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LICENTIATE THESIS

Measurements of efficiency in a Supply chain

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Preface

This licentiate thesis was carried out at Luleå University of Technology at the Division of Industrial Logistics from January 2005 until November 2008. I have had an idea about starting my studies aiming at a Licentiate in Engineering for a long time. The preparation for this thesis has been ongoing during the ten years I was working with Supply Chain Management prior the start for this studies. After completion of my Master of Science in Mechanical Engineering and my Master of Business Administration in Accounting I started to work for Ericsson AB with Supply Chain Management. I really enjoyed my work so the studies were put on hold for many years. I have however learnt from my fantastic grandparents Siri and Sven Pettersson that you are never too old to learn something new and that the age is not an obstacle for doing things. They live in their own house in the countryside, where they at the age of 89 and 90 still manage to take care of everything by them selves.

I started this study as an Industrial doctoral candidate where I could combine the studies with my work at Ericsson. I would like to express my appreciation to my supervisor Professor Anders Segerstedt for letting me start the studies while continuing to work. Dr Diana Chronéer, Stefan Karlsson, Peter Wallström have made valuable comments on the preliminary manuscript. I am also grateful to my manager at Ericsson that approved this set up.

I would like to express my deepest appreciation to my family. They have all supported me during this period. My sister Gunilla has helped me with checking language and spelling. My man has helped me a lot with the figures in the thesis. My mother and father Maj-Inger and Hasse Pettersson have always supported me. Thank you all.

Stockholm in November 2008

Annelie Pettersson

Abstract

This licentiate thesis addresses the topic of measurements in the Supply chain and specifically measurements of Supply chain efficiency. This thesis has the following objectives:

- To present ways of measuring performance of the Supply chain.
- To present ways of measuring cost in the Supply chain.
- To suggest a quantitative method to evaluate how efficient a Supply chain is and combining the cost concept with the performance concept.
- To discuss and evaluate on which organisation level in the individual company the Supply chain efficiency preferably should be measured.

The thesis contains nine chapters. Chapter two to four include a literature review of Supply chain, Supply Chain Management, efficiency, methods and definitions for performance measurements of the Supply chain and Supply Chain Costs.

Chapter 5 describes an empirical study where 30 companies are interviewed. All companies are based and have production and business in Sweden; many of them are also large companies with business worldwide. Three companies from ten different groups or branches are interviewed. The ten different branches are:

- Manufacturing industry
- Pharmaceutical/ medical technology industry
- Telecommunication industry
- Commodity industry
- Consumer products industry
- Contract manufacturer
- Materials
- Automobile industry
- Paper industry
- Construction industry

An index for measuring efficiency in a Supply chain is presented in chapter 7. The index is based on concepts and theories presented in chapter 2 to 4 and the empirical study. The model is combining cost and performance. The index is tested on Ericsson AB and this is presented in chapter 8. Final conclusions and extensions are presented in chapter 9.

Sammanfattning

Den här licentiatavhandlingen tar upp mätningar i Supply kedjan och specifikt mätning av ”Supply chain excellence”. Den här avhandlingen har följande syfte:

- Presentera sätt att mäta prestation i försörjningskedjan.
- Presentera sätt att mäta kostnad i försörjningskedjan.
- Föreslå en kvantitativ metod som mäter effektivitet i en försörjningskedja genom att kombinera kostnadskonceptet och prestationskonceptet.
- Diskutera och undersöka på vilken organisationsnivå i ett företag mätningar av effektivitet i dess försörjningskedja bör göras.

Licentiatavhandlingen innehåller nio kapitel. Kapitel två till fyra innehåller en genomgång av litteratur gällande Supply chain, Supply Chain Management, effektivitet, metoder and definitioner för prestationsmätningar i Supply kedjan och Supply Chain Cost.

Kapitel 5 innehåller en empirisk studie där 30 företag som har verksamhet i Sverige är intervjuade. Tre företag från tio olika branscher är intervjuade, de tio branscherna är:

- Tillverkningsindustri
- Läkemedels/Medicinskt industri
- Telecom industri
- Dagligvaruhandel
- Sällanköpsvaror
- Kontraktstillverkare
- Material industri
- Bilindustri
- Pappersindustri
- Byggindustri

Ett index för att mäta effektiviteten i en Supply kedja presenteras i kapitel sju. Indexet baseras på koncept och teorier som är presenterade i kapitel två till fyra och den empiriska studien. Indexet kombinerar kostnads fokus och kundfokus. Det föreslagna indexet är testad på Ericsson AB och detta är presenterat i kapitel åtta. Slutligen presenteras slutsatser och förslag till fortsatt arbete i kapitel nio.

Contents

1. INTRODUCTION

This licentiate thesis focuses on performance measurements and cost measurements in the Supply chain; it concentrates on measurement of Supply chain efficiency. How is efficiency measured in a Supply chain and does it exist a simple model or index for measuring efficiency in a company are questions that will be investigated and evaluated in this thesis. The focus in the thesis is on an individual company in the Supply chain. This company will manage their Supply chain based on what is best for the own company. Collaboration with other companies in the Supply chain will present win win situations for the own company and for other companies in the Supply chain (cf. Christopher (1998)). The company has difficulties to measure the whole Supply chain; the customers, the suppliers, the suppliers' suppliers etc. There are other actors in the Supply chain that focus on their own business. These actors can also be part of several other companies Supply chains; for example can a manufacturer of glass be part of both Volvo's Supply chain and Scania's Supply chain. Therefore the focus in this thesis is on efficiency for the individual company in the Supply chain.

Supply Chain Management (SCM) has received an increased amount of interest both from researchers and in the industry. The SCM concept came up just before the 1960s according to Huan et al. (2004). The study of SCM increased in the 1980s and had a dramatic increase in the 1990s (cf. Huan et al. (2004)). More and more companies have to focus on their Supply chain in order to be successful in their business. Already in 1997 top managers had recognized the importance of having effective Supply chains to create competitive advantage according to Higginson and Alam (1997) and Cooper et al (1997).

The margins for many companies are becoming smaller and smaller due to increasing demand from the customers on lower prices. Solvang (2001) writes that one of the biggest challenges for manufacturing Supply chains is to continuously improve their performance so that their competitiveness can be sustained in long term. To be able to survive on the market the companies have to cut cost in all areas and focus on SCM. Tummala et al. (2006) state to make changes to the Supply chain helps to lower cost and enables a company to more easily compete based on the price. Many concepts for Supply chain design and Supply chain modelling have been presented during the last couple of years with different focus according to Svensson (2003). An interesting question related to this is what should a company aim for when designing a Supply chain?

Companies are working with improvements in the Supply chain and are aiming for Supply chain excellence and World-class Supply, but what does this mean? Is Supply chain excellence to have short lead-time and high delivery precision or is it to achieve a low cost for the Supply chain? This differs a lot between

different companies and also at different times. A trend has been that a company is focusing on cost one year and the next year they focus on performance. Christopher and Towill (2000) are describing the trends for Supply Chain Management from the beginning of the eighties to end of the nineties. In the beginning of the eighties the focus was on cost effective Supply chains. During the coming years quality was in focus and then in the end of eighties the focus went back to cost. In the beginning of the nineties it was high availability that gave market shares. The strategy was to combine cost effectiveness to the break-even point between forecast driven flow and customer order drive flow. In the end of the nineties many companies had reached high availability and then shorter lead-time came in focus. The same factors quality, cost, availability and lead-time are considered, but the priority differs.

A company needs to have performance measurements to be able to evaluate the efficiency of the Supply chain. According to Sink and Tuttle (1989) you can't manage if you can't measure. Christopher (1998) claimed that companies have to achieve both cost leadership and service leadership to have an efficient Supply chain. If a company only measure internal performance measurements as for example order handling time and yield in production the measurements can't be used for evaluating the efficiency in a company. Lambert and Pohlen (2001) also claimed that most of the supply related performance measurements have an internal focus and do not measure how the company drives profitability. If this still is valid there is an indication that there is a gap of a measurements measuring efficiency. This thesis will evaluate the performance measurements in the Supply chain used today and identify if efficiency can be measured.

1.1 Introductory definitions

This section describes some definitions that are important for this thesis. These definitions are discussed more in detail in chapter 2, 3 and 4.

Supply chain: A company's Supply chain is defined by Christopher (1998) as "the network of organisations that are involved, through upstream and downstream linkages, in the different processes and activities that produce value in the form of products and services in the hand of the ultimate customer."

Supply Chain Management: Supply Chain Management is described by Ellram (1991) as the integration of control and planning of materials and product flow from supplier to customer. Simchi-Levy (2000) defines Supply Chain Management as " a set of approaches utilized to efficiently integrate suppliers, manufactures, warehouses, and stores, so that merchandise is produced and distributed at the right quantities, to the right locations, and at the right time, in

order to minimize system wide costs while satisfying service level requirements."

Supply Chain Cost: Supply Chain Cost is the total cost in the Supply chain. Supply Chain Cost is defined by Bowersox and Closs (1996) as cost components related to:

- Order handling
- Purchasing
- Cost for stock handling
- Cost for systems needed to handle the Supply like for example the order system.
- Manufacturing cost

Supply chain efficiency: Efficiency is according to Beamon (1994) the measure of how well the measurement of how well the resources expended are utilized. Supply chain efficiency is how well the resources in the Supply chain are utilized.

Logistics: Lambert et al (1998) says "Logistics is that part of the Supply chain process that plans, implements, and controls the efficient, effective flow and storage of goods, services, and related information from the point of origin to the point of consumption in order to meet customer's requirements.

1.2 Background

This research project is initiated to fulfil an aim for more knowledge about models for measuring the cost and performance of the Supply chain. The focus in this study is to present methods and models for measuring Supply Chain Cost and Supply chain performance and to suggest a quantitative method to seek to evaluate efficiency based on both cost and performance.

I have been working with Supply Chain Management at Ericsson AB and Flextronics since 1995. Performance measurements and efficiency measurements have been two interesting areas during my work. From other people also working in the Supply chain of these two companies I have noticed an interest for more information and knowledge concerning the performance measurement area. This has been a great inspiration to do this work. Naturally the environment and the daily work at these two companies influence me; but by strong supervision, a literature review, many interviews of other companies, I hope I have broadened myself and can avoid general categorical statements based only on my intuition and experience unknown for readers outside Ericsson

and Flextronics.

1.3 Scope and objectives

This report is written within the Supply Chain Management area and focus will be on the efficiency of the Supply chain and to be more specific the cost and the customer aspect.

Supply Chain Management has a wide scope in the literature on SCM and there are a lot of models describing the Supply chain from different perspectives. Some models are describing how to set up a Supply chain based on product mixes, locations, inventory planning etc. Other models describe what to measure in the Supply chain like the SCOR model. (The SCOR model is described in section 3.2.2). Shapiro (2001) points out that the Supply Chain Cost isn't the only thing that a manager shall optimise. It is also important to consider customer service aspects such as lead-time.

The traditional objective of Supply Chain Management is according to Shapiro (2001) to minimize the total Supply Chain Cost and to meet the given demand. Cutting costs in the Supply chain most likely affect the performance like for example delivery precision and lead-time. It is easier to get a short lead-time by having buffers, but buffers cost and therefore the Supply Chain Cost is increasing. Segerstedt (1999) writes profitability is achieved by the difficult balancing of facility utilisation (high), capital and inventory investments (low) and market services (high). The challenge for a company is to combine the ***cost*** (establish high facility utilisation, low capital investments) and ***performance*** (short delivery times, high delivery precision, satisfied customers, short lead times, short days of inventory) and optimise both of them to get the best result for the company. Schary and Skøjtt-Larsen (2001) describe the Supply chain Triangle, which is showing the conflict between cost and performance. The main objective for a company is to provide service to the final customer, but at the same time minimize the cost.

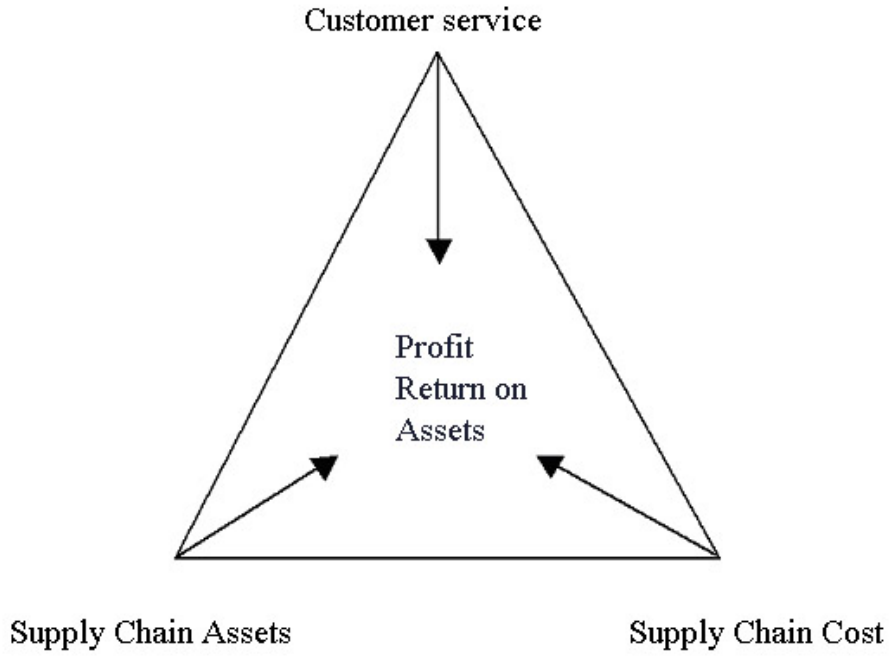

Figure 1.1 The Supply chain Triangle Schary and Skøjtt-Larsen (2001).

The most efficient Supply chain is the one that has the lowest possible cost and at the same time meet the customer's expectations on service like delivery precision and lead-time. My experience from working in the industry is that to achieve both high customer service and low cost is a challenge for companies. The company has to be good in measuring performance and cost to be able to know it they work with the right things in their aim to be more efficient within Supply Chain Management. They also need a good tool or method to evaluate how efficient the Supply chain is

This thesis has the following objectives:

- To present ways of measuring performance of the Supply chain.
- To present ways of measuring cost in the Supply chain.
- To suggest a quantitative method to evaluate how efficient a Supply chain is and combining the cost concept with the performance concept.
- To discuss and evaluate on which organisation level in the individual company the Supply chain efficiency preferably should be measured.

1.4 Method

This study has been performed within the subject Supply Chain Management. The study was divided into four steps. The first step in the study was to generate a theoretical framework based on previous theoretical studies. Searches for books and articles have been performed in Libris and different databases like Ebsco Academic Search Elite, Emerald and Wiley. The following search words have been used: ***Supply Chain Management***, ***Supply chain***, ***Performance measurements***, ***Supply Chain Cost***, ***Supply chain efficiency***

The second step included performing an empirical study. The theoretical framework and the empirical study together constitute the base for the presented index. The empirical study includes interviews with 30 companies based on the criteria that they have business present in Sweden and that the study shall include 3 companies from each of the ten sectors: Manufacturing industry, Pharmaceutical/ Medical technology industry, Telecommunication industry, Commodity industry, Consumer products industry, Contract manufacturer, Materials, Automobile industry, Paper industry and Construction industry. The interviews were done with a company representative selected by the company as being able to answer questions about Supply chain issues. The interviews were performed either as telephone conversations or as personal meetings.

The third step was to generate an index measuring efficiency in a Supply chain. The index has been based on conclusions from the theoretical framework and conclusions from the empirical study, but also based on findings and ideas gathered from practical work within the Supply chain area at Ericsson AB.

The last step was to test the index, draw conclusions and compare the findings with the index. The index was tested on Ericsson AB.

1.5 Outline

Chapter 1 consists of the introduction part of the report and describes definitions used in the report, background, scope and objectives, method, outline and limitations. Supply chain, Supply Chain Management and efficiency are described in chapter 2. Chapter 3 includes methods and definitions for performance measurements of the Supply chain.

Supply Chain Cost is described in chapter 4. Chapter 5 presents a summary of the literature review presented in chapter 2, 3 and 4. Chapter 6 describes the empirical study done of 30 companies having business in Sweden.

A connecting index or type of a model to measure Supply chain performance and efficiency is presented in chapter 7. The index tries to connect separate and dispersed measurements of efficiencies to a common measurement. The index is based on concepts and theories presented in chapter 2 to 4 and the interviews in chapter 6.

In chapter 8 the common index for efficiency is discussed and applied on Ericsson AB. It is discussed how it can be measured on different levels of the organisation, for products, for plants, for business units etc. Chapter 9 includes conclusions and comments on this work. Suggestions for further studies conclude the report.

1.6 Limitations

Supply Chain Management has a wide scope and includes a lot of theories about how to set up the chain. The thesis is not going into details regarding everything included in the term Supply Chain Management. The aim for this report is to give a view of methods that can be used to evaluate if a Supply chain is efficient or not, and in the end suggest a model or index that combine different measurements.

The first part of the empirical study is limited to 30 participating companies with different products and services. The companies are working in different lines of business like telecom, clothing, paper industry, steel industry, car industry, construction industry and other. Many of the companies are large companies working all over the world. The number of participating companies, the size of the companies and type of industry has to be considered when evaluating the results from the empirical study.

The second part of the empirical study is done at one single company, which not can be seen as a representative for all companies. This means that the result of this study must be considered with this in mind. The result from this part of the empirical study has to be presented without real figures due to respect for confidential information.

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2. SUPPLY CHAIN MANAGEMENT

2.1 Introduction

In order to discuss Supply chain excellence, the scope of a Supply chain and Supply Chain Management has to be known. In this chapter a Supply chain from a general perspective as well as the management of a Supply chain is described. Questions being discussed include how a Supply chain should be managed in order to be considered excellent, i.e. be the most efficient Supply chain, and what models support the management of a Supply chain.

2.2 Supply chain

Currently a lot of definitions of a Supply chain exist. Different people define the term ”Supply chain” in different ways. For instance, Christopher (1998) defines the Supply chain as “the network of organisations that are involved, through upstream and downstream linkages, in the different processes and activities that produce value in the form of products and services in the hand of the ultimate customer.” Ballou (2004) says that Supply chain “ refers to all those activities associated with the transformation and flow of goods and services, including their attendant information flows, from the sources of raw materials to end users.”

Many aspects of Supply chain may be discussed. Some discussed aspects are: the number of companies involved in the chain, Supply chain versus Demand chain, chain perspective versus the own company and which parts of a company are involved in the Supply chain

According to certain definitions of Supply chains there has to be more than one company involved in the chain in order for it to be defined as a Supply chain. Holmberg (1997) claims that at least two organisations are required to form a Supply chain. Shapiro (2001) says that a Supply chain comprises geographically dispersed facilities where raw material, intermediate products or finished products are acquired, transformed, stored or sold and transportation links that connect facilities along with products flow. The facilities can be operated by the own company or by vendors, customers, third party providers or with other companies with which the company has business arrangements. The definition Supply chain may not be depending on the number of companies involved in the chain, but rather on what functions are involved.

To be able to discuss Supply Chain Management and Supply chain cost it is very important to define what parts of the company that should be considered to be a

part of the Supply chain.

Common functions in a company are:

- Research and Development
- Marketing and Sales
- Supply
- Service
- General administration and business controlling

Research and Development (R&D) is the function of the company in which products are developed. The ways the products are developed have a deep impact on the Supply. Thus, it is very important with a close co-operation between R&D and Supply to get the lowest possible Supply chain cost. For example, if the product developers develop a product in different variants that the customer can choose from, this has the effect of a higher Supply cost in the end. The company that manufactures the product needs to have more variants of components to build the products with in stock to be able to manufacture the different variants. More variants of components in stock gives more inventory cost.

