LAPPEENRANTA UNIVERSITY OF TECHNOLOGY
School of Industrial Engineering and Management
Supply chain and operations management

MASTER'S THESIS

Developing Supply Chain Process Management and Measurement in Global Manufacturing Company

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April 17th, 2016
Lappeenranta

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ABSTRACT

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Title: Developing Supply Chain Process Management and Measurement in Global Manufacturing Company

Year: 2016 **Place:** Lappeenranta

Master's thesis. Lappeenranta University of Technology. School of Industrial Engineering and Management, Supply chain and operations management

85 pages, 14 figures and 14 tables

Examiner: Associate professor Petri Niemi

Keywords: manufacturing industry, pulp supply chain, process management, supply chain performance measurement

The objective of this research is to create a current state analysis of pulp supply chain processes from production planning to deliveries to customers. A cross-functional flowchart is being used to model these processes. These models help finding key performance indicators (KPIs) which enable examinations of the supply chain efficiency. Supply chain measures in different processes reveal the changes need processes that affect the whole supply chain and its efficiency and competitiveness.

Structure of pulp supply chain differs from most of the other supply chains. The fact that there are big volumes of bulk products, small product variations and supply forecasts are made for the year ahead make the difference. This factor brings different benefits but also challenges when developing supply chain.

This thesis divides pulp supply chain in three different main categories: production planning, warehousing and transportation. It provides tools for estimating the functionality of supply chain as well as developing the efficiency for different functions of supply chain. By having a better understanding of supply chain processes and measurement the whole supply chain structure can be developed significantly.

TIIVISTELMÄ

Tekijä: Janne Neuvonen

Työn nimi: Developing Supply Chain Process Management and Measurement in Global Manufacturing Company

Vuosi: 2016 **Paikka:** Lappeenranta

Diplomityö. Lappeenrannan teknillinen yliopisto. Tuotantotalouden tiedekunta, Toimitusketjun johtaminen

85 sivua, 14 kuvaa ja 14 taulukkoa

Tarkastaja: Apulaisprofessori Petri Niemi

Hakusanat: tuotantoteollisuus, selluliiketoiminnan toimitusketju, prosessijohtaminen, toimitusketjun suorituskyvyn mittaaminen

Tämän työn tarkoituksena on luoda nykytila-analyysi sellun toimitusketjuprosesseista. Vuokaavion avulla kuvataan nämä prosessit tuotannonsuunnittelusta asiakkaille saakka. Kuvaukset auttavat löytämään toimitusketjusta suorituskykymittarit, joiden avulla pystytään tarkastelemaan toimitusketjun tehokkuutta. Toimitusketjun eri osa-alueiden mittaamisella tuodaan esille muutoksia tarvitsevat prosessit, jotka vaikuttavat koko toimitusketjuun ja sen tehokkuuteen sekä kilpailukykyyn.

Sellun toimitusketjuprosessit eroavat muista toimitusketjuista monella tavalla. Asiakkaille toimitetaan suuria määriä bulkkituotteita, tuotekategorioita on vähän ja toimitusketju suunnitellaan ennusteiden mukaan vuodeksi eteenpäin. Tämä tuo hyötyjä mutta myös haasteita toimitusketjun kehittämisessä.

Tämä työ jaottelee sellun toimitusketjun kolmeen eri kategoriaan: tuotannonsuunnitteluun, varastointiin ja toimituksiin. Työ tarjoaa yritykselle mittareiden kautta työkalut toimitusketjun suorituskyvyn arvioimiseen sekä toimitusketjun eri osa-alueiden tehokkaampaan kehittämiseen. Parempi ymmärrys toimitusketjuprosesseista ja niiden mittaamisesta auttaa merkittävästi koko toimitusketjun rakenteen kehittämistä.

PREFACE

Last years of studying have been challenging but also rewarding. I got many great memories and a bag full of know-how with me. Writing this thesis has deepened my knowledge and given me a lot of new information of supply chain and operations management.

First of all, I would like to thank Matti Tamminen and Timo Seppälä for giving me this opportunity. Their valuable advices and comments supported and helped me through this study. The cooperation in the company was significant and I want to thank everybody for the guidance, patience and explanations.

Many thanks to associate professor Petri Niemi for committed guidance and feedback through this process.

Last but not least, I want to thank my family, friends and especially Laura for supporting me during my studies and this thesis. Without you all, I wouldn't be in this point now. This is a good start towards future challenges.

Lappeenranta, 17.4.2016

Janne Neuvonen

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LIST OF ABBREVIATIONS

BSC	Balanced scorecard
BPM	Business process management
KPI	Key performance indicators
PI	Performance indicators
PMM	Performance measurement and management
P&PI	Pulp and paper industry
RFID	Radio frequency identification
S&OP	Sales and operations planning
SC	Supply chain
SCC	Supply chain coordinator
SCOR	Supply chain operations reference -model

1 INTRODUCTION

Worldwide thinking of supply chain has changed in the last years and made supply chain a management priority for pursuit global growth and profitability. Supply chain is a core enterprise process which includes the activities required to produce and deliver goods and services and also interaction with consumers, customers and suppliers. Many companies focus on their supply chains only when something is wrong or a benchmarking showing supply chain performance lagging. The best-performing supply chains always find ways to add value and push the boundaries of performance to stay one step ahead of competitors. (Cohen 2013, p. 1-2)

Pulp and paper industry (P&PI) is a significant field in Finnish society and is a major employer with tens of thousands of employees directly. A significant number of employees are also employed through its networks indirectly. The pulp business has evolved and grown significantly in the last few years. Fast urbanization, growing middle class and increasing use of packaging products has driven markets to big increase. The growth is still high and therefore it is important for companies to develop their activities in order to improve their competitiveness. Supply chain management (SCM) is one of the key elements to concentrate on because optimizing your operations maximizes speed and efficiency of supply chain. This study brings out the current state processes of pulp supply chain that need to be developed, measured and followed in the future.

1.1 Background

The topic for this master thesis was developed while I worked as a supply chain coordinator at the case company pulp mill. The supply chain structure in the company is already well developed but there are still some potential process elements that need deeper dedication. Changes in production volumes and customer fields are forcing to make changes and develop processes to meet the current state challenges. Annual pulp production capacity is over 3,5 million tons and still increasing due to the investments in production capacity. Pulp business is one of the company’s growing operations. Company’s pulp business aims to strengthen

their position in the markets by providing efficient and modern production, a competitive product portfolio and sales and technical customer services in main markets and consistent focus on quality. Supply chain process management and measurement plays an important role achieving these objectives. (Group's website)

The case company wants to develop process management and the use of key performance indicators (KPI) to strengthen their supply chain structure and strategy. These indicators are used for measuring supply chain performance from internal business process perspective and are defined as concrete translations of the vision and strategy of the logistical function. (Koskinen 2008, p. 34) Efficient supply chain has to decrease lead-times, to be more streamlined and excess processes need to be eliminated and developed. The basis for this development is a survey of the present state and measuring efficiency of current supply chain. (Sillanpää 2015, p. 290) The primary aim is to maximize the overall value generated. There are many definitions in literature for supply chain management but it is primarily concerned as "managing relationships with suppliers and customers in order to deliver the best customer value at the lowest level". (Chithambaranathan et al. 2015, p. 309)

Pulp mills focus mostly on maximizing production volume and efficiency and it is not always the best kind of thinking in volume-based mass production. Higher inventory levels and quality problems are examples for possible disadvantages. Sometimes smaller production volumes with better quality and inventory controlling could make bigger profits than just trying to maximize the production volumes. Finding better solutions and options for planning production, warehousing and transportation improve the total profitability of the supply chain processes.

