beamon (1999) states, the goal of the supply chain analysis is resource minimization. She believes that, if the supply chain is reconfigured only to reduce resources, output and flexibility will be affected as well. Therefore, it is vitally important that, the resource measures are linked to output and flexibility measures. The linkage between the three measures is presented in the Figure 6. (Beamon 1999)

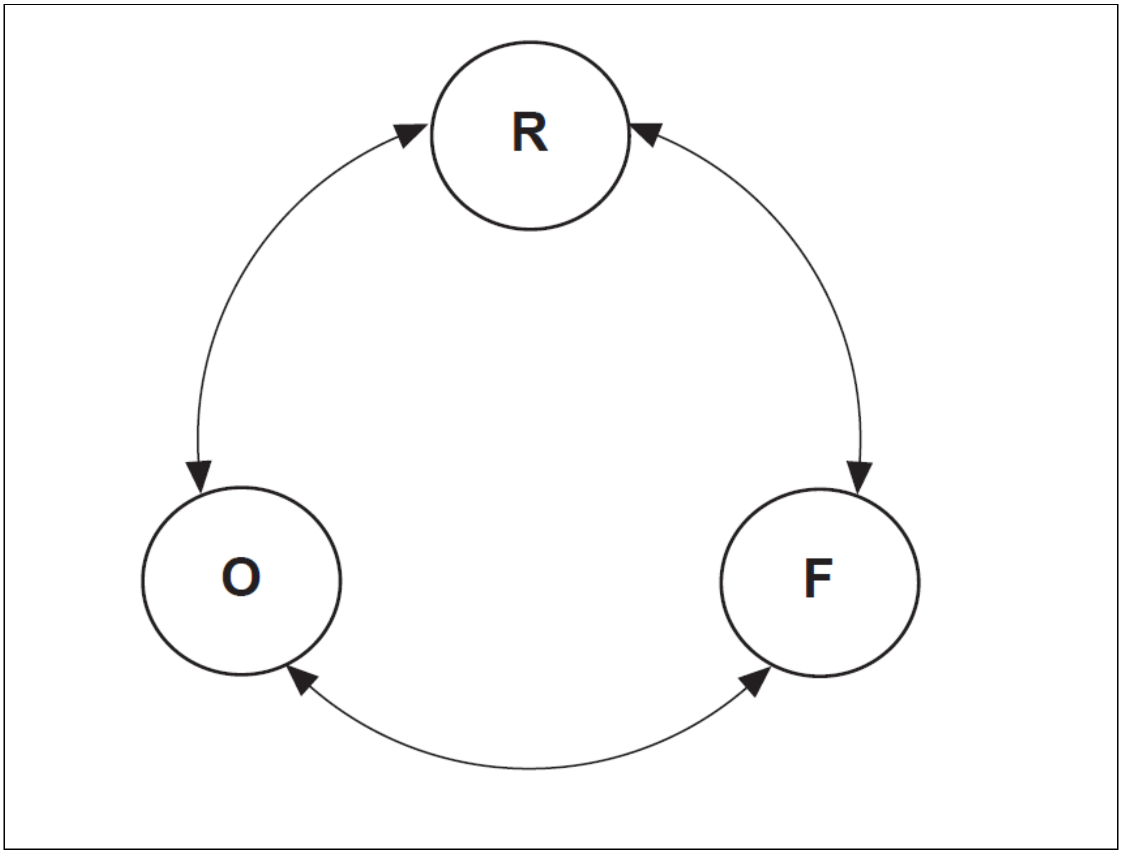

Figure 6. Linkage between resource, output and flexibility measures (Beamon 1999:281).

As can be seen from the Figure 6 above, each of the measures are linked with each other. The simplicity of the framework supports the linkage, as only three measurement categories are identified.

in Beamons (1999) framework, output is measured by the quantity of products, quality and customer responsiveness. According to Beamon (1999), these measures must correspond to the company's strategy and customers' requirements. For the output measures, a minimum level is often required. Beamon (1999) points out that, when measuring the output of a system, different output levels should also be considered, as the demand might be fluctuating (for example, for weekly production volumes). This would help to view what the cost are, if products are delivered early to the customers, and whether there is any value added in early delivery. (Beamon 1999)

Flexibility of a supply chain ensured by these measures has several advantages. These include issues such as reduction of backorders, increased customer satisfaction and the ability to respond to demand fluctuation, to mention a few. According to Beamon (1999), a flexibility measure shows the system's ability to accommodate demand and schedule fluctuations of the supply chain. Beamon (1999) identifies four categories of to measure flexibility: volume, delivery, mix and new product flexibilities. As flexibility is a measure of potential, the importance of flexible supply chain is emphasized in uncertain business environments. Additionally, decisions, for long-term planning for production and new product introduction, can be made based upon flexibility measures. (Beamon 1999)

According to Beamon (1999), at least one individual measure should be placed for each of the three identified areas. The company, however, should be careful in choosing them. As Beamon (1999) states, despite the fact that each of the performance measures have a different goal, presented in Table 2, each type is vital to the overall performance of the supply chain. Although using too simple measures can make the measurement system easy to implement, according to Beamon (1999), this approach may ignore important performance tradeoffs, such as balancing lead time to customer against on-time delivery. Therefore it is imperative that the selected metrics support the goals presented in Table 2. (Beamon 1999)

Table 2. Goals of performance measure types (Beamon 1999:281).

Performance measure type	Goal	Purpose
Resources	High level of efficiency	Efficient resource management is critical to profitability
Output	High level of customer service	Without acceptable output, customers will turn to other supply chains
Flexibility	Ability to respond to a changing environment	In an uncertain environment, supply chains must be able to respond to change

The obvious benefit of Beamons (1999) framework is its simplicity. At the same time it is a weakness of the framework, as every supply chain system is unique and complex.

Despite this weakness, the framework captures the essence of performance measurements. The framework categorizes the different aspects of performance drivers in supply chains and constructs them under one simple performance measurement system.

3.3 Summary of the Frameworks

The frameworks, presented in the previous sections, are all dedicated to increase the performance of the whole supply chain. Each of them clearly describes the key elements of supply chain performance: time, cost and quality. Generally, any of the presented frameworks would be suitable to the case company as they are. However, since the case company has not implemented a performance measurement system, this study shall propose a customized framework. Even the structure of case company's supply chain is not very highly complex; it seems that, a dedicated system is still preferable to be developed. In addition, as none of the presented frameworks include supplier management, which is a key driver of supplier performance, according to Chuah et al. (2010), it will be included in this study.

Another common factor in all discussed frameworks is the fact that, the performance measurements in supply chain are the concern of the whole supply chain, rather than just one company in the supply chain. The alignment of the measures and metrics need to be co-operatively designed and developed, in this way, the measures will fully describe the performance of the whole supply chain. Because a single party of the supply chain can only optimize its own processes within the supply chain, therefore overall development of the performance requires the participation of each member of the supply chain.

Although each one of reviewed frameworks are developed for entire supply chain measurements, they all are applicable for focusing the measurement system to upstream supply chain only. As the scope of this study was to focus on the supplier performance measurements of the case company, the reviewed research literary provides enough grounded information in order to develop a framework for supplier measurements.

3.4 Supplier Management

The following sections shall discuss the supplier relationship management as well as partnership and collaboration as ways to improve supplier performance.

3.4.1 Supplier Relationship Management

Supplier relationship management (SRM) is a concept that aims for co-operation and collaboration with suppliers to improve the performance of the supply chain (Park et al. 2010). SRM is an extension of supply chain management, which can be implemented with key suppliers of a company. Hughes and Wadd (2012) define SRM as enterprise-wide analysis of the activities with supplier, collaborative planning of operations, leveraging the supplier assets to gain competitive advantages and managing the interactions together with the supplier. According to Hughes and Wadd (2012), supplier relationship management is more than merely part of the enterprise resource planning system or playing golf with supplies. Proper supplier relationship management requires that a company systematically manages all the interactions across the business with suppliers. Liker and Choi (2004) describe, how Japanese automotive manufacturers, Toyota and Honda, are deepening and developing their relationships with their suppliers, which leads to mutual benefits for both, the customer and supplier.