What is contained within the function marketing and sales differs between different companies. For a telecom company that deliveries base stations, this function includes the people who are out selling the product and all activities related to marketing. Marketing activities may include commercials in newspapers, events and so on. For a company selling groceries M&S also includes advertising activities. For such companies, the cost for the store and the personal working in the store is related to Supply (cf. Ica, Axfood and Coop).

The Supply function includes inbound logistics, outbound logistics, sourcing, production and distribution. In the Supply part, claims and warranty handling is also included. Inbound logistics is taking care of material flows going into the company and outbound is taking care of material flows going out from the company. Sourcing is responsible for contract agreements with the suppliers of material.

Service is the function of the company taking care of after sales activities. This means that they take care of selling spare parts and providing technical support after the end of warranty period of the product.

General administration and business controlling is the function within the company taking care of activities that cannot be related to the other four parts. The general management is part of this. Business controlling and other

administrative support functions are also a part of this if they cannot be related to any of the other. A person working with business control for the Supply part is a part of Supply.

Out of these five functions of a company, Supply is part of the Supply chain, but also parts of the other functions may be included in the scope of the Supply chain.

The Supply chain structure differs between different types of products and services. Examples of three types of general Supply chains are:

1. Supply chain for products that are sold in a store
2. Supply chain for products that are ordered from a supplier
3. Supply chain for services.

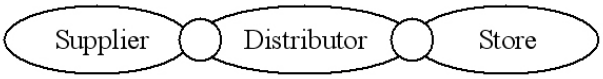

Figure 2.1 Supply chain for products sold in a store

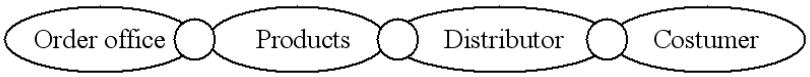

Figure 2.2 Supply chain for products ordered from a supplier

Figure 2.3 Supply chain for a service

In the grocery industry, customers go directly to a store and purchase what they would like to have. The Supply chain in figure 2.2 starts with the customer placing an order to the supplier. The supplier books the order and starts

production. The product is then delivered to the customer. Specific for Supply chains for services on the other hand, is that no physical product is delivered. The service can be delivered in many different ways, such as in a hair saloon, by mail or by phone. Irrespective of the differences between what function of the company that is taking part of the Supply chain and how the product or service is delivered, the term Supply chain is applicable to describe the chain.

The Supply chain can describe the activities that are involved in the chain, or the companies, or the different functions.

There are different types of Supply chains. One common thing for all Supply chains is that all actors in the flow are suppliers to the end customer. Fisher (1997) states that the reason for problems in many Supply chains has been a mismatch between the product type and the type of Supply chain. A customer can require different Supply chains over time. Collin (2003) has found that it is important for a supplier to have the right Supply chain for a customer in different business situations.

Mattson (2002) describes a plain Supply chain without starting with the customer.

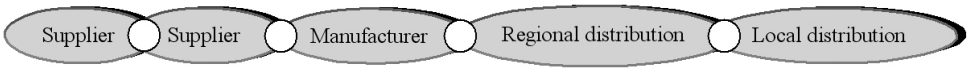

Figure 2.4. A plain Supply chain. Mattson (2002)

All companies are part of a Supply chain and all have suppliers and customers according to Mattson (2002). The companies in a chain affect each other's efficiency more or less. Co-operation can give synergy effects or eliminate negative effects. For example a good co-operation in forecasting between two companies in the Supply chain benefits both companies. One of the two companies is supplying parts that are used in the production by the other company. The company that deliver the parts benefits by getting a good forecast and can plan their material supply in a better way. This can lead to that the company can sell their parts to the other company for a lower price. The other company benefits by getting a lower cost for the parts they are purchasing. When taking actions like changing suppliers or giving up customers the whole chain has to be considered. Supply chain for a company are all activities related to Supply of products or services to the end customer. The activities can be within the own company, but also outside the own company.

Christopher (1998) writes that many discussions in the literature focus on the Supply chain from the chain perspective meaning that the whole Supply chain shall be optimised and that you cannot focus on just one company. This is from the perspective that you have to consider the whole Supply chain when you manage it to get the best result, but it is always the profit of the own company that is the most important. This thesis focuses on the Supply chain from the own company perspective. This means that the Supply chain shall support the company to maximize their profit. Most often other companies are involved in the Supply chain and have to be considered in the management of the Supply chain. Win win situations for all companies shall be aimed for, but in the end is it the own company that must be as profitable as possible. Buffers can for example be avoided in the own company, but can be a part of the Supply chain. Another company in the Supply chain can be requested by the own company to put up a buffer to be able to provide a short lead-time. The cost and the risk for the buffer can be taken by the other company or by the own company.

There is also a discussion about Supply chain versus Demand chain. People that talk about Demand chain mean that everything starts from the demand from a customer and therefore it should be called Demand chain instead of Supply chain. This is right, but there is still a Supply of products or services from a supplier to a customer and therefore Supply chain is a better term. According to Christopher (1998) there was criticism towards SCM that it is not customer oriented and then the term Demand chain management was coming up. Hoover et al. (2001) defines the Demand chain is the chain of activities communicating the demand from markets to suppliers.

Figure 2.5. Supply chain, based on Hoover et al. (2001)

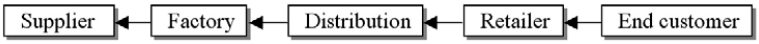

Figure 2.6.Demand chain, based on Hoover et al. (2001)

Hoover et al. (2001) says that a new concept describing customer relationship is needed to take the next step in SCM. This step is to create Demand-Supply chains. The purpose of the Demand chain thinking is to give the customer an

extended choice that also includes the relationship level according to Hoover et al. (2001). Demand-Supply Chain Management requires a closer co-operation between the Supply function and the Marketing & Sales function in a company.

One of the most important trends in the second half of 1990 has been the concentration to core business. More outsourcing means that the Supply chain is increasing and it gets more important to manage the Supply chain. It is important to be part of the right chain according to Paulsson et al. (2003).

Mattson (2002) says that the way people look at Supply chains have become wider during the years. The information flow has become more important, the overall perspective is more important and the end customer has come in focus. Mattson talks about two types of Supply chains. The first Supply chain has internal actors from departments or functions within the own company handling value adding or moving of material. It could be purchasing, manufacturing, assembly, customer order handling and distribution. All these departments can be customers and suppliers to each other. Customers and suppliers are part of the systems surroundings, but are not within the system boundary. The second type is Supply chains with external actors. Now more than the own company is included in the Supply chain.

2.3 Supply Chain Management

The term Supply Chain Management came up around 1980 by the Boston Consulting Group, but came in focus in the beginning of 1990. There is according to Mattson (2002) and Paulsson et al. (2003) no clear definition of the term SCM. Mattson (2002) says that the definition is not clear, neither in the literature nor in the practical use. Paulsson et al. (2003) says that there is a lack of a clear definition of SCM and the term has developed over time.

There are according to Cooper and Ellram (1993) three reasons for companies to engage in SCM. The reasons are to reduce inventory holding cost, increase customer service and increase competiveness of the Supply chain.

2.3.1 Supply Chain Management and Logistics Management

Mattson (2002) writes that the terms Logistics management and SCM are used as synonyms in many cases. Christopher (1998) says that the scope of logistics spans the organisation from the management of raw materials, through to the delivery of the final product. The mission of logistics management is to plan and co-ordinate all those activities necessary to achieve decision levels of delivered

service and quality at lowest possible cost according to Christopher (1998). Supply Chain Management is an extension of Logistics management. Logistics management is primarily concerned with optimisation of flows within the organisation while SCM wider external. The concept SCM has been derived from logistics management. LaLonde and Maters (1994) discuss that a Supply chain strategy should always include two or more firms in a Supply chain entering into a long-term agreement.

2.3.2 Supply Chain Management definitions

There are many definitions of SCM in the literature. The definitions focus on different things. There are cost focus, customer service and inventory cost focus and the flow focus. Shapiro (2001) writes that the traditional objective of SCM is to minimize the total Supply Chain Cost to meet fixed and given demand. This total cost may include the following:

- Raw material and other acquisition costs.
- Inbound transportation cost
- Facility investment costs
- Direct and indirect manufacturing cost.
- Direct and indirect distribution cost
- Inventory holding cost
- Interfacility transportation cost
- Outbound transportation cost

Christopher (1998) defines SCM as the management of upstream and downstream relationships with suppliers and customers to deliver superior customer value at less cost to the Supply chain as a whole.

Johnston (1995) defines SCM as the process of strategically managing the movement and storage of materials, parts and finished inventory from suppliers through the firm to customers. Kranz (1996) defines SCM as the effort involved in producing and delivering a final product from a supplier's supplier to the customer's customer.

Carter et al. (1995) define SCM as a co-ordinated approach for managing the flow of goods from suppliers to ultimate customers, and that the goal is to meet customer service objectives while minimising inventory and related costs. Simchi-Levy (2000) says that " Supply Chain Management is a set of approaches utilized to efficiently integrate suppliers, manufactures, warehouses and stores, so that merchandise is produced and distributed at the right quantities, to the right locations, and at the right time, in order to minimize

system wide costs while satisfying service level requirements"

2.3.3 The scope of Supply Chain Management

Why Supply Chain Management? Many companies are discovering that efficient Supply Chain Management is what they need to focus on in order to increase profit and market share. There are companies that have reduced their manufacturing cost as much as is practically possible and then the key issues is SCM. The company has to focus on the whole Supply chain to find new areas where cost can be reduced. Chandra and Kumar (2000) mention that many firms have moved aggressively to improve SCM to balance customers demand with the need for profitable growth. Hoover et al. (2001) mean that a difficult part of SCM is to offer better value to the customer and at the same time reduce costs.

Hoover et al. (2001) state that the objective of SCM is efficiency improvements of the product delivery process from raw material suppliers to the end customer in accordance with. The primary purpose for the efficient Supply chain is to fulfil demand at the lowest possible cost The objective of SCM is efficiency improvements of the product delivery process from raw material suppliers to the end customer according to Hoover et al. (2001). SCM can also impact the important customer value of price by significantly reducing costs. Customer value is also important for determining the type of Supply chain required to retain customers. A customers Supply chain strategy is determined by the type of products or services it offers and the value of various elements of this offering to the customer.

Pagh and Cooper (1998) presents a model and a classification for generic Supply chain strategy:

1. Full speculation: activates both manufacturing and logistics processes based on forecast before a real customer order is received.
2. Manufacturing postponement: some manufacturing operations as assembly and packing are only performed when the real customer order is received.
3. Logistics postponement: manufacturing is based on forecast and logistics is based on postponement.
4. Full postponement: both manufacturing and logistics activities are postponed until the customer order is received.

SCM has a wide scope. Simchi-Levy(2000) say that Supply Chain Management takes into consideration every facility that has an impact on cost and plays a role in making the product conform to customer requirements. The objective of

Supply Chain Management is to be efficient and cost effective across the entire system. Cost efficiency means consideration of the total systemwide costs, from transportation and distribution to inventories of raw materials, work in process and finished goods and that the cost is minimized. Supply Chain Management is not simply about minimizing transportation cost and reducing inventories, but rather on taking a system approach to find improvement areas.

The theories within the SCM area are connected to many different areas. There is a need to move from atomistic theory generation towards holistic and cross-disciplinary theory generation beyond the traditional boundaries of SCM according to Svensson (2003). SCM should be considered to come from economics, engineering, operation management, production management and logistics. This requires a holistic theory generation writes Svensson (2003).

SCM spans over all levels in a company.

- The strategic level deals with decision that have long–lasting effect on the firm. This includes decisions regarding the number, location and capacity of warehouses and manufacturing plants and flow of material through the logistics network.
- The tactical level includes decisions that are typically updated anywhere between once every quarter and once every year. These include purchasing and production decisions, inventory policies and transportation strategies including the frequency with which customers are visited.
- The operational level refers to day-to-day decisions such as scheduling, lead-time quotations, routing and truck loading.

Most research has tended to focus on specific operational and tactical aspects of the Supply chain such as client-contractor relations according to Love (2004). SCM includes activities from purchasing, order handling, production and distribution. All these areas include other activities. All these activities have to be considered when setting up a Supply chain

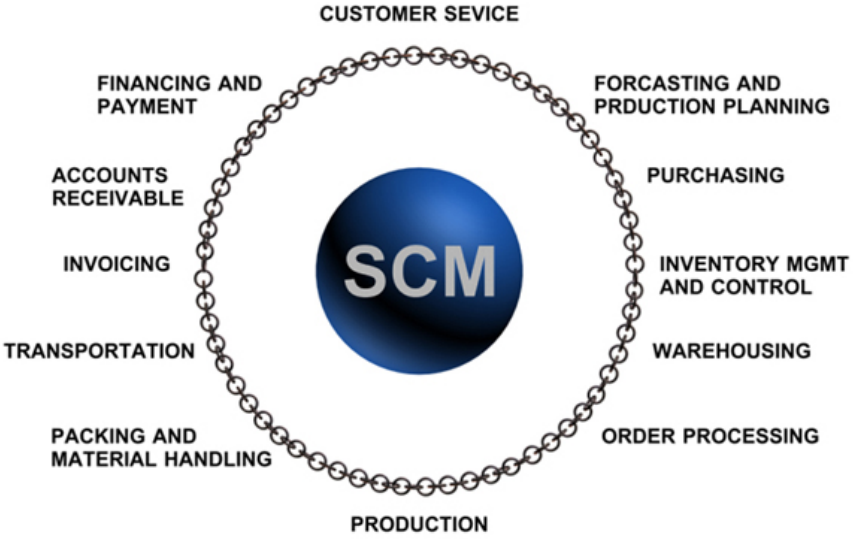

Figure 2.7 Activities within a company that are parts to consider in SCM.

It is important that the top and highest management in a company understand what Supply Chain Management is and it's importance. These people are deciding about the strategies and focus areas for the company. They have to show interest for SCM and make it visible within the own company to get the right focus for all employees within the company and get a good result.The Supply chain has in the industry for a long time been something that just should work and nothing that the management has to put focus on. The managers in the Supply chain are the critical dimension writes Van Hoek et al. (2002). A survey undertaken by Price-WaterhouseCoopers of 400 of the largest European companies found that the biggest barrier to change in European Supply chain projects was culture and not language or IT systems as one may expect according to Van Hoek et al. (2002).

Fernie (1995) carried out an international comparison of SCM in the grocery retailing industry. He found significant differences in inventory held in the Supply chain by the US and European grocery retailers, which could be explained by their SCM adoption. The European had come further in the Supply development and had been able to reduce inventory. Companies are on different levels of Supply knowledge. The levels differ between different lines of business and in different parts of the world. An example of a company that are good in SCM or particularly in Supply chain collaboration is Zara. The company is a fashion retailer and they have synchronised its global production networks with

customer requirements so that it would be able to respond quickly to the changing tastes of fashion-conscious customers according to Walker et al. (2000). Supply chain collaboration can be defined as two or more independent firms jointly working to align their Supply chain processes so as to create value to end customers and stakeholders with greater success than acting alone describes Horvath (2001). When chain members involve in collaboration, there can be a dilemma between accommodating decisions that take into account the interest of the Supply chain as a whole and preserving decisions in the interest of an individual firm. Companies benefit from focusing on identifying the constraint that prevent the chain members from achieving overall profitability. The constraint can be either physical or non-physical and internal or external.

According to Mentzer et al. (2001a) Supply Chain Management were still in the early 2000s a very popular development area among companies. The importance is especially significant in the area of high tech industry. To set up an excellent Supply chain strategy requires high knowledge in the SCM area. Profit maximization, maximum competitive advantage, select service level and minimal asset deployment is part of the strategy to set up the Supply chain defines Bowersox (1996).

Christopher (1998) means that the whole purpose of logistics strategy is to provide customers with the level and quality of service that they require and do so at less cost to the total Supply chain.

There are a lot of factors to consider when deciding how to set up a Supply chain. Mattson (2002) mention:

- Number of suppliers
- Number of sub suppliers. Module suppliers or many sub suppliers
- Distance to supplier
- Size of supplier
- Co-operation with the supplier
- Direct shipments
- Storage location local, regional or central
- 3PL (third-party logistics) distributors (provides logistics services to other companies)
- Number of distribution alternatives.

There are three types of flows to consider when starting up on improving the Supply chain according to Paulsson et al. (2003). The three types are product flow, information flow and monetary flow. Holmes (1995) has also described the three flows in SCM.

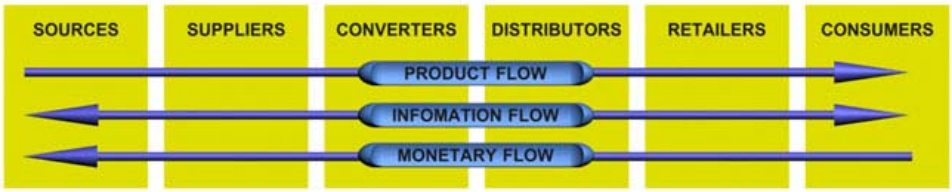

Figure 2.8 The three flows in SCM (Holmes, 1995)

It might be difficult for Supply managers in the industry to understand all theories and methods. This makes it difficult to choose the right things. A lot of strategies and methods are under the Supply Chain Management umbrella. In the production area Lean production and agile manufacturing are two strategies that are in focus. Schonberger (1996) describes agile manufacturing as being able to respond quickly to shifts in the life-cycle. Lean production is according to Paulsson et al. (2003) based on the Japanese aim to reduce unnecessary time stoppers and work assignments. In automotive industry the term just in time has been in focus. Textile and retail industry have worked with quick response. The telecom industry lead-time improvements, delivery precision and outsourcing have been key areas within SCM. Other common terms within SCM are 6 sigma, vendor managed purchasing, direct shipments, RFID, yield improvements, ITO, 3PL, VMI, E-commerce and cross docking.

ITO is Inventory Turn Over, which is the number of times the stock in a company turns around. 3PL is third part logistics and means that an external part takes care of the distribution services. VMI is Vendor Managed Inventory and means that the supplier managed the stock for the customer. E-commerce is selling and buying of products and services over electronic systems like Internet. Cross docking is a term for unloading materials from an incoming truck and loading these materials in outgoing trailers with no or little storage in between.

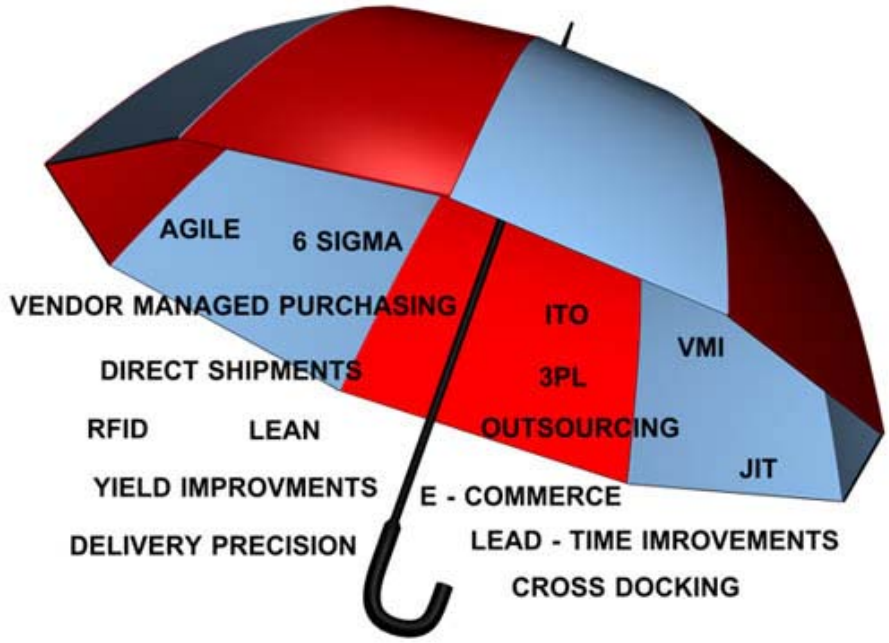

Figure 2.9 SCM umbrella

The objective of Supply Chain Management is to be efficient and cost effective across the entire system according to Simchi-Levy (2000), but what does efficient an cost effective mean?