1.2 The main objectives and restrictions

Target for this master's thesis is to create a concept that makes supply chain processes more efficient to manage considering the synergies in production planning, warehousing and transportation and fitting into existing sales and operation planning (S&OP) process. The main purpose is to get information for top

management's need to improve cost efficiency, production control, stock management, agility and whole SC optimizing. The thesis answers to the following research questions:

- *What are the current state key processes and key performance indicators (KPIs) in the case mills supply chain?*
- *What are the recommendations that the company should pursue in order to achieve more efficient supply chain processes?*

The thesis focuses on the most critical points in SC processes and find the most relevant metrics to clarify these problems. The company will get more information of their supply chain processes and its performance as a result of this study. They will also get recommendations of how to improve and make supply chain processes more efficient. The thesis will give arguments and alternatives for the future to change the ways of working, the use of systems and transportation methods. Long-term effects or customer relationships are not taken into account in the calculations and the results are largely based on the current state analysis.

1.3 Research methodology

The thesis can be presented as a process of six different phases and these are shown in figure 1. First process part is to sharpen the content of the work. The content is made with supervisors and examiner of this study. Next step is to strengthen theoretical background and find relevant sources to gather these theories for literature review. After theory part specific information is gathered through interviews, visits, telephone calls, e-mails and databases. After information is gathered, confirmation from supervisors and examiner for the used methods is needed. The last phase of the research is to do modifications and corrections before finishing the thesis.

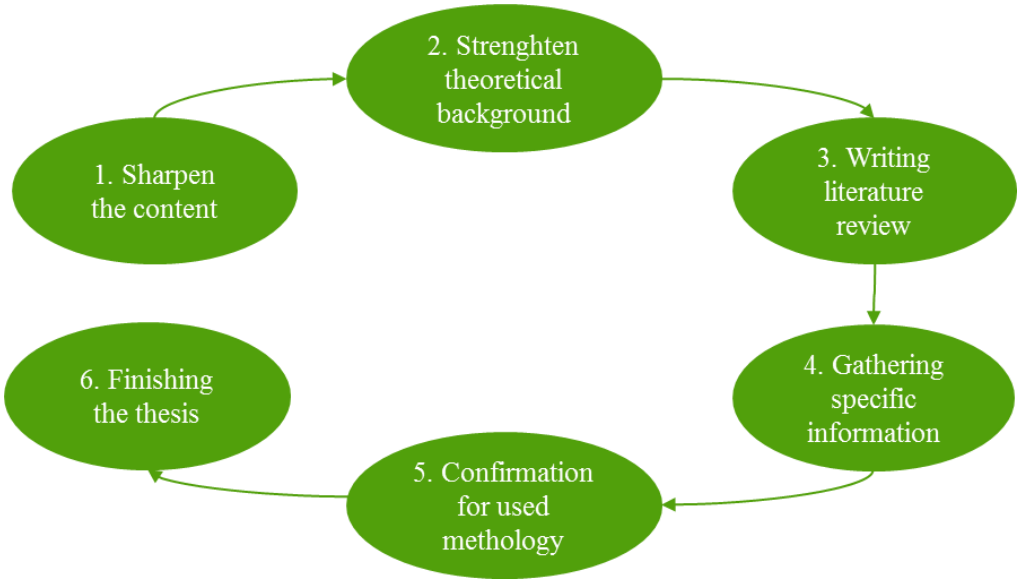


Figure 1. Research methodology phases

The information used in this thesis has been gathered from different sources. Theoretical part is mostly based on literature review but the specific information is gathered from company supervisors and other people related to company's supply chain. Data used in empirical part is gathered mainly from company databases, discussions and e-mails. After analyzing the available data it was used for finding reasonable measures and conclusions for the thesis.

1.4 Structure of the study

The thesis consists seven chapters after introduction part and are shown in table 1. In chapters 2-4 the theories relevant to this thesis are presented. Chapter two has a theory related to supply chain process management and is divided in four different subtitles. Chapter three focuses on pulp supply chain process elements and is divided in three different categories. Chapter four contain the theory of performance measurement and benchmarking of supply chain processes. Chapter five gives an overview of the supply chain processes in case company mills and chapter six is for analyzing supply chain measurements related to case supply chain. Chapter seven shows a benchmarking case to recognize best practices and models from another mill of the company. In chapter eight the conclusions of this study are summarized

and proposals for future developments are made. Chapter nine summarizes the thesis.

Table 1. Structure of the thesis

Chapter two	▪ Theory of supply chain process management
Chapter three	▪ Theory of different pulp supply chain process elements; production planning, warehousing and transportation
Chapter four	▪ Theory of supply chain performance measurement and benchmarking
Chapter five	▪ Case company process modeling
Chapter six	▪ Performance measures in case supply chain
Chapter seven	▪ Benchmarking case at mill 3
Chapter eight	▪ Conclusions, analysis, limitations and proposals
Chapter nine	▪ Summary

1.5 Business environment

Forest industry is economically, socially and politically an important sector for the whole global economy. Pulp and paper industry is part of the forest industry and the biggest companies are located in Northern Europe, North America and Asia. (Mikkilä et al. 2008, p. 500) The pulp and paper industry is the third largest in Europe with manufacturers of newsprint, printing and packaging paper, board and tissue. The use of high technology, capital intensive processes and products that require depth knowhow is characterizing for this industry. Research and development is one of the key elements to meet global changes of technology, competition from emerging markets and changing consumer demand. (Roese et al. 2012, p. 2) Ernst & Young has listed the features which are common to all sectors of the pulp and paper industry: capital intensity and big investments, R&D and innovation focusing on incremental, low level of consolidation, cyclicality and mature phase of the product life cycle. (Ernst & Young 2011, p. 10)

The shifts in world economic balance started already before financial crisis of 2008. Markets in China and India are now the main drivers of global growth because of the continuing crisis in the developed economies. Over 3 billion people have joined the “middle class” in last 20 years and it has a fundamental impact for businesses globally. (Ernst & Young 2013, p. 2-7) Intensifying competition, rising production costs and the fall in demand in the traditional markets have been the major causes for the pulp and paper industry change. (Ernst & Young 2011, p. 26-27)

Internationalization and globalization are affecting the pulp and paper industry companies operating activities in many different ways. Increased competition is increasing the price competition in the industry. Also competitive position reached by the companies in the field is threatened more easily when the number of players in the area is increasing. According to a survey conducted by Ernst & Young, the pulp and paper industry companies have recently enhanced their ability to change, strengthen the trust of customers and stakeholders as well as improving the companies’ price competitiveness. (Ernst & Young 2011, p. 26-27)

Pulp and paper industry have changed radically during last decades and the changes will continue in the future. Main challenges to still focus on in the future are demand and supply imbalance, impact of electronic media, increasing energy costs, industry consolidation, geographic growth, carbon trading and climate change, wood and fibre availability, cost reductions, research and development and improved business forecasting. (Ernst & Young 2011, p. 26) Responding to these challenges requires good process management and reporting tools in place to support decision making and implementation. Changes must be embraced rather than resisted. Agility of decision making should replace the tradition of overwhelming caution and new ways to define and reconfigure the business must be found. Cost efficiency should also become a natural part of the corporate culture. (Ernst & Young, 2011, p. 32)

2 PROCESS MANAGEMENT

Improvement of enterprise performance through the identification, assessment, and improvement of the business processes has become standard practice. Business process management (BPM) is still relatively new field although “process” seems so intrinsic to the management. (Sharp et al. 2009, p. 13) Process management is not process identification or modeling but it is still essential to clearly define and model processes. Processes set the objectives and requirements of resources. Only when we know the current way of working we can consider its development. (Virtanen et al. 2005, p. 113-115)

Word process is hard to clearly differentiate from other related terms such as function, task, step or operation. There are hundreds of different definitions for process but it is frequently defined as a set of related activities. Processes are selected portions of larger streams of activity and organization’s processes are largely a mystery to its members. A good illustrative example is that organizational members know the leg, the tail, the ear, the trunk and the tusk, but not the elephant. Organization’s processes are obtained only as the result of a lot of hard work. (Nickols 2012, p. 1-2, 9, 11)

Figure 2 shows the four main steps in the development of activities under the process. First company needs to identify the key processes and that creates the basis for the development of the organization to be fast, flexible and customer-oriented. In the second stage the development project will be organized. That includes process descriptions analyzing, communications, measurement and analysis of the skills, tools and performance. Continuous development involves process development, strategic planning and accomplishment of the changes. (Laamanen 2001, p. 50) Also Virtanen et al. (2005, p. 114-115) mentioned these key steps.