Park et al. (2010) studied a Korean semiconductor manufacturing company and developed a framework for supplier relationship management. Their framework integrates the supplier management functions, which are, shaping purchasing strategies, supplier selection, collaboration, and supplier management (Park et al. 2010). Additionally Park et al. (2010), propose continuous improvement process to develop the SRM system. Also, a research by Chuah et al. (2010) indicates, that supplier performance can be improved with supplier management. In this research, Chuah et al. (2010) state that, there is no single formula to fit all situations. However, a key finding of Chuah et al. (2010) is that, the supplier management practices can improve the performance of the suppliers. A research conducted by Theodorakioglou et al. (2006), reveals that supplier management improves quality much in the same way as quality management practices. Theodorakioglou et al. (2006) state that supplier management is can be used to support supply chain management. For these reason supplier management practices need to be understood by managers, in order to leverage and benefit from SRM (Chuah et al. 2010).

Like any other process, supplier management or supplier relationship management, needs to measurable. Giannakis (2007) presents a framework to measure the performance of supplier relationships. The framework uses four structural variables, trust, power, involvement, and commitment, which are further decomposed into more measurable second level variables, which can asses and identify the performance of relationships. Giannaikis (2007) uses both qualitative as well as quantitative data to assess the supplier relationships with his proposed framework. A gap analysis of the data provides the perception of an organizations relationship with another organization.

As supplier management requires time and resources from companies, it is not feasible to apply a standard SRM process to all suppliers. Park et al. (2010) suggest classifying suppliers using the purchasing portfolio matrix. The purchasing portfolio matrix is a tool to position the suppliers according to the complexity of the supplied goods and importance of purchasing (Kraljic 1983). The Figure 7 shows the matrix.

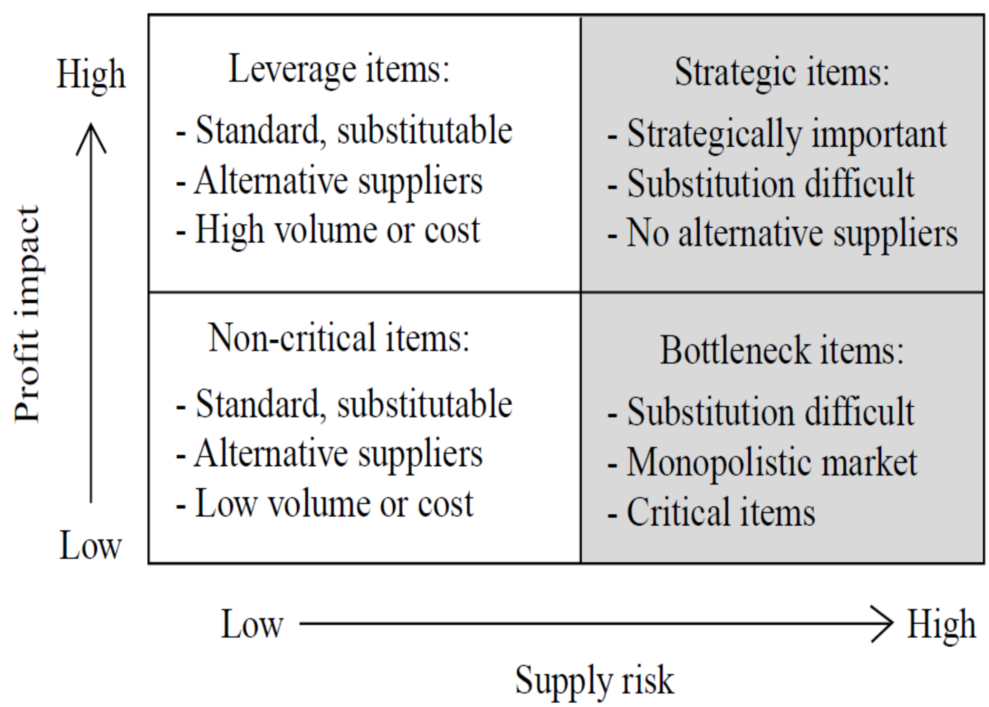

Figure 7. The purchasing portfolio matrix (Park et al. 2010).

In the figure 7, the x-axis in the supply risk (e.g. complexity of the product, entry barriers), and y-axis is profit impact (e.g. cost of product, purchasing volume). The suppliers in the top right corner are ones that need more management. And on the opposite, bottom left, are the suppliers that do not require so much management or even any kind of management at all. (Kraljic 1983)

Once the supplier base is analyzed and suppliers positioned in the previously mentioned matrix, company can focus to utilize SRM concept to strategic suppliers. The lower risk suppliers, which are at right side of the matrix, do not require the same kind of relationship management as the suppliers on the left side. Also the positioning the suppliers to the purchasing portfolio matrix, can help a company to find the bottleneck items, in the lower left-hand corner in Figure 7, which are difficult to substitute, but have low volumes.

For SRM view, the suppliers and items that have strategic value to a company need to be managed properly. Partnership and collaboration with such suppliers is quite common or at least something to be considered. In such a deep supplier relationship, where companies share strategic goals, resources, and even assets, active management of the relationship is paramount. (Liker and Choi 2004, Hughes and Wadd 2012)

3.4.2 Partnership and Collaboration

The research of supplier relationship management conducted by Hughes and Wadd (2012), also point out that, partnership and collaboration should be considered in supplier relationships. The level and depth of partnership determine the effort needed to manage and develop the relationship. Lamming (1996) argues that a lean supply is goes beyond partnership, where borders between functions, companies, and customers are artificial. Similarly Rivera et al. (2007), discuss a lean supply chain as solution to companies' partnership efforts. However, as Rivera et al. (2007) point out, lean supply chains face several challenges, which need to be solved before, partnership and collaboration can be leaned.

As stated, the level of required partnership and collaboration is highly dependent on relationship between the companies. The structure of the supply chain can as well, be determining factor in the partnership level on companies. In some cases, a lean supply chain, with deep relations between the supply chain members, can be the most successful (Lamming 1996, Rivera et al. 2007). In addition, for some supply chains end agility is desirable (Christopher and Towill 2001, Lee 2004).

Ramanathan et al. (2011) argue that, the improving the collaboration between supply chain partners improves the performance of the supply chain. And same conclusion is made by Liker and Choi (2004) as they describe the success of Honda and Toyota. Accoding to Cassivi (2006), collaboration in planning, forecasting, and replenishment activities, bring supply chain partners closer together and facilitates information flow across the supply network. Ramanathan et al. (2011) have developed performance metrics framework for supply chain collaboration. According to Ramanathan et al. (2011), these metrics, which are included in other supply chain performance measurement systems, provide additional information on the success and benefits of collaborative relationship between supply chain partners. Ramanathan et al. (2011) argue that, effective communication is a crucial factor in successful, collaborative relationship. Similarly to Cassivi (2006), Ramanathan et al. (2011), recommends companies to share information on sales, inventory, and other forecast related issues to decrease the possible bullwhip effect on the supply chain. Partnership and collaboration provide basis for deep relationships between companies, which then provide competitive advantage for the whole supply chain.

Liker and Choi (2004) agree that, partnering and collaboration with suppliers requires better understanding of each other's processes. Liker and Choi (2004) demonstrate how close relationships with suppliers lead mutual benefits for both the customer company as well as the supplier. The partnership efforts of Toyota and Honda, as described by Liker and Choi (2004), have generated model where the supplier continuously learn and improve. This kind of continuous improvement and learning is one of corner stone's lean manufacturing philosophies (Womack and Jones 2003).

To summarize the supplier management, it can be concluded, that the supply chain performance can be improved trough supplier relationship management when used as a part of supply chain management. Once implemented, supplier management practices benefit customer as well as the supplier. The supplier management has to consider as strategic tool to manage the supplier relationships, as well as the collaboration in the supply chain.

3.5 Initial Framework for Analysis

This section presents a draft of a performance measurement system, based on the reviewed literature. The draft does not describe the metrics, but only a general framework that will be further developed in the results of this study. Although each of the earlier presented frameworks are created to measure the performance of the whole supply chain, this developed framework for the case company, shall only concentrate on supplier performance measurements, as stated in the research question.

When considering the supply chain of the case company, which will be presented in the Current State Analysis in Section 4, the measurement system should contain four elements: time, cost, quality, and supplier management in some form. Shepherd and Günter (2006) discuss of flexibility and innovativeness in addition to time, cost, and quality in their review of supply chain performance measurements. Beamon (1999) includes these in the resource part of her framework. This initial draft combines these under the supplier management measure. The scope of this study is to focus on the upstream supply chain of the case company; therefore, the measures are related mostly to the plan and source processes of the supply chain. The metrics to include under each of the elements are not in the scope of this study, but some examples will be given as in the Figure 8 below, which describes the overview of the drafted framework.