2.4 Efficiency in the Supply chain

What are Supply chain excellence and an efficient Supply chain? According to Christopher (1998) will the future market leaders be the ones that have sought and achieved the twin peaks of excellence. They should have gained both cost leader ship and service leader ship. The purpose of Supply Chain Management is to support the company to earn as much money as possible. This means as low cost as possible and at the same time sell as much as possible. Low cost means that the Supply Chain Cost shall be as low as possible. To achieve a low Supply Chain Cost the company need to have best possible internal and external performance. Internal performance can be for example yield, production lead-time. External performance is effecting the customers. Examples of parameters for external performance are delivery precision , lead-time, customer service and price. To achieve market leadership in the world of networks competitors have to focus on network management as well as upon internal processes according to

Christopher (1998). To remain competitive in the new global environment companies will have to seek ways to lower cost and service enhanced in accordance with Christopher (1998). This means that Supply chain efficiency and effectiveness will become even more critical.

Effectiveness is defined by Mentzer (1991) as the extent to which goals are accomplished. Efficiency is the measure of how well the resources expended are utilized according to (Beamon 1999). Efficiency in these thesis is used as describing how well a company optimize the Supply chain to maximize profitability. The overall objective of any logistics system is to maximize profitability writes Dornier (1998). When having an excellent Supply chain the company can provide products to its customers that are of high quality (De Meyer et al, 1989), at low cost (Goonatilake, 1990), within short lead-times (Haug, 1985) and give the requested customer support, (Hoover et al., 2001).

Collin (2003) says that it can be concluded that the success of Supply chains are composed of three different dimensions:

1. customer service
2. capital employed
3. total cost

Customer service and cost are opposite poles, which have to be balanced to get the best result for a company. Cutting cost in the Supply chain can result in for example a longer lead-time due to that the company cannot have buffer stock. Improvements of lead-time can be done by putting up a buffer stock, but this cost money both in tied-up capital and risk of scrapping. It is very important for a company to find the balance between Supply Chain Cost and performance towards the customers. There is no general balance that can be used for all companies and all products. Each company have to find their own balance to maximize the profit for the company. Some companies have different balance situations for their product portfolio. Some customers require very high customer service and are willing to pay for that. For other customers is the cost the most important factor and these companies tolerate reduced customer service.

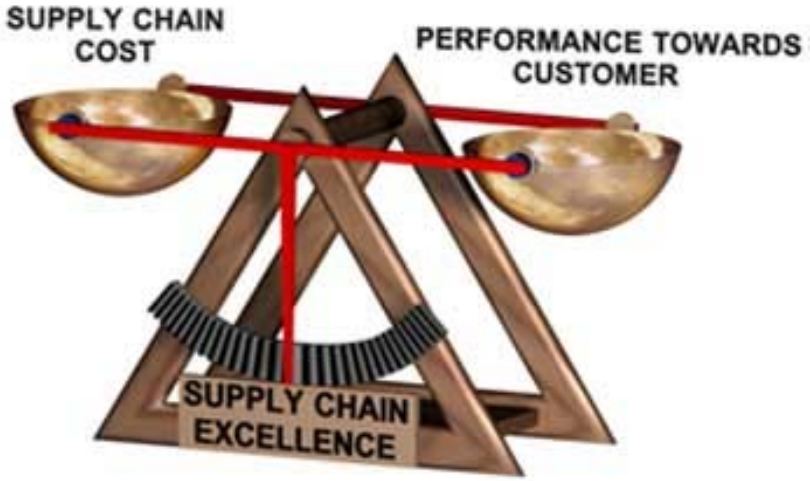

Figure 2.10 Supply chain excellence – the balance between Supply Chain Cost and performance.

Christopher (1998) means that in examinations of the efficiency of Supply chains it is often found that many of the activities that take place add more cost than value. The consideration of both cost and level of customer service is essential when setting up a Supply strategy. Bowersox (1996) says that it is necessary to evaluate the relationship between customer services levels and associated cost when finalizing a logistical strategy. The total cost concept is one of the central fundaments of today's SCM. If the consumer is excluded any generated theory of SCM will not reflect the real world since the consumer is the crucial key for the outcome of successful SCM.

What is then customer service in the Supply chain perspective? Customer service is all activities and performance that adds value for the customer. Low price, short lead-time and accurate delivery dates are three important areas that are important for a customer. According to Bowersox et al. (2000) there are at least three perspectives to create value for customers through Supply chains:

- Economic value
- Market value
- Relevancy value

There are a lot of different measurements that can be used to evaluate the efficiency of a Supply chain. This will be discussed more in detail in the next chapter which is about Performance measurements. Collin (2003) describes that

one of the most used performance indicators to analyse the effectiveness of a Supply chain is the inventory rotation that indicates how fast the material is moving further in the Supply chain.

According to Collin (2003) internal states and processes of organisations need to be contingent upon environmental characteristics for a Supply chain to be efficient. There is not a single Supply chain that suits all customers. Customer's environmental requirements should determine the appropriate structure for a Supply chain. It is not enough for a company to have competitive products and the right Supply chain for the average customer. Hoover et al (2001) means that the Supply chain has to be right for the individual customer as well

To reduce cost and improve service levels, efficient Supply chain strategies must take in account the interactions at the various levels in the Supply chain according to Simchi –Levi (2000). The Supply chain can also be referred to as the logistics network. The Supply chain consists of suppliers, manufacturing centres, warehouses, distribution centres and retail outlets, as well as raw materials, work-in-process inventory and finished products that flow between the facilities.

In a Supply chain with external actors is it important to think about that efficiency improvements have to consider the whole Supply chain. There is no good solution when the own company makes profit at the expense of another part for example a supplier. This is short-term profit and will for sure result in an increase of price in the long term. An individual, when optimising its own success has to consider both how it best utilizes its internal resources and how it best benefits of collaborative efforts in the Supply chain.

There are two important parts for efficiency and that is Supply Chain Cost and performance measurements. Performance measurements will be described in chapter 3 and Supply Chain Cost in chapter 4.

3. PERFORMANCE MEASUREMENTS

Performance measurements are becoming more and more important when SCM is coming into focus. Neely (1999) presents 7 drivers for the increasing interest in performance measurements.

1. The changing nature of work. The cost of direct labour related to cost of material has dropped rapidly since the 1950s.
2. Increased competition
3. Specific improvements initiatives ex JIT, TQM, BQR (Business process reengineering)
4. National and international quality awards
5. Changing organizational roles changing from control to empowering employees by management by objectives.
6. Changing external demands. Firms in the public sector must present information about their performance.
7. The power of information technology

What types of performance measurements are used today, are these measurements supporting system thinking and can we measure Supply chain excellence are questions that will be discussed in this chapter.

There are a lot of different measurements for a company to choose from, see section 3.1. Therefore it can be difficult to set up the right Performance measurements in a company. Some measurements are coming into more focus than others. Consultants companies working with Supply chain related questions are influencing companies with the terms they have chosen to work with. It is difficult to measure the performance in Supply chains according to Schmitz and Platts (2003). According to Harrison and New (2002) half of the companies they contacted in their research had limited possibilities to do performance measurements in their Supply chain. 19 percent couldn't measure at all. Chibba (2007) writes that large companies often measure the effectiveness by key performance indicators and that these are too broad to fully capture Supply chain effectiveness.

3.1 Types of performance measurements

Performance measurements based on financial accounting have for a long time been the primary tool according to Adams et al. (1995). The changes in the business environment from controlling of cost to customer value have changed the focus in performance management. The scope is larger writes Adams et al. (1995) and includes measurements in the customer service area like delivery

precision and lead-time, in the internal efficiency area like ITO and yield and in the financial area like distribution cost and scrap cost. The main purpose of the traditional performance measure systems was to control costs and cash flows in the organization Vitale and Mavrinac (1995) describe.

In the end of the nineties two types of performance measurements dominate in the literature according to Beamon (1999). These were cost and customer responsiveness. Customer responsiveness usually includes lead-time, stocking probability and fill rate. Cost is the sum of inventory and operating cost. Fill rate is a measure for in which grade a stock is filled. Keebler (1999) had the same thoughts and wrote that there are three principal categories of measurements, namely time, quality and cost. Both time and quality can be included in the customer responsiveness scope.

To summarise the development for SCM you can see that the way companies measure the quality of their product and services has evolved from internal quality assurance to external customer satisfaction and from there to customer value.

The types of performance measurements are discussed with different focus. The focus can be on:

- quantitative and qualitative measurements
- What level "SCM" should be measured
- financial and non financial measurements
- what measurements should be included.
- Internal and external measurements

Beamon (1998) categorizes performance measures in existing literature into two groups qualitative and quantitative. Qualitative measurements can't be quantified. Some examples of qualitative measurements are customer satisfaction and HCI (Human capital index). Customer satisfaction can be measured by asking the customers to rate the company from a scale 1-5. HCI measures the empowerment and other things related to the persons working on the company. Some examples of quantitative measurements are delivery precision and Inventory Turn Over (ITO). Delivery precision measure how many orders that are delivered in time. In time means the date that has been stated on the order-acknowledgement. ITO measures how many times the inventory turns around per year.

Gunasekaran et al. (2001) discuss on what level "SCM" should be measured and mean that the measurements shall include all three of strategic, tactical and operational levels. The highest management in a company can be interested in

measuring “SCM” on a strategic level and consider the whole company. Management on level two or three can be interested in “SCM” measurements on a tactical level meaning that they measure on a part of the company. Measurements of “SCM” on operational level will be interesting for people working on operational level. ”SCM” measurements are a good tool for managing the daily work. Gunasekaran et al. (2001) say that the Supply chain performances should be measured beyond the organizational boundaries rather than focusing locally.

Holmberg (2000) and Van Hoek (1998) say that there is a lack of balanced approach to integrate financial and non-financial measures. Examples of financial measures are Supply Chain Cost and manufacturing cost per produced item. Supply Chain Cost is the total cost to run the whole Supply chain. Examples of non-financial measures are lead-time and yield. Lead-time means the time starting when a company receives an order and ends when the material on the order has been delivered to the customer. Yield is the amounts of items passing through the production process without any faults divided by the total amount of produced items. Atkinson et al. (1997) writes that in a time when customer value is an important driver for success companies can’t only use conventional financial information in their performance measurements.

According to Atkinson et al. (1997) performance measurements are focusing on cost often in conflict with strategic goals and objectives. Shapiro (2001) says that a company should also concern about non-monetary objectives such as customer service, quality and time. Ghalayini and Noble (1996) say that areas like lead time, delivery precision and customer satisfaction most often are difficult to measure in monetary terms.

Another focus in the “SCM” performance measurement is what measurements should be included. Beamon (1999) identifies three types of measures resources, output and flexibility. Resources mean how efficient the personal resources in a company are used and how effective other resources like for example production equipment is. Output measures are for example number of products shipped and invoiced amount of money. The extend of differentiated lead-times and differential customer service levels can for example be flexibility measures. According to Keebler (1999) there are three principal categories of measurements, namely time, quality and cost. There are based on these three categories a lot of different measurements. Bowersox (1996) describes the perfect order as a part of optimal operational performance. Quality in a Supply chain is to do everything right the first time. The order should be complete in terms of service from order receipt to delivery. Bowersox (1996) sees the concept of a perfect order is the logical extension of quality.

Another focus is on internal and external performance. Internal performance measures how a company perform from an internal perspective. Internal measures are important for detailed organisational monitoring. External performance measures how the company perform against the external customers. Bowersox and Closs (1996) say that External performance is important to understand to be able to maintain the focus on customer perspective. One way to perform the external measurements is to send surveys to customers. Examples of categories in Internal performance measurements are according to Bowersox and Closs (1996):

1. cost
2. customer service
3. productivity shipped/employee
4. asset management
5. ito
6. quality claims

The term customer service include many factors. Service as a competitive factor includes the availability of the product, delivery speed and delivery reliability according to Dornier (1998).

Simchi-Levy (2000) describes that improvements in internal performance normally lead to cutting of cost, but improvements in external performance normally lead to increased cost. Simchi-Levy (2000) is discussing conflicting objectives. Every system has conflicting objectives, which have to be balanced to achieve a good result. It can be lot size versus inventory, inventory versus transportation cost and production variety versus inventory. The most comprehensive trade off is between customer service and Supply Chain Cost. Improving customer service often means that the total Supply Chain Cost increase. There are optimisation models that can assist management in evaluating objectives. The Efficient Frontier is according to Christopher (1998) the curve for how the total cost increase with higher service level. Higher service level means more service for the customer. The service can for example be short order-acknowledge time and high delivery precision.

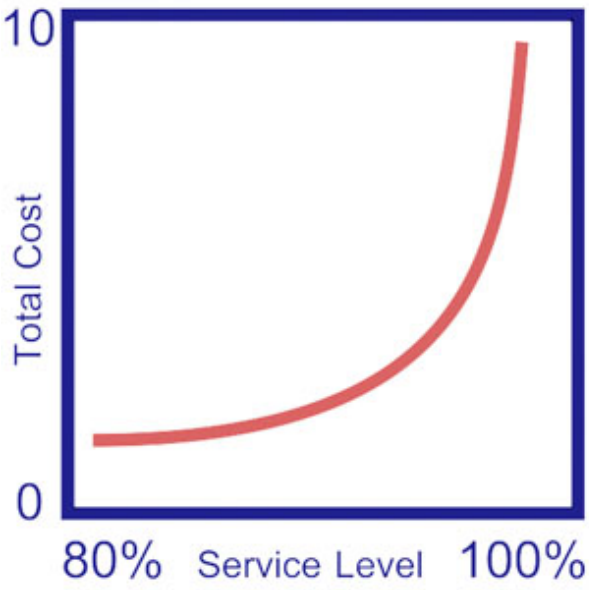

Figure 3.1 The Efficient Frontier Christopher (1998)

Beamon (1999) recommends a mix of measures; the measurements should cover the whole Supply chain. Vitale and Mavrinac (1995) say that the measurements systems focus on short term results. The ideal measurement system covers both short term and long term results. The risk with measurements covering only short term results is that the management of the Supply chain might not lead to the best result in the long term. An example is a company that focus on minimizing stock levels and gets a very result in the short term. The cost for tied up capital in stock is low and the company can still deliver material to their customers. In the long term the company runs into problems with low delivery precision and long lead-time.

3.2 Methods for performance measurements

Balanced scorecard, SCOR model and benchmarking are three methods that are used for performance measurements within the industry. These methods are also frequently discussed in the academical world.

3.2.1 Balanced scorecard

The Balanced Scorecard is a framework for measurements of the performance in an organisation. The scorecard includes both financial and non-financial data. There is no general definition of what measurements that shall be included in the scorecard. The measurement criteria differ between companies and also between departments in the same company. Kaplan and Norton (1996) have identified four general categories:

- Financial measures
- Customer-related measures
- Internal performance
- Learning

Financial measures focus on economic value added and return on investment. Customer-related measures are customer satisfaction and market share. Internal performance includes quality, response time and cost measures. The learning category includes employment aspects such as skill development, retention and information technology. Schary and Skøjtt-Larsen (2001) describes a similar model.

Figure 3.2 The Balanced Scorecard Model. Schary and Skøjtt-Larsen (2001)

The Supply chain mission shall be linked to the Balanced scorecard framework. Management decides what shall be included in the scorecard. The scorecard can for example be divided into areas like financial, customer, competitive position, internal efficiency and employee.

3.2.2 SCOR model

The Supply chain Council has developed the SCOR model. The model is a reference model and SCOR stands for Supply Chain Operations Reference. The purpose for the model is to:

1. provide a standard language for SCM that can be used cross-industry
2. facilitate external benchmarking
3. establish a basis for analyse of Supply chains
4. compare the current Supply chain with the target for the future

The aim of SCOR is to provide a standard way to measure Supply chain performance and to use common metrics to benchmark against other organisations according to Christopher (1998).

The SCOR model is based on four management processes:

- Plan: balances Supply and demand
- Source: procurement of products and services
- Make: transforming of products and services into finished goods
- Deliver: delivery of products and services.

The SCOR model has three levels:

- Top level: defines the scope and content for the Supply chain.
- Configuration level: designs the Supply chain
- Process element level: gives detailed information on each process.

A process is composed of process elements and the elements are composed of tasks. Tasks are a set of activities. The activities are standardized to make comparison between Supply chains possible. The SCOR model has 12 performance metrics. The most effective way to develop a close customer relationship is by understanding customer behaviours and designing and sustaining a Supply chain tailored to deliver value to each customer segment.

The 12 metrics are according to Huan et al. (2004):

1. Delivery performance
2. Fill rate
3. Order fulfilment lead time
4. Perfect order fulfilment
5. Supply chain responsiveness
6. Production flexibility

7. Total logistic management cost
8. Value-added employee productivity
9. Warranty cost
10. Cash to cash cycle time
11. Inventory days of Supply
12. Asset turns

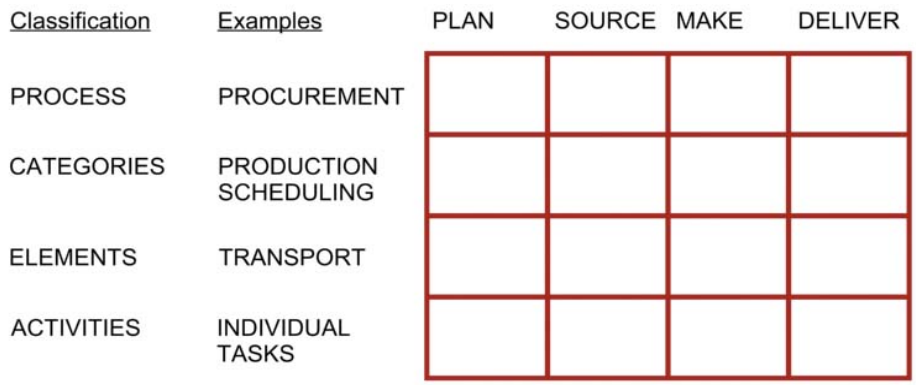

Figure 3.3 The SCOR model. Schary and Skøjtt-Larsen (2001)

3.2.3 Benchmarking

A formal definition of benchmarking is that it consists of a systematic procedure for identifying the best practice and modifying actual knowledge to achieve superior performance according to Camp (1989). Benchmarking is a process for comparison against best practise. It is important with common metrics that can be used when comparing companies. Benchmarking has five basic purposes described by Splendolini (1992):

- Strategy: planning for short and long term
- Forecasting: predict trends
- New ideas: stimulate new thoughts
- Process comparisons
- Setting objectives and targets: base them on best practice

Benchmarking can be used both internally within the own company and externally. The internal benchmarking can be used to compare different departments, but also the check how one department change over time. External benchmarking can be used to compare the own company with competitors or with companies that have high performance.

3.3 System thinking in performance measurements

Are the performance measurements considering the whole Supply chain and do them support system thinking? Beamon (1999) discuss the weakness of single Supply chain measurements. Beamon concludes that the most common weakness of a measurement is that it not covering the whole scope. It must measure all related aspects of the Supply chain and not be sub optimised. If a company decides to use cost as the only measurement of its Supply chain performance this will probably result in a Supply chain operating under minimum cost, but with a high risk of poor customer response, poor tome performance or lack of flexibility. Many researches are sceptical about the possibility to create a well-functioning Supply chain measurement system. The reasons for this are that it is difficult to measure Supply chain performance and some Supply chain performance are hard to quantify says Lambert (1998).