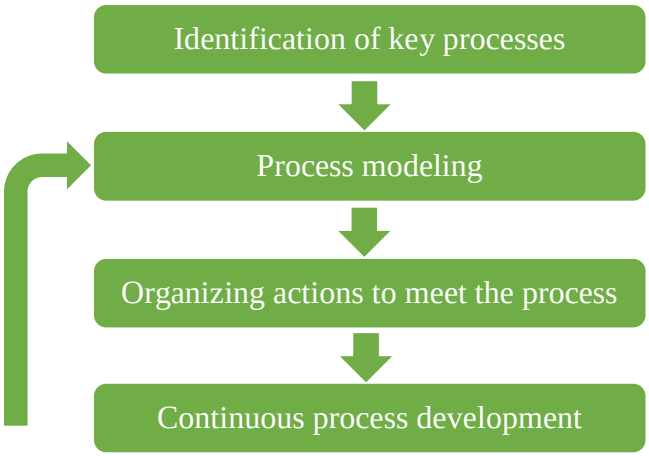


Figure 2. Main steps in the development of activities under the process (Modified from Laamanen 2001, p. 50 and Sharp 2009, p. 26)

2.1 Identification of key processes

According to Nickols (2012, p. 1, 4) focusing on a key processes is not as simple as it sounds: process definition do not define, examples are not exemplary, names do not identify and an organization's processes are essentially unknown. Process modeling is based on the identification of processes. The purpose is to find out what are the main tasks, meanings and functions related to the process. (Laamanen 2001, p. 76) Virtanen et al. (2005, p. 116) state that process identification is to separate processes from other processes and clearly define the purpose of the process and where the process begins and where it ends.

Organization's processes are usually unknowns and that's why they do not have names and cannot be identified by their name. You cannot name company's key processes until you identify them. (Nickols 2012, p. 5) Process identification prerequisite is to have a clear understanding of the organization's goals and objectives. (Virtanen et al. 2005, p. 119)

Often large organizations raises the question: Where to start?, Will we do the process map for entire group, division, business unit or department?. This requires every time an own reflection. Usually process maps are made separately in every business unit but some of the actions can be viewed in a bigger entity. One good

example is pulp and paper industry where you need cooperation with managing the multinational sales organization, optimization of manufacturing capacity and transportation planning. (Laamanen 2001, p. 69-70)

Laamanen (2001, p. 64) has found three different starting points to identify processes: analysis of operations, analysis of success factors and analysis of the customer's processes. Analysis of operations means studying the actions in the organization. At this point people usually identify the processes that do not necessarily have affect to the company's success factors. It is also hard to find the real success factors and using this method might need some new tools. Easiest and best result is obtained when people analyze the customer's processes. The aim is that processes serve customer actions as well as possible.

When making process boundaries focus needs to be on these matters according to Laamanen (2001, p. 67):

1. Important inputs and outputs find equivalents between the various processes and that is how you ensure the integrity of the process map.
2. The processes begin and end with the customer.
3. Processes begin with planning and ends with evaluation.

2.2 Process modeling

A process model is mostly graphical representation that documents the different steps that are or that have to be performed in the execution of a particular process under study. (Claes et al 2015, p. 1) It is a way to model the operations of the organization so that it could be understood, analyzed and developed. Graphical model helps communication between different departments and helps us to understand how our supply chain works. Graphical model allows for consistent analysis and thinking of possible developing points. (Laamanen 2001, p. 75)

Process modeling includes the most critical points of processes to work, shows the links and correlations between things and departments and describes the stages of operations. Modeling processes is highly important if the company wants to organize actions to meet or develop the processes. (Laamanen 2001, p.76)

According to Sharp et al. (2009, p. 56) process modeling can be summarized by identifying three kinds of processes and their characteristics:

1. Executive or strategic process: Modeling these as a process is generally not worthwhile because it is not useful to look at steps or activities.
2. Creative or collaborative processes: These parts are eminently suitable but the key is to recognize what can be modeled and what cannot.
3. Transactional processes: These processes are generally highly suitable for modeling, for example “Open account” or “Fill order”.

There are many models and techniques to model or graphically represent the processes. There are models like flowchart, data flow diagrams, role activity diagram, Gantt-chart and IDEF. Common for these models are that they contain graphic symbols which describes the functions and tasks, process start and end events and resources used by the processes. It is important to agree on an appropriate imaging technique in order to avoid misunderstandings. (Laamanen 2001, p. 79)

The thesis focuses on using cross-functional flowchart to model processes because it is flexible and easy to understand. Flowchart models the progression of the functions in organizational unit and tell the people responsible for the various functions. Unnecessary symbols usage and information sharing should be avoided until the last. There is also no need to model everything in one chart because it is better to separate these more detailed processes in subprocesses. (Virtanen et al 2005, p. 125-126) Flowcharts represents different actions or steps in a process and figure 3 shows the basic example of cross-functional flowchart.

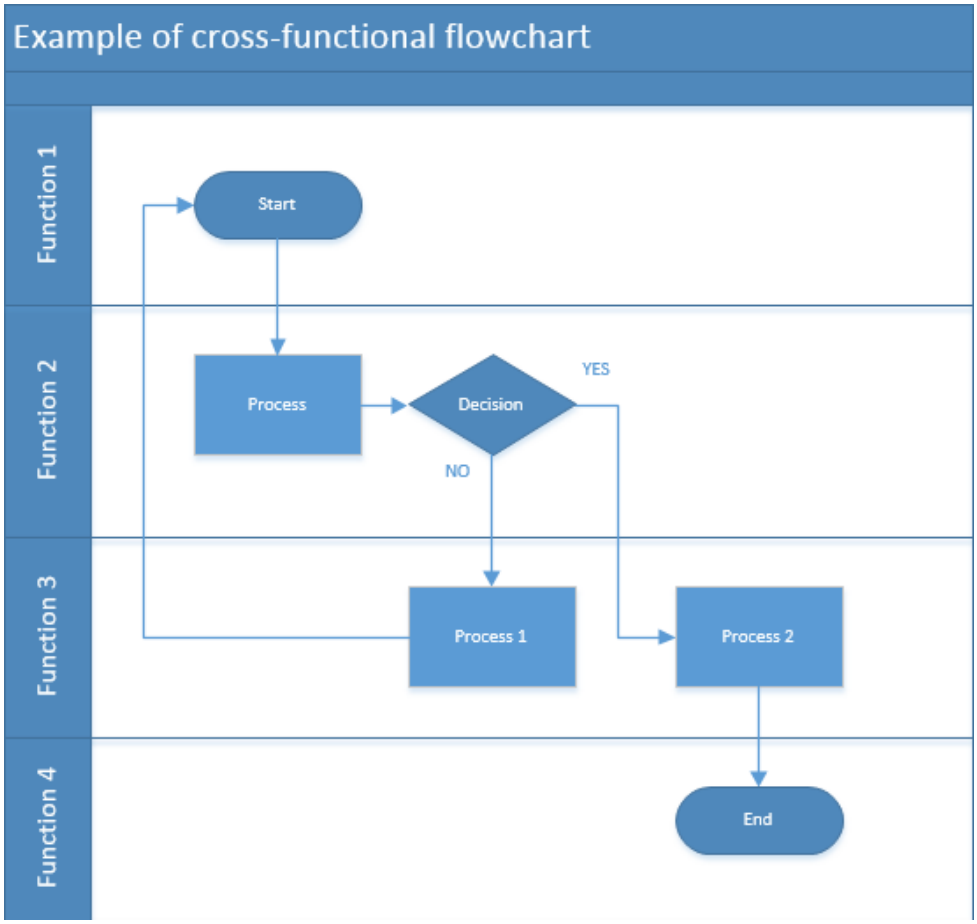
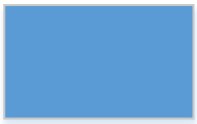