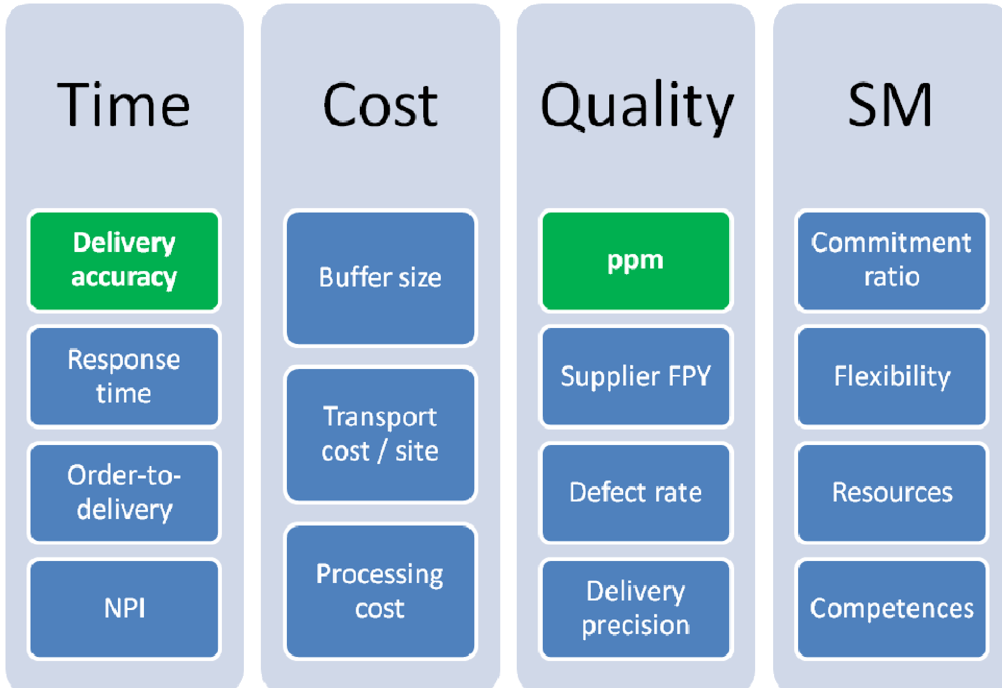

Figure 8. The supplier performance measurement framework.

As shown in the Figure 8, the current performance metrics (the green boxes), which will be described in the next section, are included in the drafted framework. The idea behind the framework is to compile a one single measure of the separate metrics in each category. These numbers are then multiplied together to create a traffic light - indicator of a supply chain, like the performance index proposed by Chan and Qi (2003). Each metric shall have its own calibrated scale, which can be converted to a percentage result. An example of this will be provided in the results section of this thesis.

Where time, cost, and quality parts are quite self-explanatory, the supplier management part requires more consideration on how and what to measure. On the question how, a solution would be the use of both qualitative and quantitative data for the measures. Shepherd and Günter (2006) listed some example of both, such as new product flexibility and production flexibility. The question what to measure is more difficult. A reasonable approach would be to assess the strategic importance of the activity or process and derive the measures that way. As an example, which is also used in the Figure 8, could be the competences of the supplier. This information can help on deciding, which supplier to use when implementing new technologies.

Summarizing the analyzed frameworks it can be concluded that a successful supply chain is measured for identifying the strengths, weaknesses, and opportunities of the chain. A good performance measurement system helps a company to improve and manage its suppliers, as well as provide valuable information for decision making to managers. Performance measurements combined with good supply chain and supplier management practices can help a company to gain and sustain competitive advantage.

4 Current State Analysis

This section analyzes the operations of the case company and provides a description the supply chain of the case company. It also presents the analysis of the measures and metrics used in the case company to evaluate the supplier performance. Finally, it ends with a description of the suppliers view to the case.

4.1 Overview of Operations in Case Company

The case company designs and manufactures dental imaging equipment and software, as mentioned in the introduction. The final assembly is done at the company's factory. Parts and sub-assemblies for the machines built in the factory are sourced from several partners and contract manufacturers, mainly from companies based in Finland. Some components, however, are purchased from offshore locations, because the suppliers do not have representation in Finland or the offshore unit is the closest supplier.

Manufacturing in the case company is managed and developed according to lean principles and methodology. Lean is a management philosophy based on the Toyota Production System. The main goal of lean is to remove or reduce waste from all processes. According to Womack and Jones (2003) this goal can be reached when the *value* is specified to a product or service, the *value stream* is clearly mapped, products and services *flow* between processes, everything is *pulled* through the system and when organizations thrive for *perfection*. Because of this lean thinking, applied in the case company, plenty of efforts have been invested to improve the manufacturing processes to reach the goals of lean. These improvement efforts have been performed with great success. Continuous improvement, in fact, is one of the core values of the case company.

Despite the great successes in improving the internal processes, the improvement efforts have not yet focused to the whole supply chain. Now, however, it seems that the company is in the state, where further development is reasonable to extend also outside of the company.

4.2 Supply Chain of the Case Company

Supply chain of the case company is a typical manufacturing supply chain. As mentioned earlier, parts and assemblies are sourced from various suppliers, mainly from Finland. Figure 9, shows the generic model of the supply chain for Printed Circuit Board Assemblies (PCBAs) in the case company.

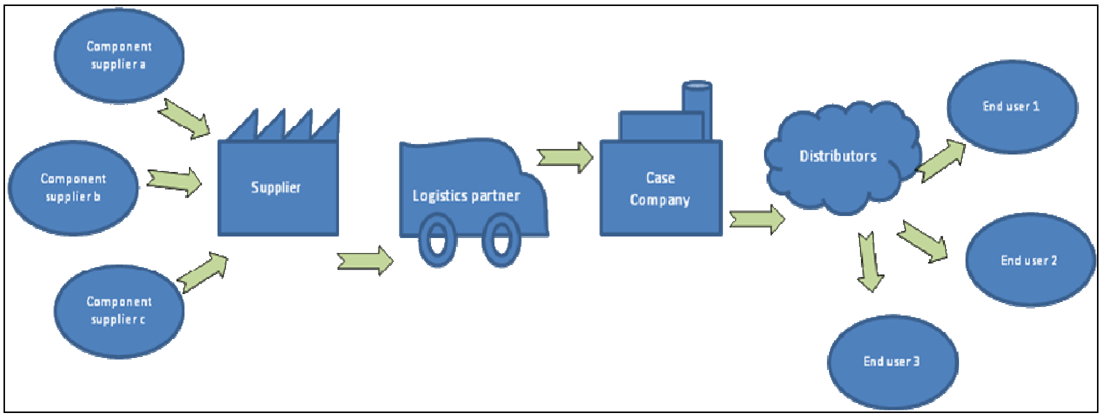

Figure 9. Case company supply chain overview.

As shown in Figure 9, the case company's supply chain begins with the component supplier for electronics manufacturing service provider. Then, PCBAs are assembled to imaging instruments and delivered to the customer through distribution a various channels. Logistics are handled by a third party, which collects the parts from the suppliers, and delivers them to the incoming warehouse. For certain parts, the logistics partner uses its own terminal for short term warehousing. After the assembly at case company, the machines are sent to distributors to be sold to end users. This kind of supply chain model is very typical of a manufacturing company and is applicable to almost any kind products or even service.

Typically, lead times for delivery are agreed with suppliers and make two, five or 20 days for the order. This variable serves as a measuring point for suppliers' delivery accuracy. The desired delivery date is confirmed by the supplier; and that confirmed date is compared to the actual date, by which the parts are delivered, yielding the suppliers' delivery accuracy of the order. Each month, these dates are analyzed for each order line, and the accuracy is presented as percentage of the on-time deliveries to the confirmed date. The delivery accuracy is further explained in Section 4.3.1.

The orders are entered into the company web-based system directly by the production lines buyer/planner. The system is then used to indicate replenishment need and managed by kanban cards. The Kanban card is a lean tool, that signals the move of materials, e.g. from the supplier to the manufacturer or from the warehouse to the production line (Womack and Jones 2003). The Kanban card contains the information about the part, supplier, lead-time, order quantity, and latest purchase orders. This technique is commonly called Just-In-Time (JIT) in production. It is one of the core elements of the lean manufacturing philosophy (Womack and Jones 2003).