3.4 Measurements of Supply chain excellence

Supply chain excellence requires that the actors in the Supply chain know how to do performance measurements according to Keebler (1999). What is the reason for performance measurements? There are several reasons and they vary between different companies. Parker (2000) has identified the following reasons for measure performance within an organisation:

- Identify success
- Identify whether the organisation understand its processes
- Identify whether the company are meeting customer requirements
- Identify bottlenecks and where improvements are necessary
- Ensure decisions are based on facts
- Show if planned improvements actually happened

Geanuracos and Meiklejohn (1993) said that most business people are coloured by the manufacturing environment rather than service focused business. Richard Schonberger does a performance measurement based on ITO. The companies are classified in different groups depending on their ITO improvements over the years. Some companies are doing well despite unimpressive ITO trends according to Schonberger (1996). An example is Coca Cola. This measurement gives information about the success in Inventory Turnover and with that decreasing tied up capital. An overall success for the whole Supply chain doesn't automatically follow this. A company can have a very high ITO and a good trend in improvements, but can still not be classified as a company that achieve Supply chain excellence due to for example very high transport cost and long lead-time. Having a comprehensive view is the essential thing in SCM and

in the aiming for Supply chain excellence.

Supply chain excellence is in this thesis a balance between Supply Chain Cost and customer service. Parasuraman et al. (1991) write that customer service expectations have two levels desired and adequate. The desired level is the service the customer hopes to receive. The adequate service level is what the customer finds acceptable. This is important to have in mind when setting up the Supply chain towards a customer. The purpose of SCM is to set up a Supply chain that meets the service level expected by the customer at as low Supply Chain Cost as possible. The desired level can be totally out in the blue and can lead to a very high Supply Chain Cost that will have an effect on the customer in the end. Therefore it is very important to understand the customer expectations and more focus on the adequate level. Paulsson et al. (2003) mean that some customers have higher expectations than others concerning for example a shorter lead-time. This expectations can in same cases be met depending on the situation and if it is profitable from a business perspective.

Dornier (1998) defines the performance criteria in two categories.

- Order winning criteria
- Qualifying criteria

In qualifying situations the supplier often is willing to have smaller margins meaning that the company can offer customer support that pass the line for what is profitable. The supplier requires higher margins in order wining situations. In this situation the supplier already has qualified as a supplier and in the future business they require higher margins.

The measurement system shall be designed to focus on strategical decisions and inspire action according to Vitale and Mavrinac (1995). The performance measurements shall support the linking of long-term strategy with short term actions. Kaplan and Norton (1996) have designed the Balanced scorecard due to the weakness in other performance measurements. The Balanced scorecard is frequently used in the industry, but it could be difficult to get a good Balanced Scorecard covering the overall performance in the company and that includes an efficiency measurement. There are a lot of criteria to think about when setting up the performance measurements.

4. SUPPLY CHAIN COST

The difference between Logistics cost and Supply Chain Cost, what is included in Supply Chain Cost and difficulties measuring Supply Chain Cost are questions that will be discussed in this chapter. According to Schary and Skøjtt-Larsen (2001) revenue and cost describe the Supply chain. In their opinion cost data gives more information regarding the Supply chain than any other source.

4.1 Logistics cost versus Supply Chain Cost

Logistics cost and Supply Chain Cost (SCC) are two terms that are used both in the industry and the academic world. SCC cost has a wider definition than Logistics cost in accordance with the wider scope for Supply Chain Management compared to Logistics Management. Logistics cost is normally referred to as cost components related to distribution cost and cost for warehouse as reflected by the definition of logistics according to Lambert et al (1998). SCC is the total cost in the Supply chain. Bowersox and Closs (1996) define SCC as cost components related to:

- Order handling
- Purchasing
- Stock handling
- Systems needed to handle the Supply like for example the order system.
- Manufacturing

Ayers (2001) writes that the SCC is sometimes considered being the same as Logistics Cost. Due to this, some misunderstandings regarding these two terms may exist.

4.2 Supply Chain Cost

In this thesis, Supply Chain Cost is defined as all cost in a Supply chain. Analysis of SCC can be performed in different ways. Different kind of grouping of cost can be found in the literature. Bowersox and Closs (1996), Chen (1997), Sachan et al. (2005) and Byrne and Heavey (2006) have done similar definitions. These definitions use for example different terms for the same thing like Production cost in the definition of Chen (1997) and Manufacturing cost in the Bowersox and Closs (1996) definition. Su et al. (2005) make a general definition without defining the cost types into different groups.

Chen (1997) says that SCC can be placed in the five categories:

- Production cost
- Transportation cost
- Warehousing cost
- Inventory carrying cost
- Internal material handling cost.

Sachan et al. (2005) have studied the total Supply Chain Cost in the Indian grain chain. They define the total Supply Chain Cost as the sum of farmer's price, total additional cost, total mark-up and total wastage.

Farmer's price is the cost of growing and processing the grain and the margin for the farmer.

Additional cost includes:

- Inventory holding cost
- Materials holding cost
- Transportation cost
- Order processing cost
- Packaging cost

Total mark-up cost is the amount added to the cost price to get the selling price. Each participant in the chain has his or her own mark-up percentage. Total wastage may be due to one or more of the following three reasons:

- obsolete losses
- transit losses
- pilfering losses

Byrne and Heavey (2006) break down the SCC into five different categories:

1. Transportation cost
2. Order processing cost
3. Production setup cost
4. Inventory cost
5. Backorder cost.

Transportation cost is the shipment cost between finished stock in Company *A* and the stocking location of the distributor. Order processing cost is the cost for

processing the orders. Production set-up cost is the cost associated with an order being set-up in the processing areas. Inventory cost is the cost for holding stock for one period. The period can for example be one month or one year. Backorder is the cost for backorders for one period.

Su et al. (2005) define the total Supply Chain Cost as the amortized fixed cost and the periodic operating cost.

4.3 Measurement of Supply Chain Cost

Solvang (2001) says that cost is one of the most important performances of a Supply chain. When measuring SCC it is important to know what you would like to measure. Quinn (1998) and Hoole (2005) describe measures of SCC that have been performed. Quinn (1998) describes a study the research and consulting firm of Pittiglio Rabin Todd and McGrath has performed. The firm found that companies considered to be best practice companies in moving product to market had a 45-percent Supply-chain cost advantage compared to the average competitor. The order-cycle time was half and their inventory days were 50 percent less compared to their competitors. Further, their delivery precision was 17 percent better.

According to Hoole (2005), the total Supply Chain Cost can vary by 5 percent to 6 percent of annual revenues between companies in the same industry sector. This is based on a benchmarking of more than 500 Supply chains. Hoole found in his research that companies that have a mature Supply chain are reducing cost faster than less mature Supply chains.

Researchers have focused on SCC savings, conflicts between different units and new customers influence on SCC. Byrne and Heavey (2006) write that improved information sharing and forecasting techniques can lead to total Supply chain cost savings up to 9,7 %. Christopher and Gattorna (2005) discuss SCC savings as a result of creative pricing strategies combined with efficient Supply chain management. The SCC savings provide opportunities for increased profits.

Hosang and Bongju (2005) discuss the conflict between different units in a Supply chain. They say that each unit tries to minimize its own cost and is not considering the whole Supply chain. An improvement in production that gives a lower production price is positive for the production department or company. The installation cost might increase more than the decrease in production and the total effect for the Supply Chain is negative

Kumar and Kropp (2006) found in their study that new customers and new

products could drive up the SCC. Product cost calculating is an important part to SCC. Alnestig and Segerstedt (1997) say product calculation is a comparison of revenue and costs. Product calculation is used to set a manufacturing cost, to estimate the value of items in inventory, to check if a product is profitable, to support the decisions of sales prices, and a part in analysis of customer profitability.

SCC is concentrating on the costs connected to the Supply chain as described above. However this cost can in practice be estimated in different ways and with different accuracy. Rough mark-ups can be used to cover for example transportation costs, order-processing costs etc. Actual costs can be reported directly to a customer order or a customer project. The latter is naturally to prefer if an accurate SCC is preferred and supports for correct decisions are wished. But even for the most accurate SCC a mixture of standard costs, from the companies' budgets and cost accounting systems, and actual invoiced costs is necessary. Some cost drivers must distribute indirect costs. Therefore measuring an accurate Supply Chain Cost can be difficult. One reason for the difficulties in measuring SCC is that the set up of the accounting systems in a company are not adjusted to SCC measurements. According to Christopher (1998), conventional accounting systems group costs into broad aggregated categories which do not allow more detailed analysis which is necessary to identify the true costs of servicing customers. Christopher (1998) describes two principles for logistics costing that also are applicable for SCC. The two principles are:

1. The system should reflect the flow of materials. It should be capable of identifying the costs that result from providing customer service in the market place.

2. The system should be capable of enabling separate cost and revenue analysis to be made by customer type, market segment and distribution channel.

Christopher (1998) also summarizes the dissatisfaction with conventional cost accounting related to logistics management as follows:

- There is a general ignorance of the true cost of servicing different customers, channels or market segments.
- Costs are captured at a too high level.
- Full cost allocation still reigns supreme.
- Conventional accounting systems are functional rather than output oriented
- Companies understand product costs, but not customer costs.

He suggests that activity based costing (ABC) should be used instead of traditional methods to support the logistics management better.

5. SUMMARY OF LITERATURE REVIEW

This chapter concludes the literature review. It also includes the motivation for conducted research.

5.1 Conclusions of the Literature review

The research in this thesis focuses on measurement of how efficient a Supply chain is. According to section 2.3.3 most research has tended to focus on specific operational and tactical aspects of the Supply chain such as client-contractor relations and there is a need to move from atomistic theory generation towards holistic and cross-disciplinary theory generation. The purpose of Supply Chain Management is to manage the Supply chain as efficiently as possible. This means that the Supply chain shall maximize the revenue for the company. A difficult part of SCM is to offer better value to the customer and at the same time reduce cost according to section 2.3.3. According to section 2.4 it is important to combine cost and customer service. The future market leaders are the ones that have sought and achieved the twin peaks of excellence. They should have gained both cost leadership and service leadership

According to section 3 it is difficult to measure performance in a Supply chain. Furthermore half of the companies contacted in a research performed by Harrison and New (2002) had limited possibilities to perform performance measurements in their Supply chain. 19 percent could not measure at all. Furthermore there are a lot of performance measurements to choose from. In the end of the nineties two types of performance measurements dominated in the literature according to section 3.1. These were cost and customer responsiveness. As discussed in section 4.2 different kind of grouping of Supply Chain Cost can be found in the literature.

To be able to measure the efficiency in a Supply chain four topics have to be investigated:

- Determination of what measurements should be included in the performance measurements to provide a good measurement of how efficient a Supply chain is.

- Determination of how Supply Chain Cost and performance towards a customer should be combined in a measurement to give a good picture of the efficiency of a Supply chain.

- Determination of what should be included in the measurement of Supply chain cost.

- Determination of the possibility to measure performance for a company.

The research in this thesis will cover these four parts.

My literature review includes four focus areas, see figure 5.1. The first area was efficiency. To understand efficiency measurements I found it important to include Supply Chain Management in the literature review. SCM is the general picture you have to understand to be able to define efficiency measurements. Performance measurements and cost measurements are two important areas that were included because they are essential to be able to manage the Supply chain in a good way and measure efficiency. According to Sink and Tuttle (1989) you can't manage if you can't measure. Table 5.1, 5.2, 5.3 and 5.4 provides an overview of the main areas in my literature review.

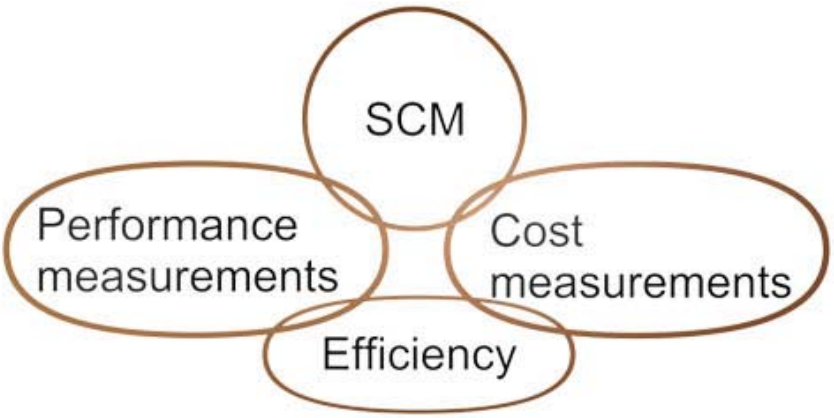

Figure 5.1 The four parts of the literature review

Supply Chain Management	Supply Chain Management versus Logistics Management	SCM definitions	SCM scope
	LaLonde and Maters (1994) Christopher (1998) Mattson (2002)	Carter et al. (1995) Johnston (1995) Krantz (1996) Christopher (1998) Simchi-Levy (2000)	Fernie (1995) Holmes (1995) Bowersox (1996) Schonberger (1996) Christopher (1998) Pagh and Cooper (1998) Chandra and Kumar (2000) Simch-Levy (2000) Walker et al. (2000) Hoover et al. (2001) Horvath (2001) Mentzer et al. (2001a) Mattson (2002) Van Hoek et al. (2002) Paulsson et al. (2003) Svensson (2003)

Table 5.1 The literature review summary Supply Chain Management

Supply Chain Cost	Logistics cost versus Supply Chain Cost	Supply Chain Cost definitions	Measurement of Supply Chain Cost
	Bowersox and Closs (1996) Lambert et al (1998) Ayers (2001)	Bowersox and Closs (1996) Chen (1997) Byrne and Heavey (2006) Sachan et al. (2005) Su et al. (2005)	Alnestig and Segerstedt (1997) Christopher (1998) Quinn (1998) Solvang (2001) Christopher and Gattorna (2005) Hoole (2005) Hosang and Bongju (2005) Byrne and Heavey (2006) Kumar and Kropp (2006)

Table 5.2 The literature review summary Supply Chain Cost

Performance measurements	Types of performance measurements	Methods for performance measurements	Measurement of Supply chain excellence
	Adams et al. (1995)	Camp (1989)	Parasuraman et al. (1991)
	Vitale and Mavrinac (1995)	Parasuraman et al. (1991)	Geanuracos and Meiklejohn (1993)
	Bowersox (1996)	Splendolini (1992)	Vitale and Mavrinac (1995)
	Bowersox and Closs (1996)	Geanuracos and Meiklejohn (1993)	Kaplan and Norton (1996)
	Ghalayini and Noble (1996)	Vitale and Mavrinac (1995)	Schonberger (1996)
	Atkinson et al. (1997)	Kaplan and Norton (1996)	Dornier (1998)
	Beamon (1998)	Schonberger (1996)	Keebler (1999)
	Christopher (1998)	Christopher (1998)	Parker (2000)
	Dornier (1998)	Dornier (1998)	Paulsson et al. (2003)
	Van Hoek (1998)	Lampert (1998)	
	Beamon (1999)	Beamon (1999)	
	Keebler (1999)	Keebler (1999)	
	Holmberg (2000)	Parker (2000)	
	Simch-Levy (2000)	Schary and Skøjtt-Larsen (2001)	
	Gunasekaran et al. (2001)	Paulsson et al. (2003)	
	Shapiro (2001)	Huan et al. (2004)	

Table 5.3 The literature review summary Performance measurements

Efficiency	Discussions in	Main points
	De Meyer et al. (1989)	Excellent Supply chain when a company provides products with high quality
	Goonatilake (1990)	Excellent Supply chain when a company provides products at low cost
	Mentzer (1991)	Effectiveness is defined as the extent to which goala are accomplished.
	Haug (1995)	Excellent Supply chain when a company provides products with short lead-time.
	Bowersox (1996)	Relationship between customer services level and cost is important.
	Christopher (1998)	The future market leaders will be the ones that have achieved cost and service ledership
	Dornier (1998)	The overall objective of any logistics system is to maximize profitability
	Beamon (1999)	Efficiency is the measure of how well the resources are utilized
	Bowersox et al. (2000)	Three perspectives to create value for customers are economic, market and relevancy value
	Simch-Levy (2000)	Efficient Supply chain strategies must take in account the interactions at the various levels
	Hoover et al. (2001)	Excellent Supply chain when a company provides requested customer support
	Collin (2003)	Success of Supply chains are composed of Customer service, Capital employed, Total cost

Table 5.4 The literature review summary Efficiency

5.2 Motivation for conducted research

Based on the literature review the research in this thesis can be motivated as follows.

Empirical study:

Section 3 states that it is difficult to measure performance in the Supply chain. The measurement of SCC is especially difficult according to section 4.3 because a normal set up of the accounting system in a company are not adjusted to SCC measurements. Various aspects on performance measurements, cost measurements and efficiency measurements in the Supply chain were found essential in my literature review, see chapter 2, 3 and 4. To understand how these theories are used within the industry my research progressed with an empirical study. The aim with the study is to get a picture of how companies are working with performance measurements, cost measurements and efficiency measurements. I couldn't find a clear efficiency measurement in the literature review. Therefore I decided to investigate how companies define efficiency in the Supply chain and if there is measurements that measure efficiency. Chapter 6 presents an empirical study performed where 30 companies in Sweden are interviewed.

Index for measurement of the efficiency in a Supply chain:

As discussed in section 2.3.3 there are a lot of strategies and methods to choose from when setting up a Supply chain and it is difficult to know if the best strategies and methods are chosen. Section 3.3 points out that the weakness of measurement in a Supply chain is that measurements do not cover the whole scope of SCM and that some performance measurements are hard to quantify. The literature review presented in chapter 2.3 and 4 don't identify a method for measuring efficiency in the terms of a combination of customer service and cost. Three common methods for measuring performance in the Supply chain are Balanced Scorecard, SCOR model and benchmarking, see section 3.2. None of these methods have an explicit measurement for efficiency in the Supply chain. The SCOR model includes different kind of measurements, but no comprehensive measurement for efficiency in a Supply chain. The types of measurements included in the Scorecard differ between different companies, but also within a company. The Scorecard includes measurements that together can give a view of the efficiency, but there is no single measurement that measures efficiency. Benchmarking is a way to comparing best practice. Delivery precision and ITO are two examples of measurements that can be used for

benchmarking, but I haven't been able to identify an efficiency measurement that has been used for benchmarking.

The literature review identifies a theoretical gap regarding efficiency measurements. No model or index for efficiency was explicitly found in the literature review. I therefore decided and try to formulate an index for efficiency measurements combining several measurements. The proposed index in chapter 7 is based on the combination of SCC and performance towards the customer. The result from the empirical study regarding if there are efficiency measurements or methods for measuring efficiency used in the industry is a base for the index formulation.

Examination of the index in a company:

As mentioned in section 3 it is difficult to measure efficiency in the Supply chain. SCC can also be difficult to measure as discussed in chapter 4.3 due to that the accounting systems in a company are not adjusted to support the SCC measurement. The suggested index from section 7 is tested on a company selling products and services all over the world and with companies in countries all over the words. This test of the index presented in chapter 8 is performed to evaluate if the index can be used in industry. The test evaluates if the measurements included in the index can be measured on different levels in the company and if the accounting system supports the measurements. The different levels of the company are for example company level, product level and department level.

6. EMPIRICAL STUDY

This chapter includes an empirical study with the aim to investigate how companies in ten different sectors are performing performance measurements in the Supply chain and how they possibly define and measure efficiency in their Supply chain. Companies are continuously working with improvements in the Supply chain and are aiming for Supply chain excellence and World-class Supply, but what does this mean? Is Supply chain excellence to have short lead-time and high delivery precision or is it to achieve a low cost for the Supply chain? This differs a lot between different companies and also at different times. The study is set-up to investigate how companies with business in Sweden define an efficient Supply chain and are working with Supply Chain Management, Performance measurements and Supply Chain Cost.