Figure 3. Example of cross-functional flowchart

Most flowcharts should be modeled with only basic flowchart symbols and should follow basic set of best practices. It makes flowchart diagrams easier to understand and read. Sometimes it is important to model processes with high precision and it may increase the need for various symbols. Specific models need specialized knowledge and development for a peer group with a similar knowledge. (Smartdraw) Table 2 show the names and descriptions for the symbols used in flowcharts in this thesis.

Table 2. Basic flowchart symbols (Modified from Smartdraw and Rfflow internet pages)

SYMBOL	NAME	DESCRIPTION
	Start/End	This shape is for the first and the last step of your process. It shows the starting and ending points.
	Process	This shape represent a process, task action or operation in process and is usually most common shape. The text in process box almost always include a verb.
	Decision	Decision shape ask a question and your answer to the question shows which arrow you should follow. Answer is usually yes/no or true/false.
	Document	This shape represent a document or a report.
	Flow or control	You go shape to shape by following these lines with arrows. These shows the flow through the chart.

Modeling technique can be divided in six different parts according to Laamanen (2001, p. 89-93) and the meaning is to find answers for the following questions:

1. Scope of application

   Where the process is applied and where it begins and ends?

2. Customers, their needs and requirements

Who are the customers and stakeholders of the process?

Where they use the products and services of the processes and what are the requirements they impose?

3. Target

   What is the target for the process?

   What are the success factors of the process and how you measure them?

4. Feeds, products and services

   What are the feeds, products and services?

   How to manage data?

5. Process map

   What is the meaning of the process? What kind of process map?

6. Responsibilities

   What are the key roles and the main ground rules?

2.3 Organizing actions to meet the processes

After identifying and modeling processes it is important to recognize and understand them. There have been created an illusion of process management without actions. According to Laamanen (2001, p. 96) there are six important parts for organizing actions:

1. Evaluation of processes
2. Registration of roles
3. Starting the measurement
4. The creation of teams and networks
5. Analyzing competences and tools
6. Process audits.

First needs to be clearly defined the company's mission statement and then identified the strategic objectives according to them. These include for example market share, quality, cost and flexibility. Every functional area needs to understand their role in achieving the strategic objectives. There is need to develop global performance measures that are capable of defining the company's overall competitive position to top management. Performance goals and strategic

objectives are communicated at all organizational levels. Ensure the consistency of strategic objectives at each level among performance levels and compatibility of performance measures. Performance measures are used to identify competitive position, problem areas, updating strategic objectives and making tactical decisions. Periodically reevaluate the measurement systems and process scopes. (Wisner 1991, p. 9)

2.4 Continuous process development

The developments of processes are characterized by the fact that these are related to the core of the process to increase performance. (Laamanen 2001, p. 203) If the problem or need for development is focused on the systems then you should take analytical approach. If the problem is in human relationships then analysis is just a disadvantage. (Laamanen 2001, p. 209)

A large number of different concepts have been created for process development. According to Laamanen (2001, p. 209) there are three different concepts:

1. Process design and improvement of performance
2. Problem solving
3. Benchmarking (sharing the best practices).

All of these concepts are characterized by describing processes, measurement, analyzing and testing solutions. These concepts can be demonstrated with a PDCA-model (Demigns circle: Plan, Do, Check, Act), which is maybe the most used development concept in the world. But all of these three concept have also unique approaches. Looking at the processes in the light of the needs of the stakeholders and drive for continuous development is characteristic for process design and improvement of performance. Problem solving –concept is focused on recognizing problems that disturb organizations actions or good performance and benchmarking is a concept which seeks answers to questions: “Are we good enough”, “How good should we be?” and “How good we could be?”. (Laamanen 2001, p. 209-211, 217) More about benchmarking in chapter 4.4.

3 SUPPLY CHAIN PROCESS ELEMENTS IN MANUFACTURING INDUSTRY

Rules of the supply chain processes in a dynamic and global market place change rapidly due to the uncertainty in demand, changes in technology, and changes in competition. (Prater 2013, p. 56) The thesis looks supply chain process elements from internal business process perspective. It starts with the sales and operation planning and finishes with deliveries of the products to the customers. We can separate strategic objectives to three different main categories; production planning, warehousing and transportation. Measurements of these processes are likely to be included as critical performance measures in any organizations perspective. (Jong et al 2005, p. 341) Figure 4 shows the main categories that this thesis focuses on.

Figure 4. Main process elements of the thesis

Supply chain management (SCM) emphasises efficiency and effectiveness in a supply chain network to ensure sustainability and then profitability, growth and competitiveness. Competitive environment creates pressure for supply chain managers to quickly respond to inventory shortages, customer complaints and unreliable transport situations. This all needs to happen without affecting to customer satisfaction when at the same time there is a pressure to reduce costs, shorten lead times and lower inventory levels. (Chithambaranathan 2015, p. 309-310)

3.1 Supply chain planning

Supply chain planning sets the stage for carrying out activities like production planning, inventory management or deliveries. Planning provide information of

volumes for the production planning, warehouse management and deliveries. Planning is critical for business performance because it allows the company to balance demand and supply. (Cohen 2013, p. 50-51) The planning horizon in pulp supply chain extends from almost a half a century down to hours and minutes. Planning horizon can be divided in three different parts: strategic planning, tactical planning and operative planning. (Carlsson et al. 2009, p. 173-174)

Strategic planning (long-term planning) is very long-term because for example investments for new pulp mill intend to last for more than 30 years. Strategic decisions would relate to the location of a new pulp mill, opening or shutting down pulp mills, product and market development, inventory location etc. Long-term planning has a major impact on all the investment decision. It will establish parameters like inventory levels, technology needed, maximum distance to customers and capacity. (Carlsson et al. 2009, p. 173)

Tactical planning (mid-term planning) addresses the responsibilities for realizing the different supply chain activities. It also addresses the usage rules defining production, distribution delays, lot sizing and inventory policies. Defining those rules through a global analysis of the supply chain is one of the most important part of the tactical planning. This planning serves as a bridge from long-term strategic planning to detail operational planning. Tactical planning ensure that the direction which has been established in the strategic planning is followed in the operational planning. This means allocation of customers to mills and definition of distribution capacity. Distribution planning depends on the type of transportation. Vessels (ship or badge) and rail transportation needs further planning than trucks. (Carlsson et al. 2009, p. 173-174)