In the case company's supply chain, the pickup of parts and components is agreed by the supplier and the logistics partner. The logistics partner makes milk runs daily. Milks run is a concept in which the transport vehicle, e.g. truck, collects and delivers freight on the same route. The deliveries are received at the incoming warehouse, inspected against the purchase order, and the placed to the supermarket of the production lines. The supermarket is another lean concept, which is used in manufacturing. It is a warehousing method of parts, which are stored close to actual production line. Parts are placed on the shelf, much like in a regular super market, so that every part is easy to find and pick up. From the supermarket, parts are placed to set-boxes, which are delivered to the assembly cells in the production line. The set-box contains only the parts needed in a production cell. A single production line has several assembly cells, in which a certain pre-defined parts are assembled to the machine under construction. As the machine moves along the line parts, assemblies are added to it until the machine is ready for packing and shipping.

Throughout the production lines, quality assurance is embedded in assembly cells. In each cell, the operator does only the defined tasks assigned to that cell. This is called Standard Work. The standard work defines everything that the operator is required to do in the assembly cell. The operator must do only what is defined by the standard work instructions. This way the human errors can be minimized. The standard work defines each component, screw, tool, cable connection, etc. what is required to build an assembly or what need to mounted to the machine. If an operator misses something, the next cell is unable to perform the standard work assigned to that cell, and the defect is noticed immediately and can be corrected. Testing is also done according to a standardized plan.

The final cells in the production line are testing cells. In different production lines, the number of testing cells is different, but typically, there are three testing cells: primary testing, alignment testing, and final testing. Primary testing includes electrical safety testing and some adjustments of the machine. In alignment testing, the operator adjusts the machines parts like, lasers, x-ray beam, and sensors. The final test is where the image quality is calibrated and inspected. Any defect in any of the testing cell is reported as failure in the machine. From these failures, the production linens yield is calculated.

All failures that are caused by the production line, e.g. wrongly assembled parts or loose bolts, are discussed with the operators daily, so that the same mistake is not repeated with the next machine. If the failure is due to a defect component or part, that has passed the suppliers quality assurance, the defect is reported to the supplier and a customer complaint, a claim, is opened to the supplier. The supplier is required to immediately send a replacement and correct the faulty part. In practice, a new part is picked up from the super market an paced in the machine. The defect parts are collected to claim shelf in the production line, from where they are sent back to supplier for repair, according to the agreement with the supplier. Some parts can be repaired and reworked at the site, and in these cases, the cost of repair and rework is claimed from the supplier. These claims are used to calculate the suppliers' quality ppm, which is explained in more detail in the next section. Finally, when all the tests are passed, the finished machines are packed and shipped to distributor's warehouse.

In the case company, suppliers are provided with an annual production plan, which is derived from the sales plan, to use as a forecast of orders. This plan is updated monthly to create a short-term forecast. With this forecast, the suppliers can plan their own production schedule and procurement. The accuracy of this forecast is estimated to be (+/-) 20%. With such a large variance, it is possible that a bullwhip effect can be caused at the supply chain. The bullwhip effect is a phenomenon that distorts the demand information in the supply chain (Lee et al. 1997). Lee et al. (1997) state that forecast updating is one of the major causes of the bullwhip effect. Another major cause is order batching (Lee et al. 1997). In the case company, the risk of batching is minimized with the milk runs, so that an order is immediately placed when a replenishment signal is given with the Kanban card. The accuracy of this forecast is not however currently measured.

4.3 Performance Metrics and Data

As mentioned in the introduction, the case company currently lacks a functional performance measurement system at the case company. Although separate metrics and measures are used, they are not parts of a centralized system or framework. This subsection describes the measures and metrics currently used in the case company; these include delivery accuracy, and quality metrics.

4.3.1 Delivery Accuracy

The delivery accuracy, as mentioned previously, is one of the metrics currently used to evaluate supply chain performance in the case company. The data for the metric are gathered from the case company's Enterprise Resource Planning (ERP) system. In this system, purchase orders are placed together with the requested delivery date. When the order is recorded, the system sends the order to the supplier. The supplier checks the order and confirms the delivery date. If the required date does not suit the supplier, the supplier has a possibility to postpone or organize some partial shipment. These cases, however, must be always agreed whit the production lines buyer.

Once the order arrives, the date is recorded to the ERP. Then, this date is compared to the confirmed date given by the supplier. This information will be transformed into the delivery accuracy percentage of the order. Presently, each order line is recorded individually, so that partial shipments are also detected by the metric. The delivery date has tolerance of one day, early or late, which means that if the shipment arrives one day early or one day late, compared to the confirmed day, it is recorded as on-time delivery. This metric, however, does not take into account how many days a shipment is late, and only indicates weather the order has arrived on time or not.

The information on delivery accuracy is reported to the suppliers on a monthly basis, looking back at the previous month. The targeted delivery accuracy is 95% of all the shipments. If a supplier's delivery accuracy is less than 95% or above, reasons for this are discussed with the supplier. If the supplier's delivery accuracy is continuously below the target, further actions are agreed to correct the situation. These actions may include, for instance, a daily follow up of shipments.

As stressed before, the delivery accuracy only report on the number of late shipments, but does not provide any information as for the actual lateness of shipments. Even more inaccuracy is caused by the fact that the metric does not take into account the preciseness of the order. In other words, partial shipments are only noticed if they are late. For example, if the original shipment is delivered on time at the actual confirmed date only partially, and the rest of the goods are delivered one day late, the delivery accuracy is registered as 100%. These features significantly undermine the reliability of the exiting measurement system/organization.

4.3.2 Quality

The supplier quality is the other supplier performance measure currently used in the case company. This measurement assesses the general quality level of the delivered parts. It is calculated from the quantity of claimed parts to the supplier, divided with the quantity of the delivered parts. The resulting number in presented as part per million (ppm). Any defects detected in production are claimed to the supplier, complemented with a detailed report of the defect. For all claims, a root cause analysis and report are required from the supplier. These data are recorded to the quality database, with some level of detail about the defects. The quantity of delivered parts is acquired from ERP system, with a moving average of three moths used for calculating the quantity of delivered parts. This is done, because some suppliers deliver their parts irregularly, based on the actual demand.

The quality ppm is a recently new metric in the case company. This measuring was started in the beginning of 2012. Before the metric was implemented, supplier quality was measured according to the number of claims. Judging by the results, it was concluded that the measuring of the supplier ppm, gives better information on the suppliers performance than the old measurement. This discrepancy is explained by the fact that the old metric did not take into account the number of parts delivered. Additionally, in the past, the reports on the measurements were done rather informally, with e-mails and by phone.

Currently, the target level of the quality ppm for all suppliers is set at 3850 ppm. If a supplier's quality is not reaching this target, this is discussed with the suppliers at a monthly meeting. If needed, a detailed action plan to improve quality developed and agreed with the supplier. Usually, the suppliers provide their own corrective actions to the quality issues, which then are audited by the case company.

The quality data are derived currently form several different databases, which are not linked together. To analyze the data effectively, lot of manual work needs to be done. The systems contain different level of detailed information of quality issues, such as failed parts in production, defects in the field, supplier claims.

4.4 Challenges of the Current Performance Measurement System

This section shall discuss the challenges of the current measurement system. The available data, on both current metrics, provides more information, than is currently used in the metrics.

As already pointed earlier, the delivery accuracy only measures late deliveries by each purchase order line. This data consist the number of days that the delivery is actually late, but the trigger for the metric only accounts, weather the delivery in on time or not. Likewise, the data contains the information of partial shipments, which is not used in calculations. This way the excess work, by incoming warehouse, for the same purchase order is not measured.

As previously mentioned, the quality ppm metric is limited to only measure claimed parts to received parts, within a certain time frame. It does not provide a part or process specific quality data. This means that a certain type of failure trends, e.g. assembly mistakes or soldering defects in PCBAs, are difficult to detect, unless suppliers root cause analysis can provide such information. Because this data is not available of these repeating defect types, therefore, it requires lot of effort until possible process improvements or reengineering of such parts can be started.

Delivery accuracy and quality ppm, which are the two metrics, currently used in supplier performance evaluation in the case company, are compiled manually from the company's ERP system and quality database. The Figure 10 shows how these two metrics are compiled. On the left side is delivery accuracy and on the right side is the quality ppm.