6.1 Method

The study is based on answers from leading Supply Chain Management professionals within Swedish industry. 30 companies were contacted and interviewed by mail, phone or personal visit. The criteria for selection of these companies where that they should represent different sectors. Ten sectors were selected and three companies representing each sector were contacted. The sectors are:

1. Manufacturing industry
2. Pharmaceutical/ medical technology industry
3. Telecommunication industry
4. Commodity industry
5. Consumer products industry
6. Contract manufacturer
7. Materials
8. Automobile industry
9. Paper industry
10. Construction industry

All responding companies operate on the global market. The majority of goods are exported to other markets outside Sweden. Many of the suppliers are located in other countries.

The reason for interviewing people from different sectors was to observe if the answers differed from different branches or sectors. Inside a branch different companies may naturally have different opinions and treatment about the Supply chain, therefore three companies from the same sector were interviewed. Only

one Supply Chain Management professional, their names and positions are listed in the section of references, in this many relatively large companies were interviewed. I may have found another professional, top or middle management, also working with SCM in another part of the company answering to my questions a bit different. However, I argue that the strategy about Supply chain is one of the key strategy parts in a company and the information and the general thinking about it is mostly well distributed both in the formal and informal organisation even if it is not formally documented. I also prioritised to interview people from several companies than many from one company.

6.1.1 Data collection

The empirical study was initiated in April 2006. The interviews with Supply Chain Management professionals within the 30 companies were conducted between May 2006 and December 2007. The study was set up to get answers on the following questions:

- How is an efficient Supply chain defined?
- Is Supply Chain Cost measured?
- Which performance measurements are the most common?
- Correlation between Supply's position in the company and definition of efficient Supply chain
- Position of Supply in different sectors
- Measurement level

Five questions were set up to cover the mentioned focus areas above. The questions are:

1. Is Supply an own part of the organization?
2. What is an efficient Supply chain in your company?
3. Is the company measuring Supply Chain Cost, and how?
4. How is performance measured in the Supply chain?
5. On which organisation levels are the measurements performed?

General Information about the companies were collected to get an overall picture of the participating companies with reference to the sector they work in and the size of the company, see table 6.1. The size of the company is defined by Net Sales and Head count. Information about Net sales and Head count is coming from annual reports 2006 and information from the company. Kitron is the participating company with lowest Net Sales and Headcount. They have 0,3 BUSD in Net Sales and 1300 employees in headcount. The company with highest Net Sales is Siemens with 138,3 BUSD. The company with highest

headcount is Flextronics.

	Company	Sector	Net sales	Headcount
1	SSAB	Materials	5,2 BUSD	8737
2	Ovako	Materials	2,2 BUSD	4300
3	LKAB	Materials	2,2 BUSD	3737
4	ABB	Manufacturing industry	24,4 BUSD	108000
5	Sandvik	Manufacturing industry	3,0 BUSD	37045
6	SKF	Manufacturing industry	8,9 BUSD	41090
7	Siemens	Telecommunication industry and others	138,3 BUSD	475000
8	Ericsson	Telecommunication industry	29,9 BUSD	63781
9	Telenor	Telecommunication industry	17,9 BUSD	35600
10	Elektrolux	Commodity industry	17,5 BUSD	59500
11	Autoliv	Commodity industry	6,2 BUSD	41800
12	Ikea	Commodity industry	27,4 BUSD	118000
13	Korsnäs	Paper industry	1,2 BUSD	1900
14	Smurfit Kappa	Paper industry	11,1 BUSD	40000
15	SCA	Paper industry	17,0 BUSD	51022
16	AstraZeneca	Pharmaceutical/ medical technology industry	26,5 BUSD	66600
17	Gambro	Pharmaceutical/ medical technology industry	2,5 BUSD	19143
18	Pfizer	Pharmaceutical/ medical technology industry	48,4 BUSD	115000
19	Flextronics	Contract manufacturer	18,9 BUSD	136600
20	Kitron	Contract manufacturer	0,3 BUSD	1300
21	Solectron	Contract manufacturer	10,6 BUSD	44500
22	JM	Construction industry	2,0 BUSD	2400
23	Skanska	Construction industry	21,2 BUSD	56000
24	NCC	Construction industry	9,4 BUSD	21784
25	Axfood	Consumer products industry	4,8 BUSD	7007
26	Coop	Consumer products industry	4,4 BUSD	8500
27	Ica	Consumer products industry	11,3 USD	11698
28	Saab (part of GM)	Automobile industry	207,3 BUSD (GM)	(GM) 284000
29	Scania	Automobile industry	11,9 BUSD	32000
30	Volvo (part of Ford)	Automobile industry	160,1 BUSD Ford	Ford 283000

Table 6.1 Participating companies

The companies that participate in the empirical study has different conditions for measurements in the Supply chain due to the type of business and the tradition in the sector they have their business. I have therefore chosen different sectors to get a wider view of the performance measurements among companies in Sweden. For companies in the Automobile industry group and in the Telecommunication industry group purchasing, production and distribution are important parts in the Supply chain. This differs from the Materials group and Paper industry group where production must be considered the important part. The reason for production to be the important part is that the machine equipment

used in production is very expensive to purchase. In comparison with material cost, administration cost, distribution cost and capital cost the cost for machine equipment is the dominant part. Therefore these companies focus on production and to maximize the utilization of the machinery. Purchasing is the important part for the Construction industry group. For this group is the purchased material the highest cost in the Supply chain and therefore the highest focus is on purchased material.

6.1.2 Analysis of data from the empirical study

Data concerning the five questions used in the interviews with the 30 companies participating in the study were gathered in a type of a database. The analysis of the data was performed in three steps. The first step included setting up the rules for quantifying the answers and identifying groups among the answers. In step two all answers were placed into the identified groups. Analysis of the result was performed in the third step. All three steps were performed for each of the five areas:

1. Definition of efficiency
2. Measurement of Supply Chain Cost
3. Measurement of performance
4. Measuring level in the company
5. Position of Supply in the organisation

The data from the question about how the company define an efficient Supply chain were divided into three groups. The first group is definitions including only cost. The second group includes definitions only relating to performance measurements, but no cost. Group number three includes efficiency definitions that consist of both performance measurements and cost. The representative of the company were asked to formulate how she/he defined an efficient Supply chain, from the answers I classified the company in one of these mentioned groups.

The analysis for SCC is based on the definition that SCC should include administration cost, manufacturing cost, warehouse cost, distribution cost, capital cost and installation cost if this cost is applicable. The warehouse cost, distribution cost, capital cost and installation cost should be the actual cost as far as possible for the product, product group, customer order or other measurement object. Manufacturing cost can be based on a fixed manufacturing cost per product that has been defined by product calculation. Administration cost can be based on a mix of actual cost and on add on based on percentage share. Administration cost from general support functions and higher management in a

company is in general coming from a percentage add on. Data from the question if the company is measuring Supply Chain Cost is divided into five groups. The first group is companies that don't measure SCC at all. These companies don't use the term SCC and don't measure any at all. Group number two measure parts of the components, but mainly based on manufacturing costs This means that a company for example measure distribution cost, but that the estimated cost is based on rough mark-ups, a percentage add on cost, and not the accurate actual cost as it should be when SCC is properly measured. The third group is measure parts of the components. This means that the company use the term SCC, but measure parts of the measurements that are included in SCC. To measure all parts in SCC all of administration cost, manufacturing cost, warehouse cost, distribution cost, capital cost and installation cost shall be included in the SCC measurement. Installation cost is only applicable when this cost is included in the Supply chain. Group number four includes answers that doesn't use the term, but still measure all cost components. This means that the company doesn't use the term SCC, but measure all parts according to the definition above. The fifth group "use the term" means that the company use the term SCC and measure all parts that should be included according the definition above accurately.

The answers from the question about which performance measurement the company use is divided into eight groups. The groups are:

1. Delivery precision: Material delivered in accordance with what is promised.
2. Lead-time: The tine from starting an order until it is ready.
3. Cost: All types of cost measurements. Example distribution cost and capital cost.
4. Inventory turn over: Measurements regarding tied up capital. Example ITO, tied up capital in money and number of days in stock.
5. Internal performance: Measurements regarding how internal performance. Example yield in production, ordering entry time and capacity utilization.
6. Customer satisfaction: All types of customer satisfaction measurements.
7. Quality: Quality from the customer's point of view. Example number of claims and number of replacement of goods.
8. Service grade: Measurements regarding service grade towards customers. Example fill rate and back order.

Data from the question about measurement level in the company is divided into 11 groups. Measurement level means what level in the company can the company measure on. The level can for example be product level. Product level can for Volvo be V50 and XC90, for Ericsson GSM and WCDMA and for Axfood fruit and bread. The 11 groups are:

1. Region: Measurement on region level. Example Europe, Africa, Asia and America.
2. Warehouse: Measurement for each warehouse the company have.
3. Business unit/division: Measurement on business unit level or division level.
4. Selling company: Measure meant for each selling company. Example the selling company in Singapore, Munich and Sao Paulo.
5. Order: Measurement for each order.
6. Supplier: Measurement for each supplier that supply material to the company.
7. Product: Measurement for different products or product groups in a company.
8. Department: Measurement for different departments within the company.
9. Production plant: Measurements for the production plant within the Supply chain.
10. Customer: Measurements for different customers the company have.
11. Company: Measuring the whole company. Example a total delivery precision for the company.

The answers from the question about the position of Supply in an organization were divided into three groups. Position of Supply means if there is a part of the organisation including organizational parts belonging to the Supply chain. The first group is no and means that the organizational parts belonging to the Supply chain are spread in the company. Order handling can for example be part of Marketing & Sales department, production part of different divisions and distribution part of the Sourcing department. The second group is yes and means that the company have all parts in the Supply chain in one organizational part. Group three is partly and companies are classified into this group if they have some parts of the organizational parts belonging to the Supply chain together in an organisation. Companies belonging to this group have for example purchasing, order handling and stock handling in one common organisation, but production and distribution are included in another part of the organisation.

6.2 Result

The result is presented in five areas. The areas are Efficiency, Supply Chain Cost, Performance measurements, level of measurements and position of Supply in the organization.

6.2.1 Efficiency

The definition of an efficient Supply chain varies between different companies. Three groups are identified among the answers. The groups are performance, cost and a combination of performance and cost. Definitions of efficiency in terms of performance are for example high delivery precision and high customer satisfaction. No cost parts are included when the definition is classified as a performance based definition. Definition of efficiency in terms of cost means that the definition only relates to cost and no other parts. The analysis and conclusions are based on the answer from one person in each company. The answers could potentially be different if someone else from the company had answered the questions. This has to be considered when analysing this study. One third of the companies in the study have both performance focus and cost focus in their definition. The most common definition is based on the performance. 53 percent of the participating companies are focusing on performance when they define an efficient Supply chain. Only 10 percent of the companies focus on cost only. One example from a company in the commodity industry group is that an efficient Supply chain keeps what is promised, delivery in time, right quantity, right quality and to lowest possible cost. This definition includes both the performance focus and the cost focus.

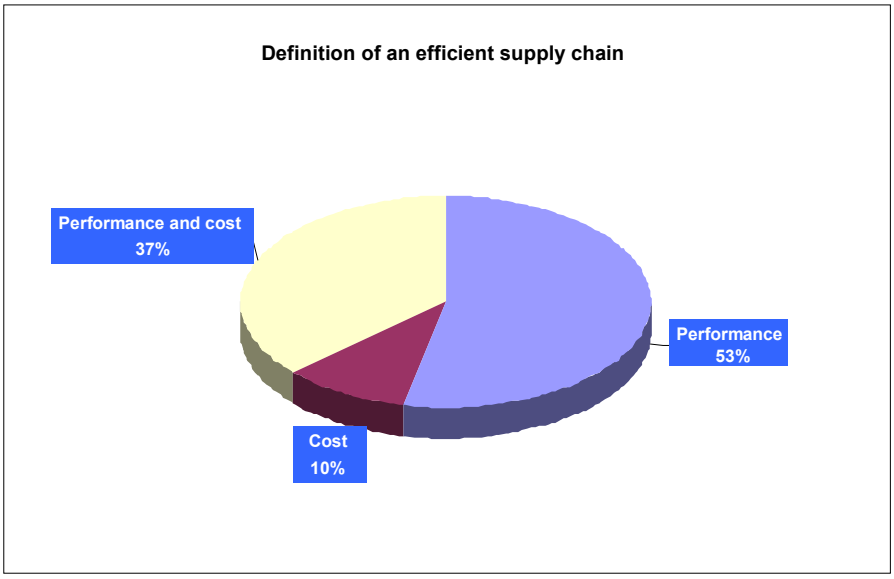

Figure 6.2 Definition of an efficient Supply chain

The automotive industry sector, the telecom sector and the commodity industry sector are most into the combination of cost and performance thinking when

defining an efficient Supply chain. An example of efficiency definition from the construction industry is A Supply chain with lowest cost and highest price towards the customer. This definition has cost focus. Another definition is total cost efficiency in the whole Supply chain and avoiding sub optimising. This definition comes from a company in the consumer products sector. An example of performance focus is Material delivery in right time, quantity and quality. Manufacturing industry and Paper industry are the sectors with the highest performance focus in their efficiency definition. Companies with cost focus in their efficiency definition are from the consumer products sector and the Construction industry sector.

To remain competitive in the new global environment companies will have to seek ways to lower cost and at the same time enhance the service towards customers according to Christopher (1998). This means that a company needs to have both cost focus and customer focus at the same time. The grade of cost focus and customer focus varies between different sectors. Some sectors have higher focus on cost depending on the market situation. Some sectors are still working with high margins and the cost focus is not as essential as for sectors with high requirements for lower prices.

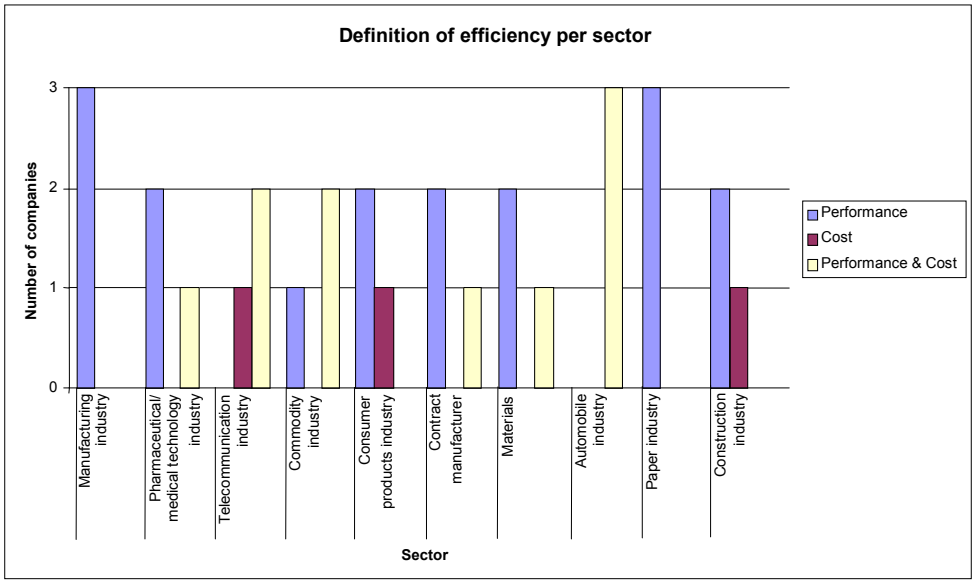

Figure 6.3 Definition of efficiency per sector

6.2.2 Supply Chain Cost

Ways of handling measurements of SCC varies between the 30 companies participating in the study. The study shows that it is only 3 companies out of 30 that say that they don't measure SCC at all. The rest is doing some kind of measurement of SCC. It is only one company that use the term SCC and measure all parts. More than two thirds of the companies are measuring parts of the components in Supply Chain Cost. Two companies measure parts of the components, but not based on actual cost. This means that for example the distribution cost is measured as a percentage of the total distribution cost in the company. The percentage figure is decided by earlier calculations. The study shows that most of the participating companies have started with the measurement of SCC, but there is still a long way to go to come up to complete measurements of SCC.

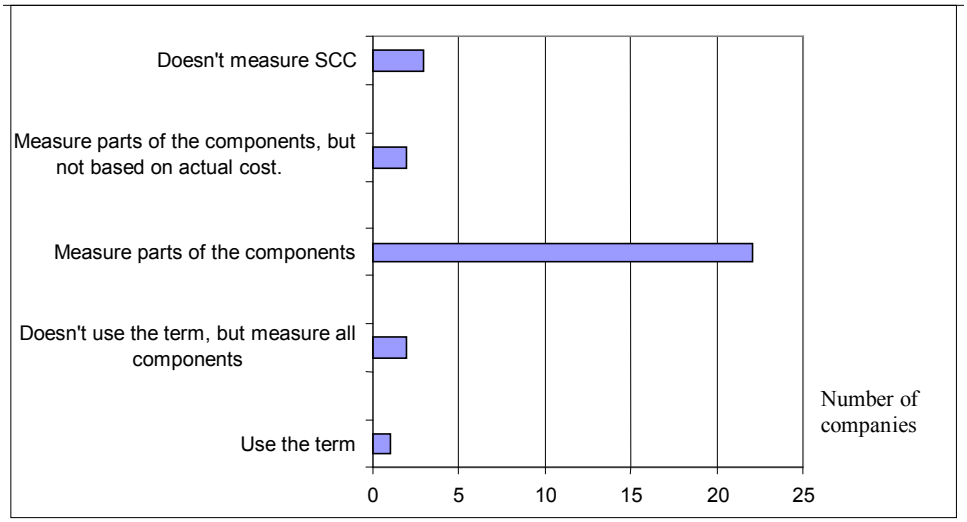

Figure 6.4 Measurement of SCC

The sectors Materials, Telecommunication and Paper industry are the only sectors with companies that don't measure SCC in any form. The company that measure SCC is within the commodity industry sector. SCC as a measurement is more interesting for companies that have to focus on having a total view on the cost in the Supply chain to be able to reduce cost. For some companies the machinery in production and transportation cost are the most dominant costs in the Supply chain. Cost for tied- up capital and distribution are the highest costs within the Supply chain for other companies.

All other sectors are measuring parts of the SCC. The way of measuring for these sectors differs. Measuring of SCC in the Paper industry has a focus on distribution cost. The focus in the SCC scope in Pharmaceutical/ medical technology industry is on production cost and distribution cost.