An example of tactical planning task is the production planning of pulp mills. The purpose of the plan is to define guidelines on monthly levels to help operational planning. The problem is to ensure that mills are sufficiently supplied while the total transport cost is minimized. An important task is planning the annual budget for the next year. The company decides the products and the volumes to offer to customers and in what quantities. The process implications need to be evaluated for

the whole supply chain (production, warehousing and transportation). (Carlsson et al. 2009, p. 174-175)

Operative planning (short-term planning) means the planning of the real-world operative actions. The precise timing of operations is really important because actions should be defined in terms of days or hours. The operative planning is normally placed to the different facilities because of the big quantity of data that needs to be manipulated. Production scheduling on the pulp lines is a typical operational planning task. Process control of pulp manufacturing needs real time operative planning decisions. (Carlsson et al. 2009, p. 175)

3.1.1 Sales and operations planning (S&OP)

Sales and operations planning (S&OP) is a key business process to use supply capabilities to balance customer demand. S&OP keeps an essential role in performing the task of integrating organizational units along a supply chain and improving competitiveness as a whole. Increasing supply chain complexity raise challenges for coordination. (Tuomikangas et al 2014, p. 244) There are a lot of definitions for S&OP and here is one according to Karrenbauer (2015, p. 12) “A set of decision-making processes to balance demand and supply, to integrate financial and operational planning, and to link high level strategic plans with day-to-day operations.”

Simple but continuous development is needed to reach the following targets for pulp S&OP at company mills (Seppälä 2015, p.2):

- Keeping stocks at targeted levels
- Maximizing profitability
- Ensuring full run of mills
- Keeping things simple.

3.1.2 Production planning and scheduling

Production planning process can be also called as a forecasting process and it must be mastered to survive in today's competitive markets. Forecasting is more accurate for short time frames than long-term planning. To make precise forecasts a company has to synchronize forecast period and lead time. Controlling demand uncertainties by using various forecasting techniques require also a fair amount of insight, judgment, and intuition. (Prater et al. 2013, p. 48, 56)

Production planning and scheduling in the pulp industry and other process industries can be very challenging. There are multiple criteria which has to be considered and properly weighted when devising a production plan. Companies must improve customer satisfaction indicators, while keeping production costs as low as possible. (Figueira et al. 2015, p. 85) Production planning represent the beating heart of manufacturing process. Its purpose is to maximize and organize the use of resources and minimize production time and costs. With an effective production planning the manufacturing process has the capability to exploit its full potential. (Production planning 2011)

The volumes and quality of the supply is hard to predict with great accuracy and that makes pulp business unique. The planning horizons range from very short to very long and that is why it is hard to use standard planning systems. (Carlsson et al. 2009, p. 181) Production planning is usually addressed manually to practitioners even when there is many advanced tools nowadays for particular tasks. Most practitioners rely only on spreadsheets and this manual process is time-consuming and completely dependent on planners' expertise. (Figueira 2015, p. 85)

Table 3 provides examples of products with different kinds of demand and supply uncertainties. It is more challenging to operate a supply chain that is on the right column than in the left column and also more challenging to operate a supply chain than is in the lower row than in the upper row. (Lee 2002, p. 108)

Table 3. Examples of products with different uncertainties (Modified from Lee 2002, p. 108)

		Demand uncertainty	
Supply uncertainty		**Low (Functional products)**	**High (Innovation products)**
	Low (Stable process)	Grocery, oil, gas, **PULP**	Fashion apparel, computers, music
	High (Evolving process)	Hydro-electric power	High-end computers, telecom

Table 3 shows that pulp products belong to the easiest category when it comes to uncertainty. Demand uncertainty is low and supply uncertainty is also low. This means that supply chain for commodity products like pulp is easier to operate than for example high-end computers but of course all have their own challenges.

3.1.3 Warehousing

All organizations keep warehouses and these can include raw materials, work in process, supplies and finished goods. Companies need inventories because there is a difference in the timing of supply and demand. In a just-in-time manufacturing environment inventories are not needed but here are reasons for obtaining and holding inventories in other environments:

- Creating buffers against uncertainties
- Utilizing economies of scale by manufacturing batches
- Decreasing purchasing and transportation costs with high volumes
- Preparing for seasonal fluctuations in demand (Muller 2003, p. 2-3)
- Exploiting speculative opportunities. (Shapiro 2007, p. 403)

The main objective of a warehouse is to offer a temporary shelter to the products. The role of a warehouse is nowadays evolved into a logistical switching facility rather than a storage facility. The need for warehouses arises when there is need to store products from the time they are produced to the time delivered. The distant

dream for supply chain authorities is to achieve a perfect match between production and logistics planning and to forecast the demand with the high degree of accuracy. Purpose is to fulfill the customer orders and have an effective utilization of space, equipment and labor. (Gill 2014, p. 471-473) Good inventory management include better forecasting, improved financial returns by reducing costs, identification of crucial products, and the ability to support just-in-time strategies. Keeping up to date to the latest inventory control trends through trade organizations, customer contacts, and so forth will give the company a competitive advantage. Knowing trends and your capabilities will allow you to gain respect from your trading partners along the way. (Prater 2013, p. 78-79)

The main operations in a warehouse are receiving, storage, order-picking and shipping. The receiving process means the collection of activities that involve the orderly receipt of all materials in the warehouse, meaning arrival of the goods to warehouse and verifying product quantity and quality. Storage process means the physical shelter for products and the function includes the movement of products to a storage location, the recording the storage locations and quantities and updating the storage records. Order-picking function means removing products from storage locations as the requirements given for a specific customer orders and fill the orders with desired quantities. Shipping is the final process and it include checked orders, packing and eventually loaded trucks, trains or ships. (Gill 2014, p. 473-474)

Determining the level of buffers (also called safety stocks) is necessary in order to protect against uncertainties. Lead-time variations and changes in customer demand need some protection by making safety stocks. There is always some cases when inventories will deplete a faster or slower rate than expected. (Benton 2014, p. 123-124)

3.1.4 Transportation

Delivery is a major process in supply chain and it is closely linked to other activities. Delivery process excellence is based on the fact that customer receives goods on time at required standards of quality and cost. For industries that produce bulky products, manufacturing plants and distribution centers must be relatively close to

each other. Delivery sub processes are shown in figure 5 and all the processes mentioned before are closely related to transportation process. (Cohen 2013, p. 57)

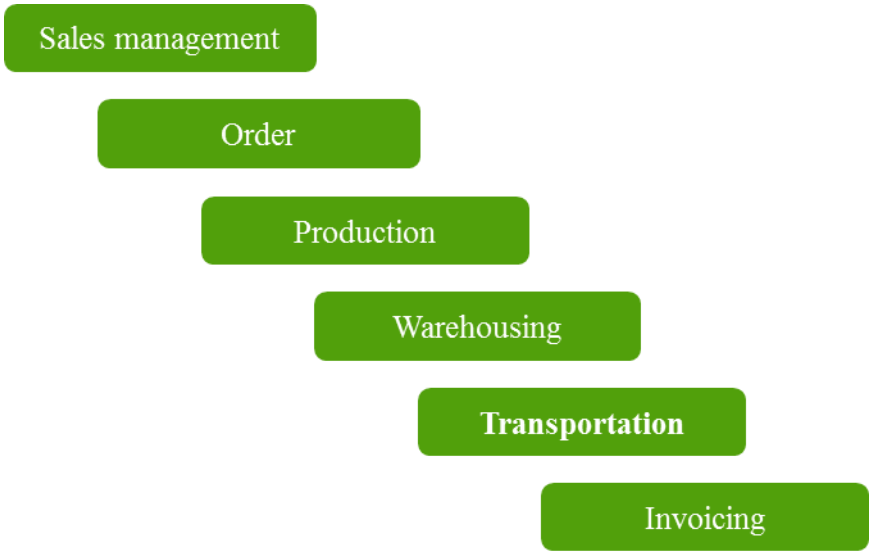


Figure 5. Delivery sub processes (Modified from Cohen 2013, p. 57)