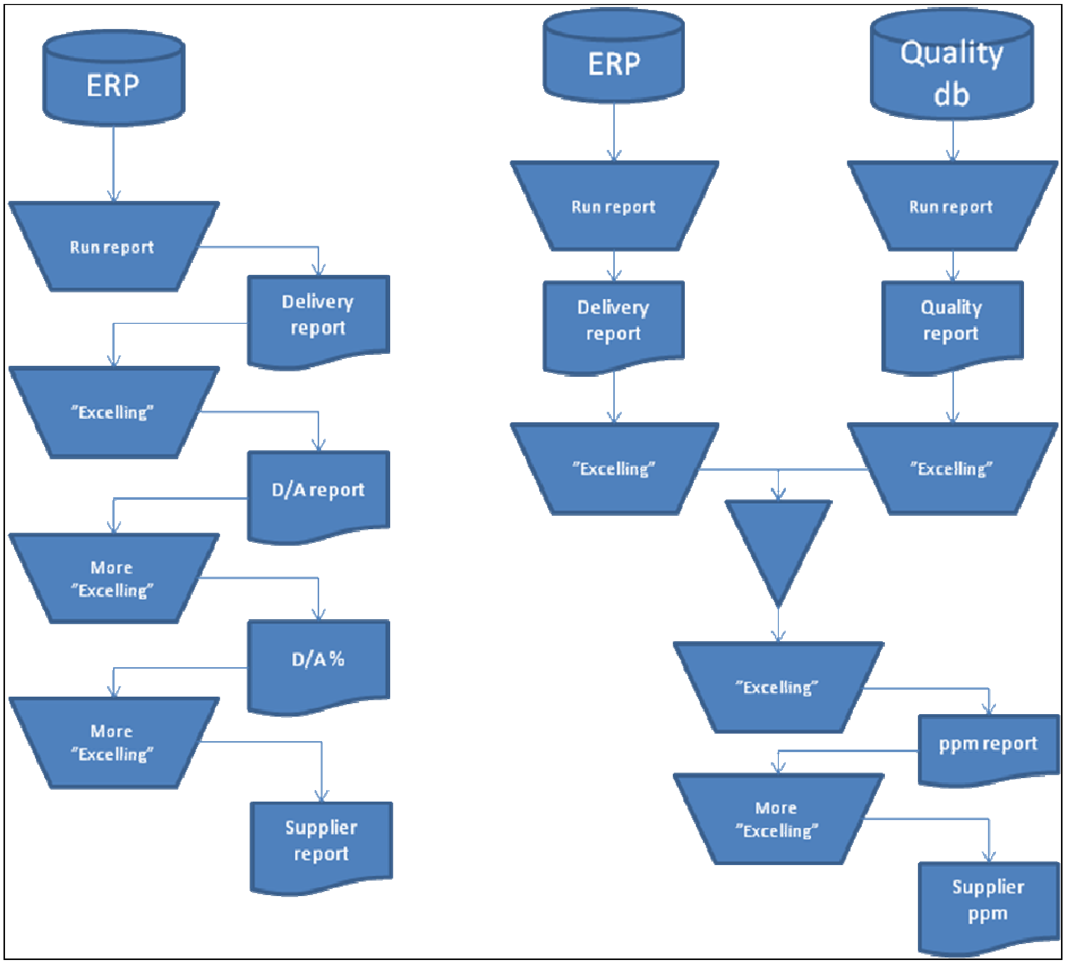

Figure 10. Flow charts to create supplier metrics. On the left is delivery accuracy and on the right is the quality ppm.

As shown in Figure 10, compiling the metrics requires several manual steps, which makes them vulnerable to mistakes and is not totally independent of the evaluator. And, as mentioned, the manual effort required to get the final figures to delivery accuracy and quality, are time consuming and the only limited persons have the knowhow to do the work.

To summarize, the current performance measurement is not providing enough information to assess the overall performance of the suppliers. The data for more precise analysis is available, but the manual compiling of the metrics limit the possibilities to reveal inefficiencies in the supply chain. Despite the limitations, delivery accuracy and quality metric currently used are however a good starting point to performance measurement system. A proposal for an improved performance measurement system will be provided in the results section of this thesis.

5 Cross Case Analysis

This section presents the analysis, which is done to compare the case company's performance measurements with the suppliers. For benchmarking, two suppliers were interviewed to provide information for cross case analysis. Also the suppliers were given the opportunity state their preference on, how their performance should be measured and what would help to improve their processes. A summary of the cross-cases is provided at the end of this section.

5.1 Supplier 1

Supplier 1 is providing PCBAs and mechanical assemblies to the case company. The supplier has several manufacturing site in Finland and operations abroad. This supplier has been a supplier for the case company for few years, and is considered as a key supplier of the case company. The PCBAs for the case company are manufactured at all sites of the supplier and mechanical assemblies are manufactured in one site in Finland. Most of the parts are delivered form this site. The other factories deliver the parts to the buffer stock in the mechanics factory, from where they are picked up in the milk run.

No formal measurement system is implemented at Supplier 1. The company purchases electronic components, sheet metal parts for assemblies, and different metals for machined parts globally from, its own suppliers. Supplier 1 measures the performance of its supply chain mainly with quality metrics and delivery accuracy, much like the case company. The delivery accuracy is measured by comparing the confirmed delivery date against the actual delivery date. This measurement is implemented in the ERP system used by Supplier 1. The delivery accuracy is reviewed monthly at internal meetings at the supplier. If the delivery accuracy is not reaching the targeted level, which is 98%, the suppliers are notified, and the reasons to late deliveries are analyzed.

Deliveries are also inspected against the purchase order and by quantity. From some critical mechanic parts, dimensions are also inspected. Quality of raw materials and components is assured during production. The target level of quality is zero defects. All non-conformities in components or raw materials is registered in quality database.

From this data the supplier quality is analyzed. Faulty components and materials are reported back to upstream suppliers. The quality measurement is also reviewed monthly. Supplier 1 reports the metrics at monthly, quarterly or annual meetings to its own suppliers. Internal performance measures by the supplier includes stock turns, first pass yield (FPY), delivery accuracy and precision.

According to the interviewee, the measurements are not directly linked to the company's strategy. The interviewee also stated that these measures are quite rough, but nevertheless give a reasonable view of the supply chain performance. He also added that they are planning to improve the measurement system and link the quality database to their ERP system. When asked about how other customers measure their performance, the interviewee stated that, no systematic or formal reporting is done. Two customers require the test data of PCBAs from the supplier with each delivery. Otherwise, the same metrics is used as with the case company.

On the questions how to measure and how to provide information to improve the suppliers performance, Two suggestions was mentioned. One was, that the case company should provide the production forecast more regularly, and that the accuracy should better. This would help the supplier to plan its operations more effectively. The other was that the update frequency of the forecast could be increased, to facilitate the flexibility of the supplier's production.

5.2 Supplier 2

Supplier 2 is an electronics manufacturing service (EMS) provider. The case company is just starting operations with this supplier, so no previous experiences exist in either direction. The company operates globally and has vast experience in the EMS business. The supplier has been working with many different kinds of customers, and provided good information for this study about EMS customers in general. The Supplier 2 is also considered a key supplier at the case company.

Supplier 2 uses On-Time-Delivery (OTD), ppm, audits and regular meetings to evaluate the performance of their supply chain. According to the interviewee, this provides clear enough view of their suppliers and supply chain. OTD is used as delivery accuracy metric at Supplier 2. It is calculated by Supplier 2 from the actual delivery date and the confirmed delivery date. The target for OTD is 96% of all deliveries, and it is reviewed monthly. Suppliers, who do not meet the target, are notified and issues are discussed at meetings with the supplier. The data is collected from the ERP system directly. Supplier quality is with ppm of non-conformities measured by Supplier 2. Incoming inspection is performed to printed wiring boards and to mechanical components. This inspection is done by sampling and the inspector verifies the dimensions and outlook of the units. Additionally the ppm data is also gathered from the production tests. The quality target is 2200ppm and at production, test yield target is 87%-97%, depending on the site and product.

Supplier 2 conducts audits and regular meetings with its suppliers to manage the supply chain performance. At these audits and meetings, the performance measures are reviewed and discussed with the suppliers. Actions for non-conformities is agreed and implemented. The metrics mentioned previously, are the key performance indicators (KPIs) of Supplier 2. Metrics are reviewed monthly at management reviews and have strategic goals. The KPIs are also reported to current customers monthly and also discussed at monthly meetings with the customers. Supplier 2 has found good improvement points based on the measurements.