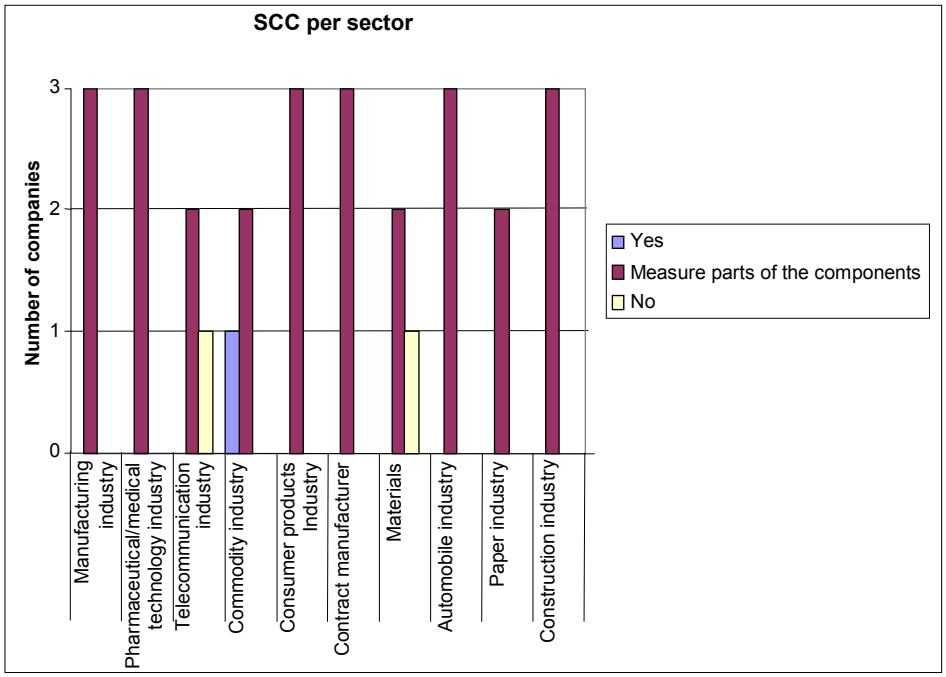

Figure 6.5 Measurement of SCC per sector

6.2.3 Performance measurements

Supply chain excellence requires that the actors in the Supply chain know how to do performance measurements according to Keebler (1999). The analysis of the answers is based on the metrics in the SCOR model, but with some adjustments. The aim of SCOR is to provide a standard way to measure Supply chain performance and to use common metrics to benchmark against other organizations Christopher (1998). The SCOR model has 12 performance metrics. The 12 metrics are according to Huan et al. (2004):

1. Delivery performance
2. Fill rate
3. Order fulfilment lead time

4. Perfect order fulfilment
5. Supply chain responsiveness
6. Production flexibility
7. Total logistic management cost
8. Value-added employee productivity
9. Warranty cost
10. Cash to cash cycle time
11. Inventory days of Supply
12. Asset turns

The metrics from the study are divided into eight groups:

1. Delivery precision
2. Lead-time
3. Cost
4. Inventory turn over
5. Internal performance
6. Customer satisfaction
7. Quality
8. Service grade

Delivery precision is corresponding to delivery performance, perfect order fulfilment in the SCOR model. Lead-time is corresponding to order fulfilment lead-time in the SCOR model. Cost covers total logistic management cost and warranty cost in the SCOR model.

ITO covers asset turns and inventory days of Supply in the SCOR model. Internal efficiency covers fill rate, Supply chain responsiveness, production flexibility, value-added employee activity and cash to cash cycle time in the SCOR model.

Three extra metrics are added compared to the 12 metrics in the SCOR model. These are quality, customer satisfaction and service grade.

The metrics from the study are also corresponding to the Balanced Scorecard. The Balanced Scorecard is a framework for measurements of the performance in an organization, see section 3.2.1.

Cost is a part of the financial measures group in the Balanced Scorecard. Delivery precision, lead-time, customer satisfaction and service grade are part of the Customer-related measures. Inventory turnover and internal performance are in the Internal performance group. The Balanced Scorecard also has a learning part or as in some scorecards employee. This part is not covered in this study.

The metrics are not exactly the same if you compare different companies. The denomination can differ, but the measurement is the same. Delivery precision is covering all measurements that measure if an order is delivered in confirmed delivery date. Lead-time is covering measurements of different lead-times like for example production lead-time and lead-time from orders receipt to delivery to customer. Cost is covering all kind of cost measurements for example SCC, manufacturing cost and distribution cost. Inventory turn over (ITO) covers all measurements related to tied-up capital. Internal performance covers all kind of measurements that are done to improve the efficiency within the company. Examples of measurements that are included in this measurement are fill rate, parts processed per man-hour, forecast precision and Supply chain responsiveness. Customer satisfaction is including all measurements related to customer satisfaction. Quality is covering measurements related to quality like for example faulty rate. Service grade includes all measurements related to the service level. Some examples are safety stock, back order and service level.

The most common performance measurement according to the empirical study is delivery precision. 63 percent of the responding companies are measuring delivery precision. Next in line is ITO where 50 percent are measuring this metrics. As number three are 40 % of the companies that are measuring lead-time. Number 4 is cost and as number 5 comes quality and service grade. Only 17 percent of the companies are measuring Customer satisfaction.

Measuring of performance in the Supply chain can be difficult according to Schmitz and Platts (2003) and Harrison and New (2002). It is difficult to measure the performance in Supply chains Schmitz and Platts (2003). According to Harrison and New (2002) half of the companies they contacted in their research had limited possibilities to do performance measurements in their Supply chain. 19 percent couldn't measure at all. One of the findings in this empirical study is that all companies in this study are measuring performance. This is positive and indicates that measuring performance in a Supply chain is seen as natural part in the management of the Supply chain.

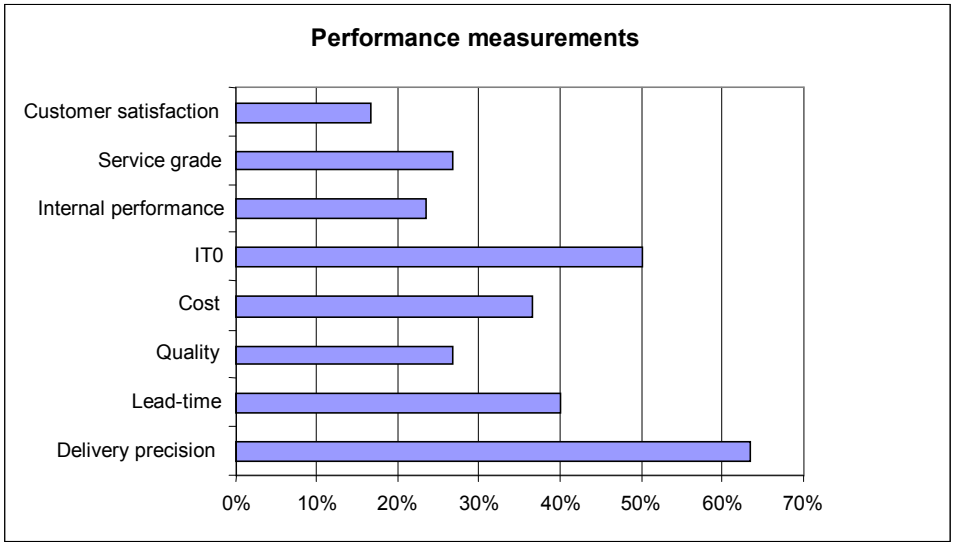

Figure 6.6 Performance measurements

The performance measurements that are performed in the 30 companies that are participating in this study are well corresponding to the measurement in the SCOR metrics and the Balanced Scorecard.

The empirical study shows that the focus areas for performance measurements differ between the sectors. For companies within the Manufacturing industry sector are the focus on delivery precision, lead-time and ITO. The most common measurements for Pharmaceutical/ medical technology industry are ITO and service grade. Companies within the telecommunication industry delivery precision, lead-time and ITO are the most common measurements. Within the commodity sector ITO and service grade are the most common performance measurements. The Contract manufacturer sectors most common measurements are delivery precision, lead-time, ITO and Service grade. Delivery precision is the most common measurement for the Materials sector and the Automobile sector. In the Paper sector delivery precision and ITO are the most common performance measurements. Within the Construction industry cost and customer satisfaction are the most common measurements.

6.2.4 Measurement level

The most common level to measure according to the 30 participating companies in the study is on product level and production plant level. 53 percent of the companies are measuring on product level and on production plant level.

Notable is that less than one third of the companies measure on company level. Effective performance measurement should be related to strategic, tactical and operational levels of the company according to Gunasekaran et al. (2004). The strategic level measures influence the top-level management decisions. Operational level measurements assess the results of decisions of low-level managers. The reference to level in this case is considering aggregate level for the performance measurements. There are three general aggregate levels: low level, middle level and top level. Low level can be order, product customer, department and supplier. Middle level can be production plant, warehouse and selling company. Top level is Business unit level, region and company. The study shows that low-level measurements are dominating.

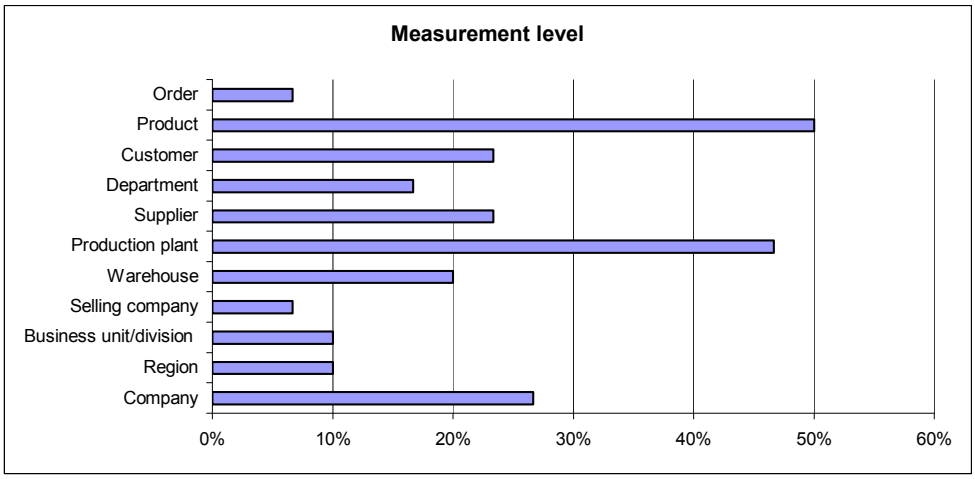

Figure 6.7 Measurement level (percentage of participating companies)

6.2.5 The position for Supply in an organization

The position for Supply in an organization is checked to investigate if there are any connections between position for supply and the way the company define efficiency and which measurements the company use to measure performance. The definition of Supply is based on the general definition of normal functions in a company. The functions are:

- Research and Development
- Marketing and Sales

- Supply
- Service
- General administration and business controlling

The functions are described in section 2.2 on page 8. Supply is in this definition including inbound logistics, outbound logistics, sourcing, production and distribution. In the Supply part, claims and warranty handling is also included. The position of Supply in an organization varies between the companies. In some companies production is the main department, in other is purchasing the main department and in others Supply. The question is Supply an own part of the organization is interpreted based on that all parts in the Supply are included in one organizational part. Partly means that the company has a Supply part, but all parts are not included. In some sectors it is common that production is an own part outside Supply and in others purchasing is the main name of the organization and other parts of Supply are sub units to purchasing. 33 percent of the companies have Supply as an own part in the organization. Half of the companies have Supply as a part of the company, but all parts are not included. 13 percent of the companies don't have Supply as an own part of the organization.

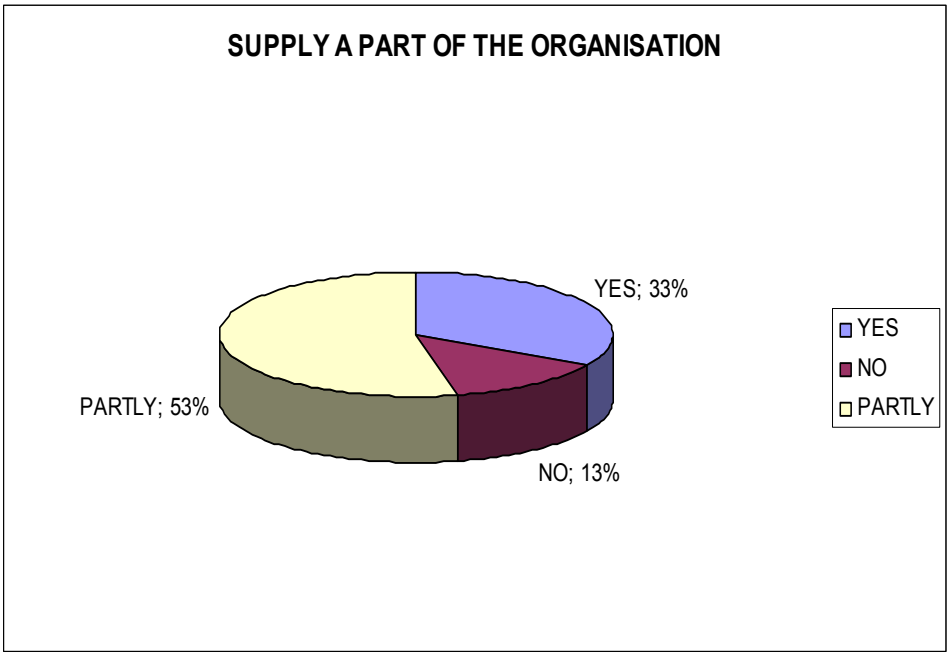

Figure 6.8 Supply a part of the organization

The empirical study shows that companies that have Supply as an own part in

the organization have a wider definition of efficiency including both cost and performance focus. These companies also have a wider scope of performance measurements including more types of measurements. Figure 6.8 shows that companies that have supply as an own part of the organization have 3 to 8 different types of performance measurements. Companies that don't have supply as an own part of the organization has 1 to 2 types of performance measurements. Companies that partly have supply as an own part of the organization are represented by a curve between with 2 to 4 types of performance measurements. Figure 6.9 shows that almost all companies defining efficiency as a combination of performance and cost also have supply as an own part of the company. Companies that don't have supply as an own part of the company define efficiency as cost or performance.

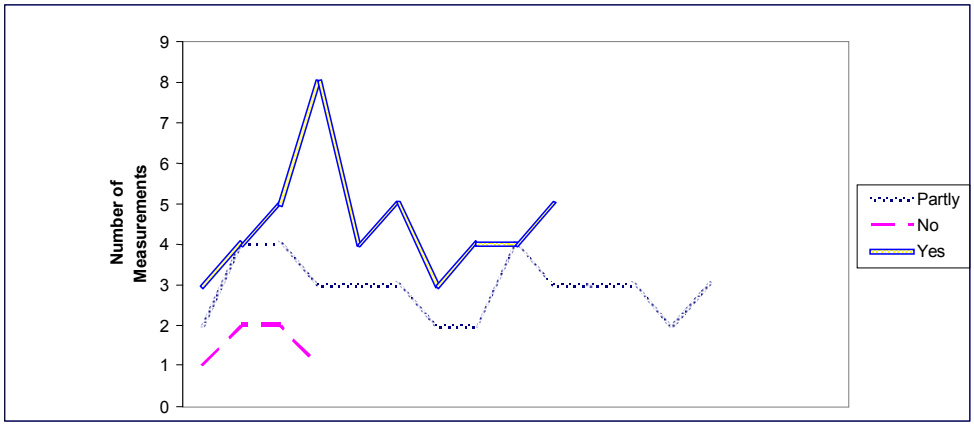

Figure 6.9 Relation between number of performance measurements and supply as an own part of the company.

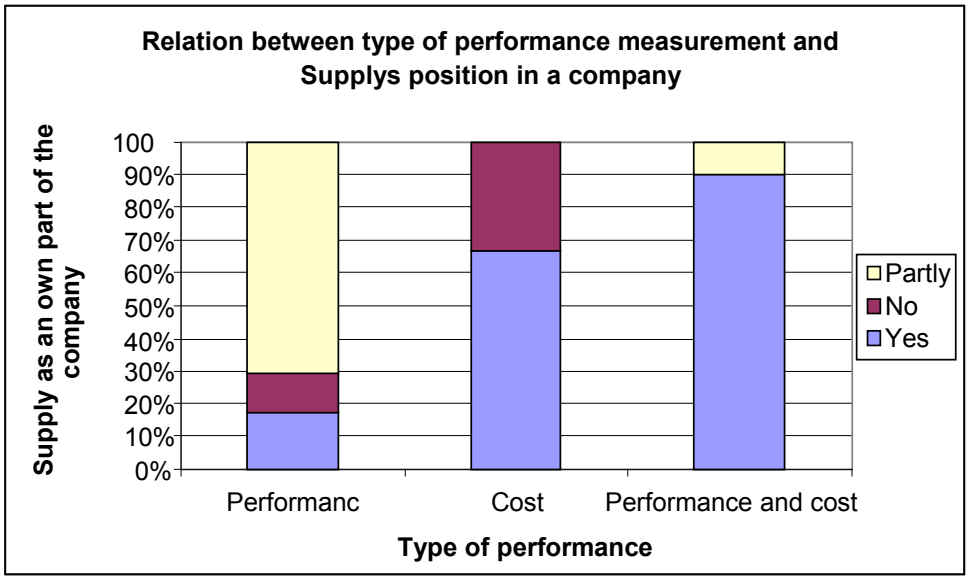

Figure 6.10 Relation between type of performance measurement and supply as an own part of the company.

6.3 Conclusions

The overall finding from this study is that the 30 companies participating in this study all have a Supply focus, but are on different development stages regarding Supply organization, measurements and efficiency thinking. The key findings from this empirical study are:

- There is more performance focus than cost focus.
- Supply Chain Cost is measured but few companies are using the term and measure all components included in SCC.
- Delivery precision, Inventory turnover and lead-time are the most common performance measurements.
- Supply is still not a natural part of all organizations.
- The most common level to measure is on product level and production plant level

Key finding 1 is that 30 % of the participating companies are focusing on both cost and performance in their efficiency definition. 53 percent of the participating companies are focusing on performance in the definition of efficiency. Christopher and Towill (2000) are describing the trends for Supply Chain Management from the beginning of the eighties to end of the nineties. In

the beginning of the eighties the focus was on cost effective Supply chains. During the coming years quality was in focus and then in the end of eighties the focus went back to cost. In the beginning of the nineties it was high availability that gave market shares.

Key finding 2 is that Supply Chain Cost is measured but few companies are using the term and measure all components included in SCC. Two thirds of the companies are measuring parts of the components in Supply Chain Cost.

Key finding 3 is that delivery precision; Inventory turnover and lead-time are the most common performance measurements. The measurements vary between different sectors. Delivery precision is the most common measurement for the Materials sector and the Automobile sector. The measurements are not giving a full coverage for cost and performance in a company.

Key finding 4 is that Supply is still not a natural part of all organizations. 33 percent of the companies have Supply as an own part in the organization. The way a company decides to set up their organization varies between different sectors. Within the paper industry sector is production the Supply part with highest focus. Production is a separate department and not included in a total Supply organization. Within the Construction industry sector is purchasing the main Supply unit. The purchasing part is the where the companies in this sector has to put most efforts to get low prices for material they are purchasing. Low price for purchased material is the key factor for getting as good revenue as possible.

Key finding 5 is that common level to measure is on product level and production plant level. Less than one third of the companies measures on company level. Few companies are measuring on order level. The measurements are not performed on all three of strategical, tactical and operational level. To get a good picture of the performance in a Supply chain all three levels should be considered when setting up the measurement levels.

One improvement area based on these 5 key findings is that Supply needs to have a stronger position in the company to get the right focus on the total Supply chain. Another improvement area is to have a combined cost and performance focus in the efficiency definitions. One more improvement area is to focus on performance measurements that consider both cost and performance. The performance measurements shall give a good picture of how efficient the Supply chain is. Measurement level can also be improved by setting up measurements covering all three levels in a company. Measuring on all three levels operational, tactical and strategic gives a better picture of how the company performs.

7. DISCUSSION FOR A GENERAL EFFICIENCY INDEX

This chapter presents a model or more modest an index to evaluate how efficient a Supply chain is. The idea with the index is that it shall give a good picture of the efficiency in a company and be easy to measure. The cost concept is combined with the customer service concept. This is based on the conclusion of the literature review that it is important to combine cost and customer service, see section 5 and findings from the empirical study regarding performance measurements related to customer service. There is a risk that companies focus on one measurement at the time. A company can for example focus on delivery precision and forget cost focus and resource utilization. The idea with the efficiency index is that the index will help the managers in the companies and the Supply chain to consider the overall scope with both cost focus and customer service focus.