Transportation process should not be underestimated because you have to remember that sale will not take place without having the right goods in the right place at the right time. Important decisions are mode of transport, the physical architecture of distribution system and to own or contract-out warehousing and transport. There are many different transportation types like trucks, railroads, and water transport. If company use more than one transport type it is said as to having multimodal transport method. Trucks are flexible, provide low damage, have wide geographical coverage, and good tracking and accuracy. There is also heavy price competition in the trucking industry and that bring prices down. Railroads are slightly slower than trucks but cost saving can be fairly substantial. Water transport is necessary because of overseas shipments for heavy, low value and non-perishable products. Containerization, strong port management, and port expansion increasing make this transportation type a reliable alternative. (Prater 2013, p. 81-83)

A well running transportation operation maximizes delivery asset utilization at the same time that minimizes labor and delivers the expected customer service level. Companies need to establish the right fleet size and composition, optimize daily vehicle routing to reduce distance and implement a performance management execution process in order to achieve these objectives. There are different

approaches available for achieving these goals but company need to ensure that the fleet operation is a key enabler to deliver products cost effectively. (Mendes 2011, p. 86) Supply chain managers must accept the different aspects of managing distribution when comparing domestic and global structure. Lead time is longer because of longer distances, transportation is more costly and multiple modes of transport is needed. (Prater 2013, p. 93)

4 PERFORMANCE MEASUREMENT OF SUPPLY CHAIN PROCESSES

Performance measurement and management (PMM) has increased enormously in the last three decades. Performance measurement can be described as the process of quantifying efficiency and effectiveness of actions and it is an important element in business performance improvement. There are several metrics developed and classified as follows:

- Qualitative or quantitative
- What they measure? (i.e. cost vs non-cost, quality, visibility, delivery and flexibility)
- Operational, tactical or strategic focus
- Related process in supply chain (Garengo et al. 2015, p. 6475)

SC performance measurement main purpose is to get information for top managements needs and show how efficient SC is. (Sillanpää 2015, p. 291) Having mapped the supply chain processes it is important to assign measures to these processes to evaluate changes and to assess the performance to both complete SC and individual processes. Relevant metrics are aligned with the supply chain strategy and reflect to important scopes. (Stadtler et al. 2008, p. 49) According to Horváth and Moeller (2004, p. 156) performance measurement delivers information which help to align operations and strategies towards the formal targets.

4.1 Supply chain performance management

Companies have to deploy metrics effectively to get the advantage from supply chain performance measurement to performance management. Monitoring performance metrics regularly and using them to continuous improvement is a key for successful performance management. It depends on the metric that how often companies should monitor them but usually monthly reporting is sufficient for most high-level metrics. It does not make sense to measure something for example weekly if there is no reason that it could change. Low-level metrics such as inventory levels and on time-delivery can be monitored weekly or even daily. (Cohen 2013, p. 188-189)

Managers throughout organization are able to track their progress towards their goals better if metrics and performance data are highly visible. This help them to spot performance shortfalls and take corrective actions quickly. Almost every performance-improvement initiative requires system support but it is in companies hand to decide if they buy a new module or a stand-alone solution that offloads data from the system. Today's information systems are capable of collecting and analysing a large amount of data but pay attention that only the data required to calculate metrics is used. Data should be "clean", accurate and up-to-date because otherwise companies risk recognizing a problem which can be misleading. (Cohen 2013, p. 189-193)

To have an effective management tool of metrics for supply chain, companies need to take care of the following matters. Integrate quantitative targets into plans and budgets if the aim is to reduce distribution costs. Also set meaningful targets which are established at the individual and departmental levels. Identify performance exceptions enabling to see what is going on. This means understanding and measuring the data at the right levels. (Cohen 2013, p. 198-199)

4.2 Challenges in supply chain measurement

Supply chain managers face many challenges when trying to make supply chain as efficient as possible. Holmberg (2000, p. 851-852) categorized measurement problems in four main problem areas:

Strategy and measurements are not connected

Many measurement initiatives are not derived from the strategy and therefore do not support the business. Measurement seems to focus on internal functions instead of overall company performance and customer needs. Different divisions and functions might have different metrics and links and this might lead them in different directions. (Holmberg 2000, p. 851)

A biased focus on financial metrics

Companies rely heavily on financial figures as KPI and these are better at showing yesterday's actions than indicating tomorrow's performance. Success in business

does not mean only a strong cash flow or meeting a financial budget. It is more likely defined as improving competency, innovation and capabilities in different areas. (Holmberg 2000, p. 851-852)

Too many isolated and incompatible measures

The number of metrics in companies tend to increase over time and it requires more resources to keep them up to date. Measurement systems usually measure too many things and also wrong unnecessary things. Companies need to focus on giving top priority to measures which they need to meet the customer needs as well as possible. (Holmberg 2000, p. 852)

The problems in a supply chain context

The increasing complexity in supply chains is understood in different ways inside the individual companies and between different partners in the supply chain. (Holmberg 2000, p. 852)

Table 4 show some challenges and operational requirements in supply chain measurement that Richards mentioned in his article. All these challenges have different operational requirements. This means all the challenges need special research and operational actions separately.

Table 4. Basic challenges and requirements in supply chain measurement (Adapted from Richards 2011, p. 33)

CHALLENGE	OPERATIONAL REQUIREMENT
Cost reduction	Productivity increase, space/stuff/equipment improvement
Perfect order	Improvement in productivity, accuracy and handling
Sales via multiple channels	Improved picking strategies and greater use of technology
Fluctuations in demand	Improved forecasting
Information flow	Real-time data transfer

4.3 Supply chain metrics

Supply chain has a process-oriented nature which should be kept in mind when choosing supply chain performance metrics. Every supply chain is unique and need special treatment. (Stadtler et al. 2008, p. 50, 52) Performance literature shows a wide collection of different performance measurement models and tools, for example supply chain operations reference –model (SCOR) and balanced scorecard (BSC). (Horváth 2004, p. 160-161)

There are countless different metrics to measure supply chain performance and managers often find it difficult to select appropriate measures for particular processes. Performance measures have a key role in companies supply chain success by evaluating performance and benchmarking the results against similar organizations. These measures can be categorized into quality, financial, time, product flexibility, overall performance and innovation. (Elrod et al. 2013, p. 39-40)

One effective measure of supply chain performance is financial cost. Companies strive to minimize costs to increase profits and these measures help companies see where the money is spent and minimize unnecessary costs. Another very important measure of supply chain performance is quality. It can be defined as the perception where the product or service meets the consumers demand. A quality product generates better revenue and fortunately there are many ways to determine the quality of a product. All tasks along supply chain consume time and therefore time is also an important measure. Companies can separate processes and calculate each of them differently and sum the total time consumed in the processes at the end. Flexibility refers to the ability of the company to adapt to changes. This could mean strikes, a breakdown in a machine or sudden increase in demand for a product. Flexible supply chain has an ability to adjust with customer needs and respond to competitive pressures. (Elrod et al. 2013, p. 40-47)

The thesis presents specific performance measures for pulp supply chain and discusses their strengths, limitations and applications. These performance measures are grouped into three different categories: production planning, warehousing and transportation. These categories have different measures in financial costs (C),

quality (Q), time (T) and flexibility (F). The letters in front of every metric in figures 6, 7, 8, 9 and 10 tells in which category it belong.