As wishes to the case company, Supplier 2 is expecting open and transparent relationship. A common measurement system, which would help both companies to improve their performance, is appreciated. Supplier has implemented most of the data collection and performance reporting to its ERP -system.

5.3 Cross-Case Summary

Both of the interviewed suppliers had similar measurements in use as the case company. The same strengths and weaknesses were also recognized at their organization. When asked about their wishes towards the case company two notable issues were mentioned by both suppliers. Firstly, an open and collaborative relationship was pointed out as desirable. Secondly, that to create trustful partnership would be a goal worth pursuing.

When asked about the measurements and metrics, the both of the suppliers stated that, the used metrics should be clearly agreed between both parties and transparent, the measurements should benefit both the supplier and customer. Additional measures were not seen as needed, however an improvement opportunity was recognized.

When reflecting the research literary and the current state in the case company and the evidence provided by the cross-cases, it is clear that an improvement opportunity exists. The next section will demonstrate how to improve the supplier performance measurement of the case company's supply chain.

6 Development of a Performance Measurement System

This section discusses the results of the study and analyzes how the previously presented frameworks could be used to develop a supplier performance measurement system for the case company.

6.1 Improved Measurement System

The objective of this study was to improve the supplier performance measurements by developing a performance measurement framework for the case company. This will be presented in next three sub-sections. First, introduces the performance measurement system framework. Second, discusses supplier management and supply chain management as a performance driver. Finally, in the third sub-section, summarizes the results. The analysis will reflect on the research literary and the cases investigated in this study.

As direct answer to the research question of this study, which was stated: "How to improve the supplier performance measurement of the case company supply chain?" A measurement system, with additional metrics, should be implemented. This measurement system can enlighten the improvement needs in the case company's supply chain. Like stated in the research literary reviewed, a reliable measurement system is a prerequisite for any improvements (Giannakis 2007). The measurement system can provide valuable information from not only suppliers' performance, but also the performance of the case company. The proposed performance measurement system is therefore, intended to be used mainly to evaluate the upstream supply chain of the case company.

Before a measurement system can be implemented, the case company should select and implement additional metrics. These are needed to provide more accurate and precise information on the efficiency and effectiveness about the suppliers' performance. As described in Section 4, currently only two variables are used for supplier performance measurement, the delivery accuracy and the claims (ppm). The delivery accuracy only measures the number of late orderliness, and does not take into account the content of the shipments, which is often not full. Similarly, the quality metric only measures the number of claimed parts, not the excess time used to handle the defect parts. Both of these mentioned cases, cause excess work in the case company, which then again accumulates additional cost.

Like presented in the initial draft of the framework in the end of Section 3, the proposed measurement system consist of four elements: time, cost, quality, and supplier management. As Gunasekaran et al. (2004:334) stated that, the competitive and strategic objectives are quality, speed, dependability, flexibility and cost. The following sections shall discuss each of the elements and provide grounded explanations to assure the validity and reliability of the developed framework.

6.1.1 Time

Time is a classic performance measurement, which focuses on the speed and agility of a supply chain. In this framework, time measure can be divided to several different metrics. Delivery time and order lead-time are good examples of metrics related to time. To measure time accurately in a supply chain environment, an automated data system is a necessity. In the previously presented frameworks, Beamon (1999) categorizes time metrics under output measures. Example measures of time in Beamons framework are measuring on-time delivery, with several metric, customer response time, and manufacturing lead-time. Chan and Qi (2003) distribute time measurements to along all of the processes in the whole supply chain. Similarly the SCOR (SCC 2012), balanced scorecard (Brewer and Speh 2000), and Gunasekaran et al. (2003) measure time in several categories.

The framework proposed by this study gathers all the time measures to one category, because this way speed can be evaluated with one variable. Time measures in supplier performance context relate to the ability of the supplier to deliver, produce, respond, or execute a certain operation in a reasonable time frame. Also as all time measures are gathered together, to time reduction analysis can be based on the same data and information. When the supply chain needs to optimized in time, the impacts improvement are directly seen in the common time measure.

The data for time measurement is already collected at case company to the ERP - system. Analyzing this data, which is already available, can provide useful information on the suppliers' performance. A simulated analysis of the data revealed that, only 48% of deliveries were full (all ordered parts delivered at one shipment) by one supplier in 2011. For rest of the 52%, the incoming warehouse had performed the reception at least twice. Another supplier scored 86% on full deliveries. A sample of this data analysis is presented in the Appendix 3. The average lateness of late orders for these two suppliers were 3,6 days and 4,1 days, respectively. Both suppliers had the maximum late delivery about 50 days. Even they both were some remainders of an earlier delivery, it can be wondered why a delivery can be almost two months late. An explanation can be that the parts were not need at all in the first place; this however contradicts the lean philosophy, of only ordering what is needed (Womack and Jones 2003). Further on, if such a measure is implemented the order quantities could be adjusted more precisely.

6.1.2 Cost

The cost element seems probably the easiest to measure, as attention to costs is always emphasized in most companies. However some cost are hidden and embedded so deep in the processes that the actual money spent is not clear. Hidden cost, like double work, is sometimes difficult to measure. Anderson and Dekker (2009b) state that, often, significant portion of the total cost is not related to purchase price, but are associated with handling of the parts.

Anderson and Dekker (2009a, b) discuss about strategic cost management in supply chains. They divide the cost management in structural and executional parts, which both include the tools and measures employ for supply chain. Structural part consists of designing the organization, product, and processes so that the cost structure can be aligned to company's strategy. The other part, executional cost management, is focused on the measurement and analysis of the actual operating costs of the supply chain. (Anderson and Dekker 2009a, b)

Beamon (1999) encloses the cost measures in the resource part of her framework. Measurements such as total cost, inventory, manufacturing cost are resources measures in Beamons (1999) framework. The framework presented by Gunasekaran et al. (2001), approaches the cost measures similarly to Anderson and Dekker (2009a, b). As their framework is divided into strategic, tactical, and operational, so are the cost metrics. In the SCOR model costs are in two categories, supply chain management costs and cost of goods sold, and these are included in several metrics of the SCOR model.

Inventory turnover is simple metric for cost, however it effectively also reveals information on the manufacturing performance and productivity. If the inventory turnover is slowing down, it means that products are not moving out of the factory. And since products are not flowing through the supply chain, inventory is piling up somewhere. To see where the inventory cost is created, the total capital tied to inventory should be measured in suppliers' buffer stock as well as in logistic pipeline and in the case company stocks.

The source of the cost data is the accounting figures. However, all cost cannot be seen directly from the bookkeeping itself, additional data should be gathered from production. These would be such as, equipment downtime, unnecessary work, and problem solving time, which can accumulate significant costs.

6.1.3 Quality

A simplest quality measure is a division between number of defect, or faulty, goods and total number of goods. This calculation gives a percentage of the quality level roughly. In a relationship with arms length suppliers this is usually the only quality measure used, and quite sufficient if the supply is bulk or commodity with low strategic value. However, if the product in question has even some level of complexity, the quality data should be analyzed more. In addition, the quality is more than just percentage of parts rejected. In partnership, intangible issues, such as quality of information, quality of operations, and quality of management, become more important.

For an overview of suppliers' quality, the measurements should consist of metrics measured by customer and metrics measured by supplier. The customer's metrics provide information on the quality in customer's perspective, such as defects passed the supplier quality assurance, and the supplier metrics reveal the capability to produce the products. Examples of supplier quality metrics are, first pass yield (the percentage of passed units in inspection or testing), process capability index (cpk, the capability of a process to produce same quality units), and defect or scrap rate (percentage of scrapped units). The total quality level can be evaluated, when the customer and supplier metrics are combined. As customer provides the field feedback and supplier's internal metrics provide real-time process data, improvements can be targeted at real quality problems.

Quality measures should also capture the accuracy of the information provided to suppliers by the case company. As the information to suppliers affects the suppliers ability operate, the quality of this information should be measured. Poor forecasting accuracy, for example, can cause a bullwhip effect to supply chain (Lee et al. 1997). Similarly the quality of suppliers reports need to be measurable, to avoid misunderstandings, which then can cause other problems in the supply chain.

As the quality is considered one of the most important value of the case company, the data for evaluating the quality, must be accurate and correct. No filtering or modifications to the data should be allowed at any part of the measurement system. The format of quality data should be agreed within the case company and with suppliers so, that the analysis can lead to the root cause of any possible quality problems.