7.1 Measuring of SCC

SCC is suggested to be divided into five main areas and a sixth area that is applicable for Supply chains there installation is included in the Sales price. The six areas are:

1. Administration cost
2. Manufacturing cost
3. Warehouse cost
4. Distribution cost
5. Capital cost
6. Installation cost

The reason for dividing SCC in these six groups is to clearly see where in the Supply Chain Cost comes from.

Administration cost includes all cost related to administration like cost for the people that handles customer orders, people that purchase material and people that book transportation. It is difficult to do an exact definition of what is included in each cost. This can differ between Supply chains and type of business.

There are a lot of different Supply chains and the SCC components vary. In some Supply chains the Manufacturing cost is the dominant part. In other Supply chain the distribution cost can dominate and in a third there are now warehouse cost and distribution cost. These 6 areas can be seen as the baseline.

Each of them can be splitted into more detailed groups.

Manufacturing cost:

1. material cost
2. test cost
3. direct and indirect labour cost
4. machine cost

Administration cost

1. cost for order handling
2. cost for people handling purchasing
3. cost for people handling claims
4. cost for people that handles support for the Supply chain like secretary, managers and others that support the Supply chain.
5. Cost for installation if that is applicable.

Warehouse cost

1. cost for inspection of incoming goods
2. cost for people working in the warehouse
3. cost for the building

Distribution cost

1. Cost for shipping incoming material if the own company is paying this.
2. Cost for shipping the material to the customer.
3. Cost for insurance and inspection of goods if applicable
4. Cost for Letter of credit if applicable
5. Cost for customs clearance if applicable

Capital cost

1. Cost for tied up capital in warehouse
2. Cost for tied up capital during transportation
3. Cost for tied up capital until the customer has paid the invoice.

Installation cost

1. Cost for people doing the installation.
2. Other cost related to the installation.

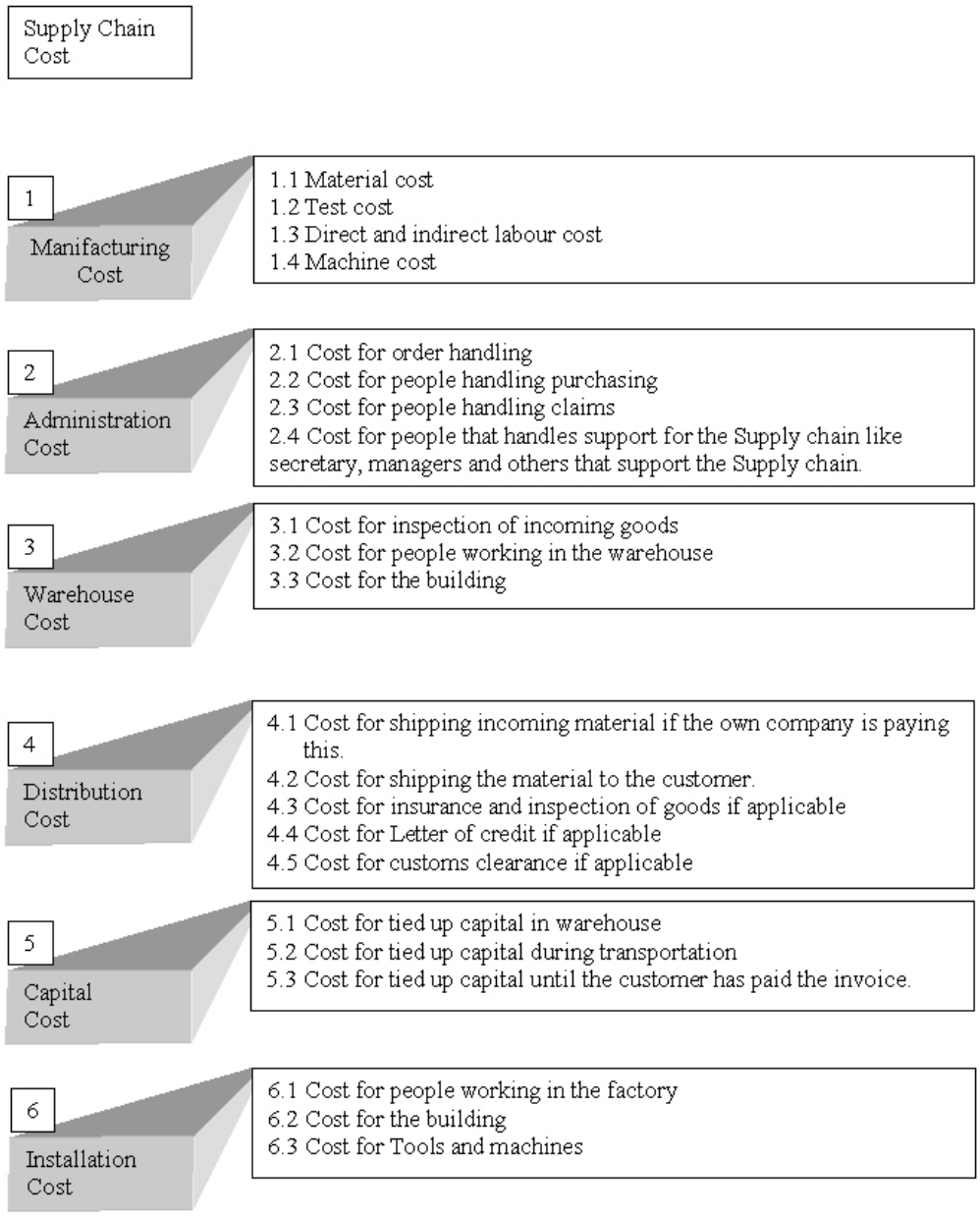

Figure 7.1 Supply Chain Cost

Total SCC is the sum of manufacturing cost, administration cost, warehouse cost, distribution cost, capital cost and installation cost. If total SCC is divided

by net sales, the income from the activity of the company, it presents a key figure that shows how large part Total SCC consists of Net sales. In a profitable company Net sales are greater than Total SCC; and a company should strive to keep total SCC as low as possible and naturally lower than Net sales. If Net sales decrease total SCC should also decrease, and if net sales increase total SCC will in most cases also decrease. Using total SCC as a measurement to compare with other companies doesn't give a correct picture and makes no sense, because companies have products with different values and cost and different sales volume. The ratio between between total SCC and Net sales is more comparable between different products, plants, markets, companies etc. However, the best and most sensible comparison is with it self over time, a decrease of the ratio is favourable and an increase should be avoided.

$$SCC_i = \frac{\text{Total SCC}}{\text{Net sales}}$$

7.2 Measuring of Customer related performances

The literature review showed that the most common performance measurements related to customer service are:

- availability of the product
- delivery speed
- delivery reliability

The empirical study showed that the performance measurements used by the 30 participating companies related to customer service are:

- delivery precision
- lead-time
- customer satisfaction

Therefore here is suggested that customer related performance is represented by a key figure Performance External (PE_i) that is a combination of delivery precision, lead-time and a more general customer satisfaction measurement. Performance External is suggested to be a measurement that measures customer service. The reason for using these three measurements is that they cover the most common performance measurements related to customers' expectations in accordance with the empirical study and the literature review. Each of the three measurements is constructed by a ratio that gives a percentage value. The

measurements are multiplied together to get the PE_i value.

$$PE_i = DP_i \cdot LT_i \cdot CS_i$$

DP_i = Delivery precision index; calculated as the number of orders delivered in time compared to the total number of orders delivered over specific time interval, e.g. last week or last month. In time means on confirmed delivery date. What in this measurement is meant by "in time" can differ, at the exact promised day and hour, may in some delivery situations be necessary. In another situation it is enough with promised day with a complementing interval of plus and minus 2 days. Nowadays a rough measure as in right week is mostly not precise enough.

LT_i = Lead-time index or a delivery time index; calculated as the number of orders delivered on ***requested*** time from the customer compared to the total number of orders delivered also over a specific time interval. Lead-time is the total lead-time towards a customer. Normally this is the time from when the customer places an order until the ordered product is delivered. To separate this lead-time from other lead-times, between items in the company's bill of material, it can also be called the delivery time. As for DP_i must be defined in the specific situation how far from the requested time is allowed and how far from it is not allowed.

Lead-time index can also be measured as a percentage of a goal lead-time. Example if the goal lead-time is 10 days and the actual average lead-time is 20 days. Lead-time index can base on this in such a way that a lead-time of 10 days presents a lead-time index of 1 or 100 percentage. An average lead-time of 20 days may then be chosen to present a lead-time index of 50 percentage, 18 days then give s 60 percentage, 16 days gives 70 percentage, 14 days gives 80 percentage and 12 days gives 90 percentage. Every company has to set up their own goal lead-time and their own percentage steps. A company can choose one of these ways of measurements depending on how they decide to measure required lead-time from their customers.

CS_i = Customer satisfaction index; can be calculated as the number of answers with higher score than average compared to the total number of answers.

The customer satisfaction index can be set up in many different ways if you compare companies. The number of questions can differ and also the number of participants in the study. A customer satisfaction survey can be set up with for example five questions where the person that answers the questions in a 1-5 scale. Examples of questions:

1. Do you get order acknowledge in time?
2. Do you get proper answers on your order related questions?
3. Is it easy to get hold of people by phone?
4. Do you have the proper information about lead-times?
5. Are the order instructions good enough?

The important thing to keep track of is if the company has improved or deteriorated since the previous customer satisfaction survey; that must be captured in the Customer satisfaction index.

7.3 Index for measuring efficiency in a company's Supply chain

The suggested Average Logistic Index (AL_i) is combining the cost concept and the customer service concept.

$$AL_i = PE_i \cdot (1 - SCC_i)$$

To have an efficient Supply chain the AL_i should be high, which means closer to 1 or 100 percentage than zero. This means that the company needs to have a low SCC index, SCC_i, at the same time as they have a high PE_i. Improving PE_i by improving the delivery precision, DP_i, by building safety stocks will increase the SCC and the total Average Logistics index may not be better. PE_i and SCC_i are not linear correlated, how they are correlated may differ substantially between different companies and even parts of companies. The dependence between PE_i and SCC_i will probably also change over time; therefore continuously measurements of actual AL_i at least every month is recommended.

The goal for the Average Logistic index cannot be a 100 percent goal; due to its construction that every part is less then 1 or 100 percent. The measurement, AL_i, should be used as a guideline to keep track of if the company is working in the right direction. The important thing is to combine the Performance External index (PE_i) and the Supply Chain Cost index (SCC_i) to maximize the profit for the company. The company should not focus on just one of the measurement. It is the important message the Average Logistic index (AL_i) presents to the user.

The best way to combine PE_i and SCC_i varies between companies. Each company has to find their own right mix for PE_i and SCC_i with focus to

maximize the profitability for the company. Some companies earn most money with a low price and other with a high external performance. In some cases a company can charge for excellent customer service. $AL_i = 0.4$ in one company may be more successful than $AL_i = 0.6$ in another company

Every part of the Average Logistic index do not have to be updated at the same time, or even be measured over the same time interval. The important thing is that all parts, SCC_i, DP_i, LT_i, CS_i, are measured in the same way every time to be comparable with the previous measurement. If for example DP_i is measured every week and other parts every month then an average of the 4 last DP_i could preferably be used as a part of AL_i.

8. INDEX TEST AT ERICSSON AB

The suggested index for measuring efficiency in a Supply chain presented in chapter 7 is in this chapter tested to be applied to a large international company. Measuring performance in Supply chains is difficult according to Schmitz and Platts (2003) therefore a type of a practical case must be presented here. The analysis is performed on the Swedish company Ericsson AB. A company that want to use the suggested Average Logistic index (AL_i) has, without exception, a computer based business system or system for Enterprise Resource Planning (ERP-system) where data is kept and from where data must be retrieved to establish the index. The business system used within Ericsson is called CBS (Common Business System). This is an Ericsson adaptation of the ERP-system SAP/R3. In an ERP-system is integrated systems or functions for handling finance, accounting, ledgers, manufacturing- and customer orders, purchase, production, sales, inventories, project management etc. (Other ERP-systems are for example Oracle, Movex, Concorde, Jeeves, IBS ASW etc.) The data for the Average Logistic index must be collected with help from the ERP-system, therefore CBS and SAP/R3 is described in section 8.2. In another company using another ERP-system there may be differences to retrieve the data but also similarities, because many ERP-systems have similar and common characteristics and construction. Due to confidential information Ericsson does not want that real figures about the different indexes shall be published, so here will only be presented from where and in what way different data are collected.

8.1 An overview of Ericsson AB

Ericsson is a world-leading provider of telecommunications equipment and related services to mobile and fixed network operators all over the world. The company has delivered network equipment to more than 1000 networks in 140 countries according to www. 40 percent of all mobile calls in the world are made through Ericsson's systems. The Ericsson organization has three Business Units:

- Business Unit Networks
- Business Unit Global Services
- Business Unit Multimedia

Research, Market Units, Group Functions and Global Customer Accounts Multi-Country Accounts are the other parts of the organization. Each Business has a Supply unit. This unit is taking care of all Supply related issues. Each Market unit also has a supply unit.

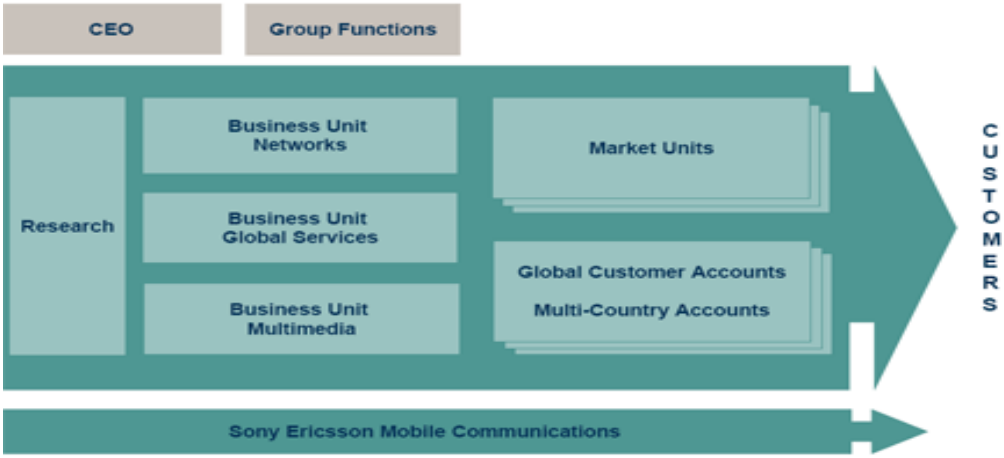

Figure 8.1 Ericsson's organization; Ericsson (2007)

Ericsson has a wide scope of products:

- Mobile systems
- Wireline systems
- Transmission and transport
- Service layer
- Services
- Mobile phones

Mobile systems include all 2G mobile standards as well as the three primary 3G standards – WCDMA, EDGE and CDMA2000. Ericsson offers radio base stations, core network infrastructure and the increasingly important service layer. *Wireline systems* include broadband multi-service communications equipment and services to fixed network operators. Ericsson offers a complete, end-to-end portfolio of *transmission and transport equipment* for mobile, fixed and other types of networks. Microwave and optical products are included in this part. One of the products is the microwave radio links. *Service layer* is where applications and end-user services are enabled and managed. Examples of products are Internet Protocol Television, MMS and Charging systems. *Services* include expertise in consulting, systems integration, managed services, network deployment and optimisation, education and technical support services. Sony Ericsson Mobile Communications (Sony Ericsson) is a part of Ericsson. It is a 50/50 joint venture combines the mobile communications expertise of Ericsson

with the consumer electronics and content expertise of SONY Corporation. The company delivers *mobile phones* and other mobile communication devices. Net Sales 2006 was 179, 9 Billion SEK.

FINANCIAL HIGHLIGHTS

SEK b.	Q1/06 *)	**Q2/06 *)**	Q3/06 *)	**Q4/06 *)**	Q1/07
Net sales	39.6	44.8	41.3	54.2	42.2
Gross margin, %	43.5	42.6	38.2	42.2	43.0
Operating income	6.6	8.3	8.8	12.2	8.2
Operating margin, %	16.7	18.4	21.2	22.5	19.3
Income after financial items	6.7	8.3	8.9	12.2	8.3
Net income	4.6	5.7	6.3	9.8	5.8
Cash flow from operations	2.4	0.2	4.8	11.0	4.6
Earnings per share, SEK	0.29	0.36	0.39	0.61	0.37

Figure 8.2 Financial figures Ericsson (2007).

8.2 SAP/R3

SAP stands for Systems, Applications and Products in Data Processing. SAP is the name of the German company based in Germany. The company was founded 1972 and has 34 000 customers all over the world according to SAP (2007). They have around 12 million users in 120 countries. R/3 is a program package developed by SAP. The package is an open Client/Server system and was developed in the late 80's. It was developed from the R2, which was developed for mainframe computers in the 80's. The modules within R/3 contain four major elements according to Bancroft et al. (1997):

- Manufacturing and logistics
- Financial accounting
- Human resources
- Sales and distribution

Manufacturing and logistics is the largest of the four modules and the most complex. The module can be divided into the five major components plant maintenance, quality management, materials management, production planning & control and project management. Each component is divided into subcomponents. Materials management includes all tasks in the Supply chain such as consumption-based planning, vendor evaluation, purchasing and invoice verification.

Financial accounting is including three major categories. The categories are financials, controlling and asset management. Financials includes accounts payable, accounts receivable, capital investments and general ledger. The controlling category includes costing, cost centre, profit centre, internal orders, profitability analysis and others.

Human resources includes payroll, benefits administration, work force planning, time management, travel expense accounting and others.

Sales and distribution includes sales order management, configuration management, distribution, export controls, billing, invoicing and others.

Each module accesses over 1000 business processes. SAP R/3 includes a set of business application software modules. The modules are designed for the client/server environment and are integrated.

Figure 8.3 Modules and components in the SAP/R3 system. Layer Hernández et al. (2006)

FI : Financial Accounting.
CO : Controlling.
AM : Fixed Assets Management.
PS : Project System.
WF : Workflow.
IS : Industry Solutions.
HR : Human Resources.
PM : Plant Maintenance.
QM : Quality Management.
PP : Production Planning.
MM: Material Management.
SD : Sales & Distribution.

SAP has solutions for different industries. There are solutions for the following industries according to SAP (2007):

- Banking
- Defence & Security
- Healthcare
- Higher Education & Resources
- Insurance
- Public Services
- Aerospace & Defense
- Automotive
- Chemicals
- Consumer products
- Engineering, construction & operations
- High Tech
- Industrial Machinery & Components
- Mining
- Oil and gas
- Logistics Service providers
- Media
- Postal Services
- Professional Services
- Retail
- Telecommunications
- Wholesale Distribution

The SAP R/3 architecture consists of three software layers according to Bancroft

et al. (1998). The layers are SAP GUI, SAP application and SAP database. SAP GUI is responsible for presenting all data from the system to the user. The SAP application contains the processing logic for the business data. Here the program code for all SAP modules is executed and the data is manipulated. SAP database is a program, which retrieves and stores data.