4.3.1 Production planning measurement

Figure 6 describes measures related to production planning and the supply chain of the thesis. There are three KPI's for measuring production planning category: faulty products/production accuracy, manufacturing lead time and production capacity utilization.

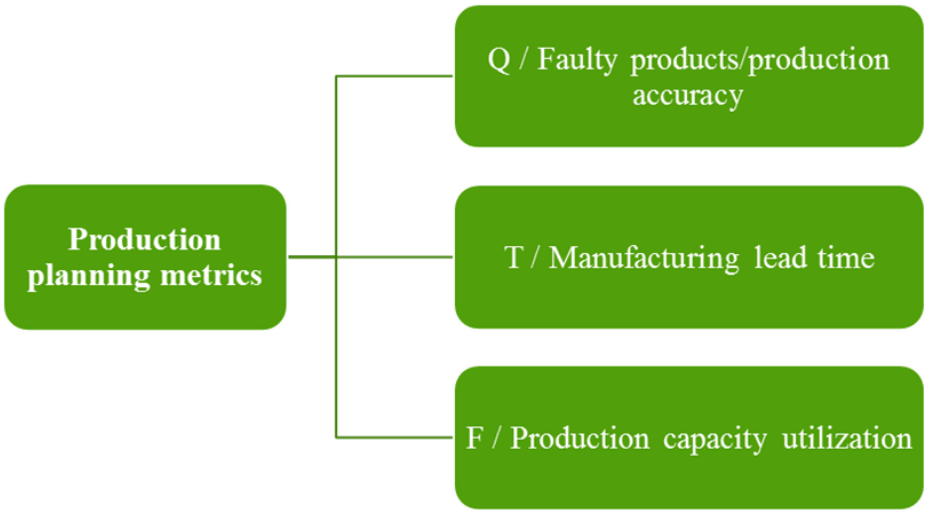


Figure 6. Production planning measures in pulp supply chain

Faulty products/production accuracy measure considers the ratio of correctly produced products to incorrectly produced products. When wrong products are produced or delivered it will have an impact to customer goodwill and brand name. This is internal measure and it is difficult to isolate the causes of inaccuracies. (Elrod et al. 2013, p. 44)

Manufacturing lead time includes the time from point of order release until order is shipped so it identifies overall manufacturing time. It could also be said as manufacturing cycle or throughput time. If this lead time is too great, the supply chain loses the ability to be agile and quickly respond to customer's needs. (Elrod et al. 2013, p. 46) Lead time is one of the key elements that customers are interested in so it can be called as an competitive advantage. (Sillanpää 2015, p. 296) This is

a helpful measure for the company to give the customer an idea of wait time. Smaller orders usually have shorter lead times than larger orders. This measure can easily make errors and lag time. It can also be misleading because other factors must be considered. Reducing all idle times, like shutdowns, tend to increase customer satisfaction. (Elrod et al. 2013, p. 45)

Companies have capacity limitations on equipment. Extend to which the company utilizes their equipment is called ***capacity utilization***. It can be calculated as follows:

$$Capacity\ utilization = \frac{Total\ actual\ capacity}{\text{Designed capacity}}$$

Capacity utilization can be expressed in percentages and is calculated over a period of time or at any point of time. (Elrod et al. 2013, p. 47) It indicates how much of the total manufacturing output capacity is being utilized at a given time. This directly affects the speed of response to customer demand through its impact on flexibility, lead time and deliverability. (Gunasekaran 2003, p. 337)

4.3.2 Warehousing measurement

Performance measurement from a warehouse perspective means ensuring accuracy, quality, timeliness and cost effectiveness within the process. Each company has different priorities, customer base and methods of operations so companies need to choose most appropriate measures exactly for their need. (Richards 2011, p. 229-235) The purpose of warehousing measurement is to find central objectives through the following processes: lowest cost for revenue value received, improved quality, supply network simplification and improved channel inventory information. (Ross 2015, p. 344) Figure 7 describes the most important measures for pulp supply chain warehousing measurement.

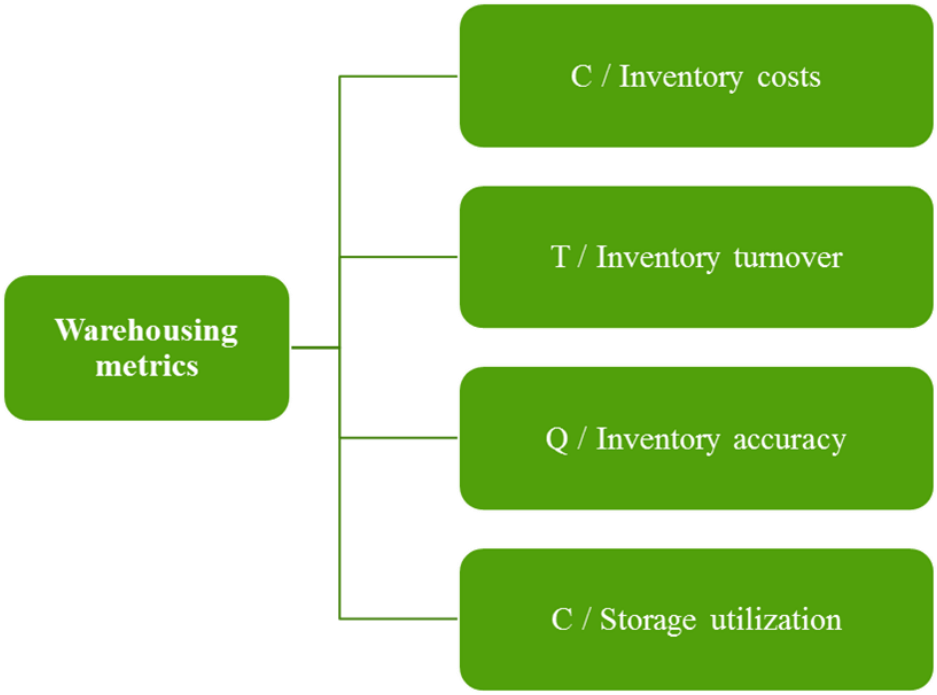


Figure 7. Warehousing measures in pulp supply chain

Inventory costs typically include raw materials, semi-finished goods, materials and products. The most identifiable component of inventory costs is defined as the "holding cost of inventory". This cost covers the capital cost of money tied up in inventory and physical cost of having inventory. Inventory cost cannot be zero because companies must maintain stock for uncertainties that may arise and this is called "safety stock". (Elrod et al. 2013, p. 42-43)

There are three costs that are related to inventory costs: safety stocks, finished good inventory and warehouse costs. Safety stock is used to cover situations such as production shortfalls, transportation failure, supply failure or information distortion. The safety stock is related to service level because decreasing the safety stock could lead to the lower service level. The safety stock is needed because of the uncertainty in the forecast so that is why organizations need accurate forecasts. (Thomopulos 2015, p. 149-151) There are several ways to determine the level of safety stock. The thesis uses the most popular approach "probability of stocking out during any lead time cycle". (Benton 2014, p. 124)

Finished goods inventory should be as low as possible. This can be achieved by reducing lead time in production, reducing the amount of waste in the process and

by reducing the physical units held in the storage. The process has a significant meaning for company's operating profit and financial performance. As seen from the figure 8, finished products storage play a significant role in structure of logistical fixed costs. Warehouse costs are called "hidden costs" because these costs are configured until the total costs are calculated. Key contributors for these costs are rent, maintenance and labor costs. Multi-national and multi-product companies use a regional warehouse approach which allows the company to reduce transportation costs and increase customer satisfaction. (Elrod et al. 2013, p. 42-43)