6.1.4 Supplier Management

As mentioned, Shepherd and Günter (2006) discuss about flexibility and innovativeness as measures, this proposal however, combines these under one category, supplier management. Supplier management metrics measure the collaboration and partnership elements between the case company and suppliers, as well as the relationship of the companies. The actual metrics can be based on qualitative data, like satisfaction surveys. This category also measures the capabilities and competences of the supplier, which can be useful measures for supplier selection. The resource measures, discussed by Beamon (1999), are also included in this measurement element.

For a measurement system element, supplier management is more a indicator of the customers view on the supplier. The metrics, such as cost-reduction initiatives by the supplier, suppliers competences or suppliers problem solving abilities, are evaluated by the customer. This data creates the basis for a supplier evaluation system, which facilitates decision making in supplier selection. In addition, the supplier evaluation system can be used both for choosing a supplier for a new part from current suppliers and for benchmarking new suppliers.

Supplier management measures how a supplier is seen by the case company. Careful consideration is required, when deciding what to measure regarding the relationships as well as, how these metrics then need to be developed. For this, an analysis of the current supplier base can support the selection of what kind of metrics to apply. The supplier base must be categorized so the similar suppliers can be measured with same metrics.

6.2 Supplier Relations Management and SCM

Findings in the research literary all supported the notion, that supplier relationship management (SRM) improves supplier performance (Hughes & Wadd 2012, Park et al. 2010, Giannakis 2007). Managing suppliers by collaboration and partnership approach provides better results, when a company puts resources and efforts to the relationships. It should not be left to single sourcing or procurement manager to maintain the supplier relationships; it should be a strategic decision of the top management on, how to pay attention to key suppliers. Likewise, the strategies of supplier should be aligned with case company’s strategy.

Not all suppliers require same level of management. The key suppliers, which supply strategic item, which are difficult to substitute and have no alternative suppliers, are the ones, which should be managed to minimize the supply risk (Park et al. 2010). The Kraljic’s matrix, mentioned in section 3.3.1, is a simple tool to use for determining the type of management practices for different items and suppliers. The case company had close to 400 suppliers in 2011. Out of all these suppliers, 10% of those had 80% of purchase order lines. By narrowing down with quantity of items and prices, approximately half a dozen suppliers can be considered as the kind, which require supplier management and relationship management. The rest of the suppliers can be left with less attention in supplier management point of view, however their performance, nonetheless, should still be measured in the same way.

Supplier relationship management can be used as an extension to supply chain management. As supply chain management controls and monitors the overall performance of the whole supply chain, supplier relationship management focuses on the upstream part of the supply chain. With the selected suppliers, SRM help both organizations to learn and benefit from each other. This mutual learning is also what Liker and Choi (2004) describe as one of the goals in their paper on supplier relationships.

6.3 Performance Measurement System Framework

The result of this study is a measurement framework, which contains four categories of measurements. These categories include time measurements, cost measurements, quality measurements, and supplier management measurements. Each of the categories contains all the respected metrics. The generic model of the framework is presented in the Figure 11, below.

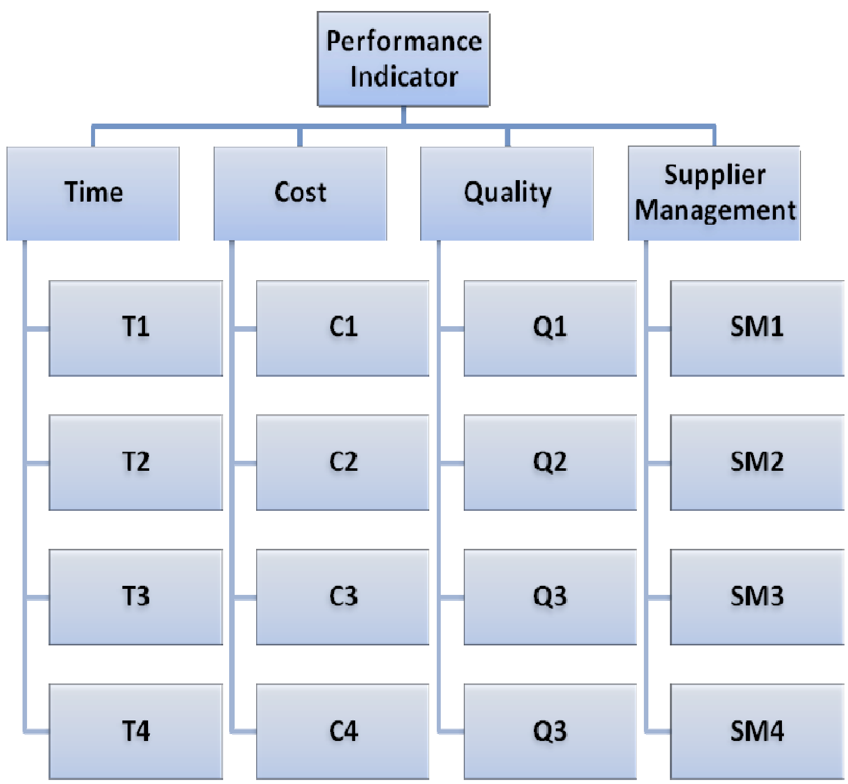

Figure 11. Performance Measurement System Framework.

As presented in the Figure 11, above, the framework consists of the mentioned four categories: time, cost, quality, and supplier management. All the metrics are combined to create one performance measurement metric in the respected category. These then again can be merged to represent the overall performance with the performance indicator. This way an overall view of the performance can be seen easily by looking at just one figure. The same kind of, single performance index was proposed in the framework by Chan and Qi (2003). Even the information of one category or, further down a single metric will be hard to see, the main indicator provides enough information to see how things are running along. Since the measures and metrics are normalized and linked, drilling down to a single metric is possible. Likewise, different organizational levels can concentrate on selected parts of the system. The measurement system indicators can be directly linked to the case company's strategy, as they provide detailed information about the supply chain.

The Figure 12 shows an example how the single metrics create the overall supplier performance indicator. In the Figure 12, the quality metrics (1, 97%, 99%, 4) are combined to on performance measurement system (PMS) category metric. This is the quality metric, 96% in this case, for the supplier. Then the PMS metrics are again combined to create the performance indicator.

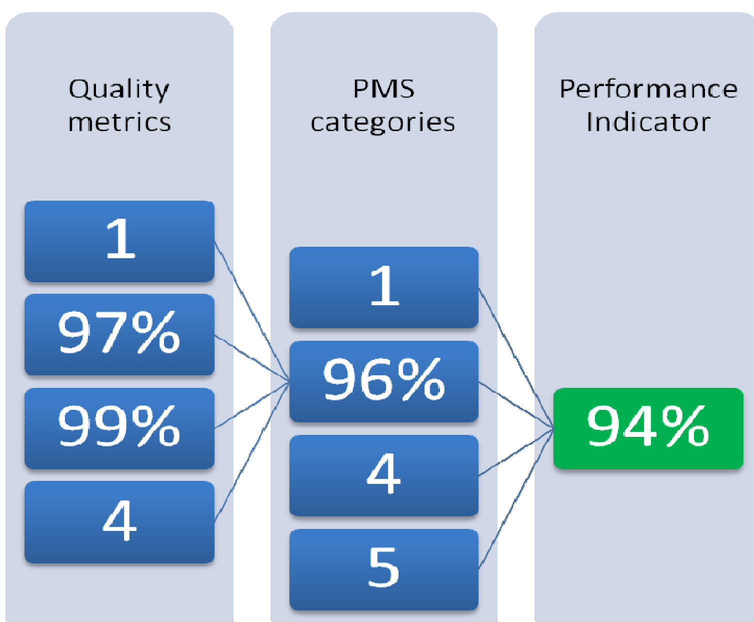

Figure 12. Example of traffic light formation of one element.

The Figure 12 shows the supplier performance indicator as percentage, but the number can be also a scale from one to five, if this is preferred. As all the metrics, regardless of the supplier, are scaled to normalized values, direct comparison between suppliers is possible. And even further, when all the measures are combined, the performance of the supply chain can be indicated, with simple traffic light indicator. However, the overall indicator can be too general to assist any decision making, but once the system is properly configured, it will easy to drill down the measures and find the metrics that need attention.

7 Discussion and Conclusions

This section summarizes the results of the study and presents the evaluation of the study in terms of its validity and reliability.