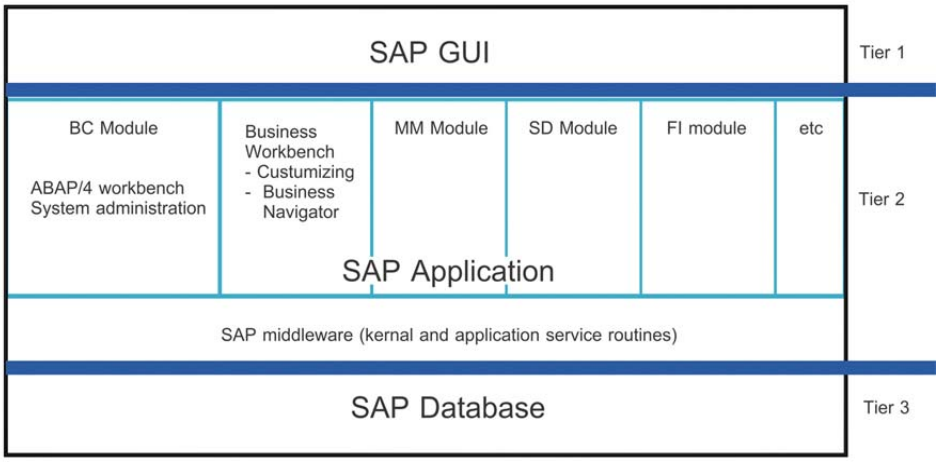

Figure 8.4 The SAP software architecture Bancroft et al. (1998).

The report structure in SAP is typically ABAP programs according to Hernández et al. (2006). Those programs function is to look up information in the database and to print or display the information. Two terms are distinguished in the SAP world. A report is the program itself and the result is represented by a list. The user doesn't have to program the reports by themselves because the SAP system includes thousands of pre-programmed reports. The reports can be taken out by selecting normal menu functions. Sometimes the users have to call for a report manually using the functions provided by the SAP system. To start a report the report name shall be entered. Reports are grouped in classes for example sales reports and stock movements.

The SAP software was developed based on the idea of a corporate as a whole instead of any of separate business departments according to Bancroft et al. (1998). All SAP programs use the same database. The key components implemented in the SAP software include:

- On-line system
- One database for all data
- Clear definition of every data item
- Software functionality configurable to customers requirements
- Client-oriented data structure
- Definition data within the framework of a document

The SAP software architecture can be defines as four building blocks according to Bancroft et al. (1998). The blocks are;

- Business application
- System administration
- ABAP/4 Workbench
- SAP implementation Guide and Business Navigator

Business application is the functional modules that are used by the business. They consist of all the business processes and their functions for sales, manufacturing, finance and distribution.

The system administration block includes the computer centre management, database administration, user authorization and others. The technical staff when installing or upgrading the unconfigured software on the servers uses this block. It is also used for security within the environment for networked work.

SAP`s proprietary programming language is called ABAP/4. All tools and data models are part of the ABAP/4 Workbench.

SAP implementation Guide and Business Navigator are accessed through the Business Workbench. These are tools that the project team for implementation uses to configure the SAP package according to the business requirements. The Business Navigator gives a graphical overview over the data model and the processes.

8.3 Index test

Measuring Supply related measurements can be complicated if there is no system support for the measurements. According to Harrison and New (2002) half of the companies they contacted in their research had limited possibilities to do performance measurements in their Supply chain. It can be a lot of manually work to perform the measurements. Measurements can always be performed, but the work effort can be considered as to high to be worth performing. The

Average Logistic index (ALI index), $AL_i = PE_i \cdot (1 - SCC_i)$, presented in chapter 6 will be tested in some different scenarios. I will in this part investigate if the index can be used in four different scenarios. Gunasekaran et al. (2001) say that "SCM" measurements shall include all three of strategic, tactical and operational levels. The chosen scenarios cover all these three levels. Business unit level gives the strategic level. Customer level and Phased out product family represent the tactical level. Operational level is represented by the Customer project level. The main focus will be on system support and work effort. The four scenarios are:

- Business Unit level
- Customer level
- Phased out product family
- Customer project

Business Unit (BU) level within Ericsson means that the measurement is performed on a total level for all deliveries within the BU. This test is performed on BNET. All deliveries are hardware, software or service deliveries. The performance part of the ALI index is including the measurements delivery precision, lead-time and customer satisfaction. All these measurements are presented in the Balanced Scorecard for the BU and are measured on regular basis. The cost part of the ALI index is not measured as a total and split into the six categories.

- Administration cost
- Manufacturing cost
- Warehouse cost
- Distribution cost
- Capital cost
- Installation cost

All cost categories are included in different measurements performed within the organization, but is not measured on the category level. To be able to get the total SCC some manual work has to be performed. All cost elements have to be collected and summed up in the Excel program. Performing this test takes less than 1 hour for one person.

Measuring on Customer level with the ALI index can be performed with some additional manual measurements. Customer level means a customer in a specific country, but can also be measured for a global customer like Vodafone and Telefonica. Two out of three measurements in the performance part of the ALI index can be taken out from a system used for measuring these kinds of

measurements. These two are delivery precision and lead-time. The figures can't be taken out directly from the CBS system however Ericsson has a database that is connected to CBS. This database is a useful tool for taking measurements and reports and this where the figures can be found. The database is taking data from CBS and performs calculations. The output from the database requires commenting by the people taking care of orders to be able to give the correct figures. The third measurement in the performance part is the customer satisfaction index. This index can be picked up from the customer satisfaction surveys that are performed regularly. Measuring the cost part of the ALI index has to be performed without direct system support.

Measuring according to the ALI index on a phased out products can be more complicated. A phased out product means that the normal Supply channel is closed for the products. Only existing customers are supported and there are no new sales for these products. Collin (2003) has found that it is important for a supplier to have the right Supply chain for a customer in different business situations. The Supply chain for phased out products is set up based on the business situation where the volumes are low and the production lead-time is long. Bowersox (1996) says that it is necessary to evaluate the relationship between customer services levels and associated cost when finalizing a logistical strategy. The ALI index can be used to evaluate how the Supply chain will be set up for phased out products. Questions like how is the total cost influenced if the lead-time is reduced are interesting to discuss for phased out products. A difficult part of SCM is to offer better value to the customer and at the same time reduce cost according to Hoover et al. (2001). This is especially difficult for products with low volume due to that it is more difficult to reduce cost for low volumes without reducing the service level towards the customer. Hoole (2005) found in his research that companies that have a mature Supply chain are reducing cost faster than less mature Supply chains. This is valid to a break point. Supply chains for phased out products can be mature, but it is difficult to reduce cost due to low volumes.

All measurements have to be performed manually, but the information collecting can be done easily with a good set-up of accounts. If order numbers are set up for the cost types where cost are allocated like for example administration cost and warehouse cost it is easy to summarize the total cost. The type of cost varies between different products. Some product families have administration cost and distribution cost. Others can also have for example warehouse cost and installation cost. The performance part has to be performed manually. The volumes for phased out products are normally low, which makes it easy to perform the manual measurement.

Customer project means a project set up in CBS. The project includes all

hardware, software and services delivered to an end customer for a specific customer contract. The performance part of the ALI index delivery precision, lead-time and customer satisfaction has to be measured manually. Manually means that the numbers has to be picked out from an Excel file and the measurements have to be calculated. The cost part of the index can partly be taken out from the CBS system. Manufacturing cost, distribution cost and installation cost is reported directly to the customer project. Administration cost is cost for the logistics person or persons working with the Customer project. This cost can be set up to be added directly to the project in CBS by doing time reporting of the working hours. Warehouse cost and Capital cost is not booked directly towards the project. The cost booking has to be set up manually.

8.4 Conclusions

Measuring in accordance with the ALI index could be performed for all four test cases. The manual part of the measurement varied between the different scenarios. The manual parts for the four test cases were reasonable. Some adjustments in the system set-ups could make it easier to measure. The manual parts can be avoided by setting up these measurements in the database Ericsson has connected to the CBS system. By give more input data to the database and set up more formulas the manual measurements can be performed in the database. The simplicity in measuring is very much depending on what level you would like to measure. If you chose a level that is out of the standard set up within the company it requires manual work to get the figures. The conclusion you can take from this is that if you want to implement a new measurement it is important to consider on what level you would like to measure to be able to set up system support for the measurement. According to Neely (1999) one of the drivers for the increasing interest in SCM is the power if Information Systems. The IT systems we have today are modern and high performing. They shall give good possibilities for performance measurements and adaptations to special set ups for measurements. According to Van Hoek et al. (2002) the biggest barriers to change in European Supply chain projects was culture, not IT systems. The culture in a company is the values and beliefs of the organisation. Manual measurements is often considered as very time consuming, but this is much depending on what grade of manual handling you are talking about. Some manual handling can be to take out figures from different systems and summarize them. It might be a 5-minute work. Other manual handling can require hours of manual work in for example Excel to get the figures. The effort it is worth to put on manual measurement is much depending on what benefits the company gets from the measurements.

Other companies may have another organisation and different organisational

levels. The work that has to be done to establish the measurements and the indexes should be rather similar to this test case at Ericsson. In a smaller company where not so many people would be involved and had to be persuaded to start this type of data probably it would be even easier to establish the Average Logistic index.

9. CONCLUSIONS AND EXTENSIONS

This chapter presents the conclusions of this licentiate thesis, discussion and suggestions for future research.

9.1 Conclusions

This thesis has considered the topic of measurements in the Supply chain and specific measurement of Supply chain excellence. This thesis has the following objectives:

- Present ways of measuring performance of the Supply chain.
- Present ways of measuring cost in the Supply chain.
- To suggest a quantitative method to evaluate how efficient a Supply chain is and combining the cost concept with the performance concept.
- Evaluate on which level of the Supply chain efficiency preferably should be measured.

Ways of measuring performance in the Supply chain is based on the literature review and the empirical study. The conclusions of the literature review were that according to section 3 it is difficult to measure performance in a Supply chain. Furthermore half of the companies contacted in a research performed by Harrison and New (2002) had limited possibilities to perform performance measurements in their Supply chain. 19 percent of the companies in that research could not measure at all. Furthermore there are a lot of performance measurements to choose from. In the end of the nineties two types of performance measurements dominated in the literature according to section 3.1. These were cost and customer responsiveness.

All 30 companies participating in the empirical study do performance measurements. According to the empirical study are delivery precision, Inventory turnover and lead-time the most common performance measurements. The measurements vary between different sectors. None of the 30 companies is measuring both cost and the performance measurements related to the customer focus. Performance measurements related to the customer focus are delivery precision, lead-time and customer satisfaction. The measurements are not giving a full coverage for cost and customer related performance in a company.

Ways of measuring cost in the Supply chain in the Supply chain is based on the literature review and the empirical study. The findings from the literature review are that there are a lot of different definitions of Supply Chain Cost. It can also be difficult to measure as discussed in chapter 4.3 due to that the accounting

systems in a company are not adjusted to support the SCC measurement. The study shows that it is only 3 companies out of 30 that say that they don't measure SCC at all. The rest is doing some kind of measurement of SCC. It is only one company that use the term SCC and measure all parts. More than two thirds of the companies are measuring parts of the components in Supply Chain Cost. Two companies measure parts of the components, but based on rough mark-ups. The study shows that most of the participating companies have started with the measurement of SCC, but there is still a long way to go to come up to complete measurements of SCC.

The suggestion of a quantitative method to evaluate how efficient a Supply chain is and combining the cost concept with the customer focus concept is based on the literature review and the empirical study. The empirical study shows that the definition of an efficient Supply chain varies between different companies. One third of the companies in the study have both customer focus and cost focus in their definition. The most common definition is based on the customer focus. 53 percent of the participating companies are focusing on the customer when they define an efficient Supply chain.

The conclusion of the literature review is that the purpose of Supply Chain Management is to manage the Supply chain as efficiently as possible. This means that the Supply chain shall maximize the revenue for the company. A difficult part of SCM is to offer better value to the customer and at the same time reduce cost according to section 2.3.3. According to section 2.4 it is important to combine cost and customer service. The future market leaders are according to Christopher (1998) the ones that have sought and achieved the twin peaks of excellence. They should have gained both cost leadership and service leadership.

The suggested quantitative method for measuring efficiency in the Supply Chain is the Average Logistic Index, AL_i. This index combines the cost concept and the customer concept.

Average Logistic Index (ALI index)= $AL_i = PE_i \cdot (1 - SCC_i)$

Performance External index (PE_i) is a combination of delivery precision, lead-time and customer satisfaction. SCC_i is the Supply Chain Cost index that is the total cost in the Supply chain divided by Net Sales.

The included parts in the ALI index are measured with different periodicity. Delivery precision and lead-time can for example be measured on weekly basis, but customer satisfaction index only once a year. Measurements performed more

frequently are easier to work with compared to measurements performed less frequently. To have an efficient Supply chain the ALI should be high. This means that the company needs to have a low Supply Chain Cost index at the same time as they have a high Performance External index.

An example with three companies with different supply set up and focus area is presented below. Which company is the most efficient company from a supply perspective? Company 1 is having high delivery precision and short lead-time. They have reached this by having buffer stocks both in production and as ready material. This company has a high PE_i and at the same time a high SCC_i. This result in a medium ALI index. Company 2 has an effective production with low cost and high yield. This company is also good in distribution and have low distribution cost, but their customers are complaining on long lead-time and poor customer service. The Performance External index is low and SCC index is low. This result in a medium ALI index. Company 3 is high ranked in customer service by their customers and has a high delivery precision. This company is having high ITO and low distribution cost. This result in a high ALI index. An example for these 3 companies is presented below.

Example:

Company 1:

$DP_i = 0.95,\ LT_i = 0.9,\ CS_i = 0.8$

$PE_i = DP_i \cdot LT_i \cdot CS_i = 0.684$

$SCC_i = 0.8$

$AL_i = PE_i \cdot (1 - SCC_i) = 0.684 \cdot (1 - 0.8) = 0.137$

Company 2:

$DP_i = 0.80,\ LT_i = 0.6,\ CS_i = 0.4$

$PE_i = DP_i \cdot LT_i \cdot CS_i = 0.192$

$SCC_i = 0.2$

$AL_i = PE_i \cdot (1 - SCC_i) = 0.192 \cdot (1 - 0.2) = 0.154$

Company 3:

$DP_i = 0.95,\ LT_i = 0.9,\ CS_i = 0.9$

$PE_i = DP_i \cdot LT_i \cdot CS_i = 0.7695$

$SCC_i = 0.2$

$AL_i = PE_i \cdot (1 - SCC_i) = 0.7695 \cdot (1 - 0.2) = 0.616$

From this example Company 3 may look as the most efficient company from a supply perspective, it may be so but it is not absolutely sure. The example shows

that Company 2 gets a higher ALI index than Company 1; but the big difference between the companies is the divergence in SCC_i which is an indication that the companies has totally different situations. The ALI index can be used to benchmark towards other companies, but with restrictions; the differences between companies has to be considered when companies are compared. The main idea with the ALI index and the helpful use is for benchmarking with the own company over time. The company can set up improvement goals based on the ALI index. Internal performance measurements like ITO, yield and machine utilization are necessary complements to the ALI index. The index considers SCC and the performance towards customers. Improving internal performance will reduce SCC. For example improved ITO will give lower tied up capital and by that will SCC be reduced.

The index is tested at Ericsson AB on the four scenarios:

- Business Unit level
- Customer level
- Phased out product family
- Customer project

Measuring in accordance with the ALI index could be performed for all four test cases. The manual part of the measurement varied between the different scenarios. The manual parts for the four test cases were reasonable. Some adjustments in the system set-ups could make it easier to measure.

The evaluation on which level of the Supply chain efficiency preferably should be measured is based on the literature review and the empirical study. According to the literature review should the measurements shall include all three of strategic, tactical and operational levels. The highest management in a company can be interested in measuring "SCM" on a strategic level and consider the whole company. Management on level two or three can be interested in "SCM" measurements. The most common level to measure according to the 30 participating companies in the study is on product level and production plant level. 53 percent of the companies are measuring on product level and on production plant level. Notable is that less than one third of the companies measure on a company level. To have a good view of the status in the company all companies should have measurements on all three levels top level, middle level and low level. Top level is the total company and Business unit level. Middle level can be production plant and department. Low level can be order, customer and product level.

9.2 Discussion

Companies are working with improvements in the Supply chain and are aiming for Supply chain excellence and World-class Supply, but what does this mean? Answering this question is difficult due to all the different definitions of an efficient Supply chain. To be able to measure Supply chain excellence you need to define what an excellent Supply chain is. This thesis suggests to define excellence as an efficient Supply chain combining customer focus and cost focus. This means that the company shall achieve the best combination of customer focus and cost focus to earn as much money as possible.

Performance measurements in the Supply chain are necessary to be able to know how the Supply chain performs. Findings from the literature review and the empirical study in this thesis are that there are four criteria that shall be fulfilled to be classified as good methods or systems for performance measurements. The criteria are:

- Shall give an overall picture of how a Supply chain perform
- Shall indicate improvement areas
- Shall give guidelines about how the Supply chain shall be managed with focus on the goal for a company to be as profitable as possible
- Shall be general to allow benchmarking towards other departments, other companies and other Supply chains.

One common model for performance measurements in the industry is the Balanced Scorecard. The measurements in a Balanced Scorecard do not always cover the whole Supply chain and it is difficult for companies to find measurements giving an overall picture of how a Supply chain perform according to my experience. This is an interesting area with many possibilities for improvements. Findings from this thesis are that the performance measurements should cover all three of internal performance, external performance and Supply chain cost. Internal performance measurements shall be used for finding improvement areas within the Supply chain. External performance measurements are customer related performance and shall be used to see how well the customer is served. SCC is important to measure to keep track of the cost in the Supply chain.

One improvement area based on the 5 key findings from the empirical study is that the function, process and organisational part Supply needs to have a strong position in the company to create the right focus on the total Supply chain. There need to be a focus on Supply in a company to be able to present good quality in Supply Chain Management. Highest management in the company has to understand that Supply is important. There is a risk in companies where

supply not is seen in the company structure that supply is seen as something minor. An important finding from the empirical study is that the 30 companies participating in this study all have a Supply focus, but are on different development stages regarding Supply organization, measurements and efficiency thinking.

An improvement area, for most of the interviewed companies and probably for most companies in general, is to have a combined cost and performance focus in the efficiency definitions. Therefore an improvement area is to focus on performance measurements that consider both cost and performance. The performance measurements shall present a good picture of how efficient the Supply chain is. Measurement levels can also be improved. Measuring on most organisational levels and by that over the time help to do decisions concerning all time horisions on an operational, tactical and strategic level, and then over the time create a follow-up of these decisions. These measurements will present an improved picture of how the company performs.

The ALI index gives a picture of the efficiency in a company. The index is designed to be simple and give an overall comprehension of the efficiency status in the company. The idea with the index is that it should be easy to measure for all kind of companies and Supply chains. It is combining cost and customer focus. Experience from the industry is that all companies benefits from measuring SCC and having a total view on the cost in the Supply chain. A complete measurement of SCC is a powerful tool to use to get the right focus in the work with SCM. A company should avoid prioritising only one thing at a time, for example utilisation of machinery, and after a while something else (cf. Christopher (1998)). The idea with the Average Logistic index is to "force" the companies to strive for several things at the same time: low costs, excellent customer relations, short delivery times and precise delivery dates, low inventories, high utilisation of machinery and equipment, right quality etc. Because as Johnson and Bröms (2000) say profitability is not created by financial goals but how well the company succeeds with its processes; the ALI index is a suggestion with one collected measurement to measure the performance of several processes.

9.3 Future Research Possibilities

In this thesis the focus has been on measurements in the Supply chain. The measurements shall give a good picture of how efficient the company is and identify improvement areas.

The problem of performance measurements is to find an easy way to measure

that can be used in different kind of Supply chains irrespective of type of company and type of products or services. To be able to benchmark the efficiency in a Supply chain there need to be a model or index that is generic and that can be applied to all companies. The ALI index that is suggested in this thesis is an idea about how the efficiency measurement can be performed. Development of this index can be an area for further research.

Many decisions within the area of SCM need support from a good measurement tool that can give guidance in the decision process. One interesting area where it would be interesting to apply the measurements ideas from this thesis is on outsourcing investigations. Connecting outsourcing decisions to performance measurements can be another area of further research.

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