7.1 Summary

As this study shows, the supplier performance measurement in the case company is still in its infancy and requires improvements in order to provide useful, fact-based information for decision-making. Despite the obvious shortcomings in the current performance measurement, the case company has managed to improve the supplier performance, but only so far. However, to move forward from the current level and focus its improvement efforts to right direction in the supply chain development, an improved performance measurement system is needed.

In the course of this study, the researcher had the opportunity become deeply acquainted with the processes of the case company and its suppliers. This presented a great learning opportunity as for the case company's supply chain and its operations. Those suppliers, who were interviewed, also provided valuable information to the researcher on their internal processes. The current state of the case company and improvement needs was identified through interviews and observations. Simultaneously, best practices and exiting frameworks were reviewed from research literature. In the development for the proposed framework performance measurements system, these data was analyzed to indicate what improvements is required. Finally, a proposal for case company's supplier performance measurement system was developed. The developed framework combines all supplier performance measurements and metrics into one coherent system, which contain four categories.

To summarize the results of the study, three main points can be identified. First, the case company should start to measure additional variables of the supplier side of the supply chain. The performance measurements need to be designed and developed in co-operation with the supplies. Additional metrics is needed to reveal the actual performance level of the suppliers and the supply chain.

Supplier relationships, is the second main point of the results. Supplier relationship management can be utilized to create trust between the supplier and the customer. Trust is extremely important in lean production, which is a method used in the case company. As the one goal of the lean production is the just-in-time deliveries, in which the parts are delivered only at the moment they are needed, the case company must be able to trust its suppliers to perform time, with perfect quality, in the right place. Based on these measurements, mentioned, the upstream supply chain can be controlled and managed, with fact-based decisions, rather than merely trusting the suppliers' opinions and estimations as for the supply chain operations. Trust, however, is crucially important in the supplier relationships.

Finally, once the measurements are implemented, they need to be linked together to a coherent measurement system. This performance measurement system can then be used as a dashboard for supplier performance evaluation that provides real-time information on the supply chain. This measurement system would indicate any problems concerning deliveries, quality issues, costs and, information flow between case company and suppliers.

As a conclusion, based on the results of this study, a performance measurement system can help to improve the performance of the suppliers, as well as supplier evaluation and assessment in the case company. A measurement system, that provides fact-based data about the suppliers' performance, can also facilitate decision making in the case company.

7.2 Managerial Implications

Based on the findings of this study, several recommendations can be made to improve the current performance measurement and evaluation of the case company's suppliers.

First, it can be recommended that the case company supply chain management ought to pay special attention to the supplier performance measurements. By measuring the supplier performance, the managers in the case company can have fact-based data to support and assist decision-making, as well as ensure visibility to improvement needs in the supply chain. All the frameworks, including the one proposed in this study, stress that a linkage between the metrics and company strategy should exist. In addition, the company policy implies that the metrics should be linked to the strategy.

Secondly, the case company should consider initiating a policy for supplier relationship management, in order to utilize the experience, competences, and skills of the suppliers. With the proper supplier management methods, it is possible to leverage the position of the supplier as a customer, so that the supplier does not feel threatened or bullied. High involvement and participation of the suppliers, even in the case company's core processes, create trust and co-operation between the key suppliers and the case company. This kind of deep partnership with its suppliers is mutually beneficial for both parties. The same rule applies to organizations as to human behavior, that is, if someone is interested and watch on what you are doing, you tend to pay more attention on what you do and try to do it better. The aim of supplier relationship management is to generate mutual benefits for both parties in the relationship.

The managerial implications of this study are listed below:

- Supply chain management team has to decide whether a performance measurement system is needed in the case company.
- Supply chain management team should then nominate the responsibilities for measuring the performance of the suppliers, as well as the performance of the supply chain.
- The performance measures and metrics need to be designed and developed in co-operation with the suppliers by the appointed team.
- Sourcing activities should include supplier relationship managed together with the key suppliers. This will lead to joint learning and improvement opportunities.

As mentioned in the Section 4, the case company has succeeded in improving the internal manufacturing processes and should now consider moving outside its factory walls. This study provides suggestions for some starting points in the improvements for the upstream supply chain. Further development of the measurement system, which would include downstream supply chain, is an issue to consider in the near future.

7.3 Reliability and Validity

This final section will discuss the reliability and validity of this study. The evaluation is based on the tests on validity and reliability by Yin (2003) and the topics presented by Huhta (2011) and discussed by Quinton and Smallbone (2006).

First, the data for this study was collected by interviewing several persons, in different position, both in the case company and in its suppliers. The framework was presented in the case company to the key informants, to test the validity of the framework. A common conclusion was, that the presented framework is feasible for case company, although some further developing is needed before the implementing the suggested measurement system into practice. In addition, discussions with other persons within the case company confirmed, that the performance measurements need improvement.

Second, multiple data sources and collection tools were used, to be able to analyze the case from different points of view. The data sources and tools include interviews, observations, documentation of processes in the case company, and current performance measurement data. The data was documented to the researcher's field notes. The conducted interviews were semi structured and the questions, displayed in the appendixes, were prepared and disclosed to the informants in advance. The interviews were not recorded, only notes were taken to collect the data. In addition, several informal discussions with the informants provided valuable information as well as guidance for this study, although these should have been documented better.

Third, the analysis of the data was conducted with rigorous attention to business problem, which the study intended to solve. The data collection was conducted with the focus to discover the root cause of the case company's problem on supplier performance evaluation. The developed provides a solution, which can be used for all types of suppliers the case company has. Although, the scope of this study focused on the upstream supply chain of the case company, the developed framework can be expanded to be used with the downstream part of the case company's supply chain as well.

Finally, even the own biases of the researcher have certainly affected the results of this study, it is clear that if some other research method would be used to analyses the same problem by someone else, the conclusions would most probably be similar. Although the findings of the study provide an answer to the initial research question, the testing of the developed framework, would have increased the validity and reliability of this study. This however was not possible, due to the time constraints of the research project.

To sum up, the supply chain performance measurement is an interesting topic for research, as it includes so many parts and processes within the supply chain. This study only scratches the surface of performance measurements, but even so, provides a good overview on the matter. For future development in the case company, it would be beneficial to focus on the metrics that could be used in the proposed framework.

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Appendix 1.
Internal interview questions

1. How is the performance measured?
    a. How is this measurement/measurements used in supply chain management?
    b. Does it give clear view of the supply chain?
2. How is the metrics compiled?
    a. From which data sources?
    b. What is the measurement frequency?
    c. Who is responsible of these metrics?
3. Are these measurements linked to company strategy?
    a. How?
4. Is there a need for additional metrics?
    a. Upstream?
    b. Downstream?
5. Other issues regarding performance measurements?

Appendix 2.
Supplier interview questions

1. How is the supply chain performance measured?
    a. How is this measurement/measurements used in supply chain management?
    b. Does it give clear view of the supply chain?
2. How is the metrics compiled?
    a. From which data sources?
    b. What is the measurement frequency?
3. Are these measurements linked to company strategy?
    a. How?
4. Is there a need for additional metrics?
    a. Upstream?
    b. Downstream?
5. Other issues regarding performance measurements of your suppliers?

6. What KPI's you measure?
    a. Which are reported to you customers?
7. How do your customers measure your performance?
    a. How do you report them?
    b. Do these help you to improve your processes?
8. What kind of metrics would help you to improve your processes/operations?

9. What kind of feedback would help you to improve your processes/operations?

10. Other issues regarding performance measurements?

Appendix 3.
Delivery data analysis

Count of full	Column Labels			
Row Labels	NOK	OK	Grand Total	Full PO
136631		1	1	1
136797	1		1	0
137173		1	1	1
137205		1	1	1
137221	4		4	0
137251	10	9	19	0
137355		2	2	1
137372	1		1	0
137426		2	2	1
137667	1		1	0
137727	3	2	5	0
137728	7	4	11	0
137795		1	1	1
137815	5		5	0
137832		1	1	1
137857	1		1	0
137885	5	1	6	0
137893	5		5	0
137897		2	2	1
137901		1	1	1
137978	1	1	2	0
138239		1	1	1
138365		1	1	1
138378		1	1	1
138402		1	1	1
138585	1		1	0
138846	2	1	3	0
138849	5	4	9	0
138868	1		1	0
138898	1		1	0
138922		1	1	1
139056	1	1	2	0
139158	3		3	0
139166		1	1	1
139222	2	1	3	0

Not full lines	Full lines
52 %	48 %

Full Pos	Total POS	%
158	303	52 %