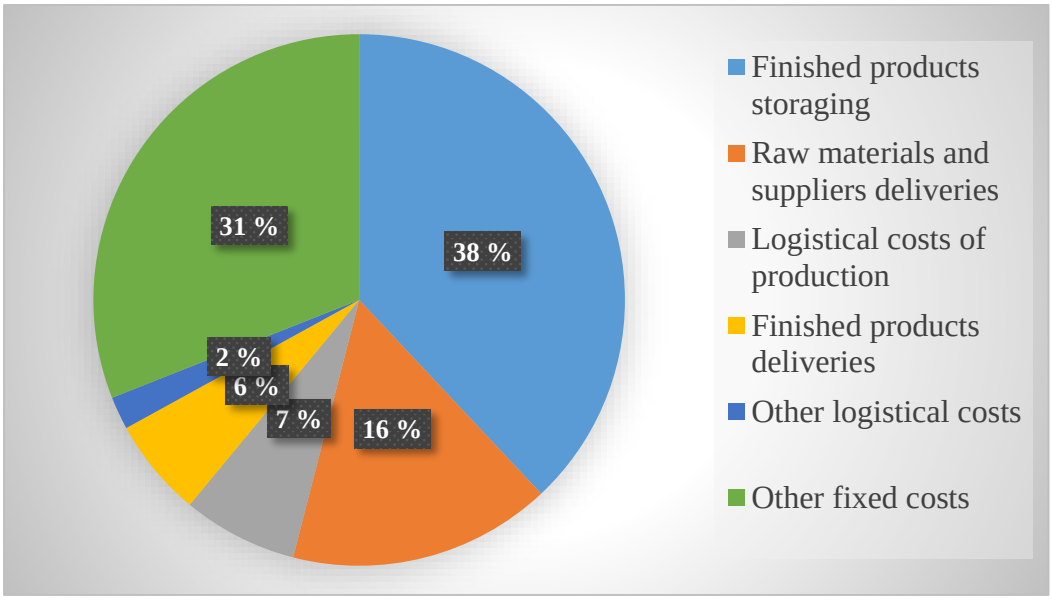


Figure 8. Structure of logistical fixed costs (Treshkina 2011, p. 68)

Inventory turnover is one of the key metrics for warehousing and it describes how often the units in the stock change. These calculations affect to the stock policies. The higher the turnover is, the better it is usually felt because committed capital for warehouse is smaller. (Richards 2011, p. 239) There are several different ways to calculate inventory turnover but the most popular one is what Ross (2015, p. 347) mentioned:

$$\text{Inventory turnover} = \frac{\text{Cost of goods sold during time period}}{\text{Average inventory valued at cost during time period}}$$

Turnover rate can be also measured by time and the statistic can be called as stop time. Consumption that this warehouse is compared to can be historical

consumption or forecast for the future. (Sakki 2009, p. 76-77) This metric can be calculated as:

$$\text{Stop time} = \frac{365}{\text{Inventory turnover}}(d)$$

Inventory accuracy is an important measure because the more accurate the stock is the better the company can fulfil orders correctly and increase efficiency. This can also be called as inventory when you count your storages. Location stock accuracy percentage can be measured as (Richards 2011, p. 240):

$$\text{Invenory accuracy} = 100 * \frac{\text{Numbers of correct locations}}{\text{Numbers of locations counted}}$$

Storage utilization is the challenge that most of the warehouse managers face at some point. Poorly utilized warehouse is usually caused by steady growth, changing storage requirements and increasing service requirements. Warehouses are built to handle planned volumes, a set number of products and limited unit loads. These are expected to adjust to customer demands as well as possible. In order to manage warehouses properly information must be maintained in real-time.

4.3.3 Transportation measurement

Increased transportation expenses can weaken the company's growth opportunities. The main reason for measuring transportation is to respond to dynamic environment needs as accurately as possible with as low costs as possible. Figure 9 shows the KPI's for transportation measurement.

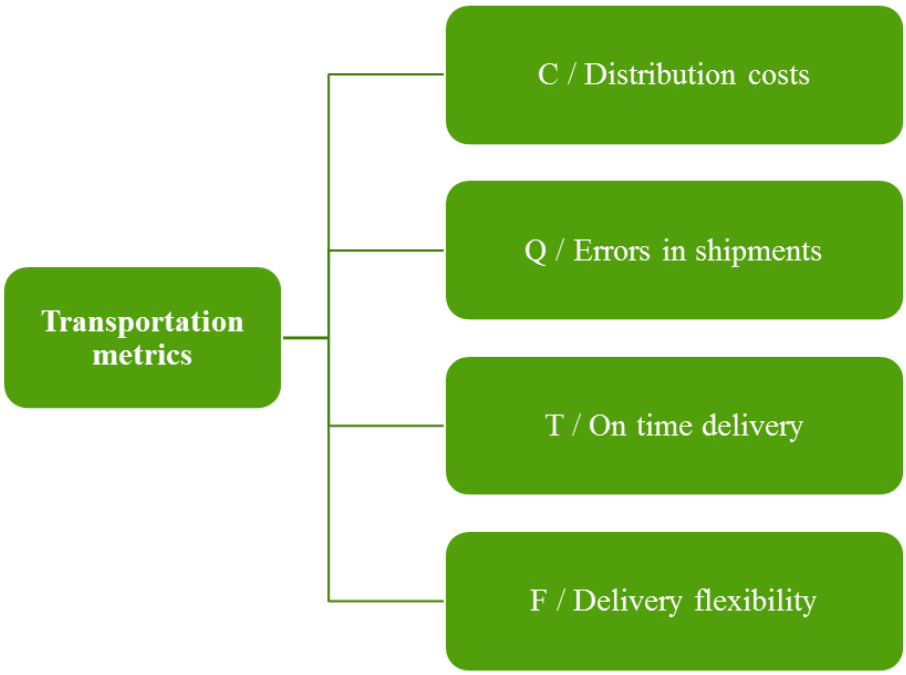


Figure 9. Transportation measures in pulp supply chain

Distribution costs are usually defined as the costs of delivering the product to the end user. It has an effect to companies' profitability in supply chain management and there is usually a desire to reduce logistics costs. Reducing costs include finding best locations and minimizing inventory and transportation costs. (Li X et al. 2006, s. 1138) Distribution costs itself include total costs of vehicles, fuel costs, labor costs, travelling expenses and other cost related to moving the products. These costs can be a larger expense than manufacturing costs. Planning and coordination is required to establish an efficient distribution system. Geographical location of warehouses and customers also reflect to distribution costs. (Elrod et al. 2013, p. 41)

On time delivery is a very important measure for customer satisfaction. The higher the percentage of deliveries on-time and the smaller the delivery window is, the closer the company is for having a world class supply chain. This means the percentage of the deliveries that was committed to customers on the schedule. One good measure also for reliability is fill rate:

$$\text{Fill rate} = \frac{\text{Delivered orders}}{\text{All orders}}$$

When monitoring the fill rate it is important to follow how fill rate changes during a time period. Companies can also measure reliability of delivery which is the difference between planned and actual deliveries. (Sakki 2009, p. 79)

Shipment errors like wrong product or wrong destination cause always additional expenses for the company. It also reduces the customers' satisfaction. These kind of errors should be minimized by improving information management, order handling and loading accuracy. (Elrod et al. 2013, p. 43-44)

Delivery flexibility means ability to schedule delivery dates. Customers will more likely be satisfied if product deliveries are on schedule. Companies and also customers can use previous data of deliveries when planning the delivery date. (Elrod et al. 2013, p. 47)

4.3.4 Common supply chain measurement

This chapter gives a brief overview of the common supply chain metrics that have an impact to the whole supply chain. Figure 10 shows the key measures that need to be taken into consideration when thinking of well performing supply chain.

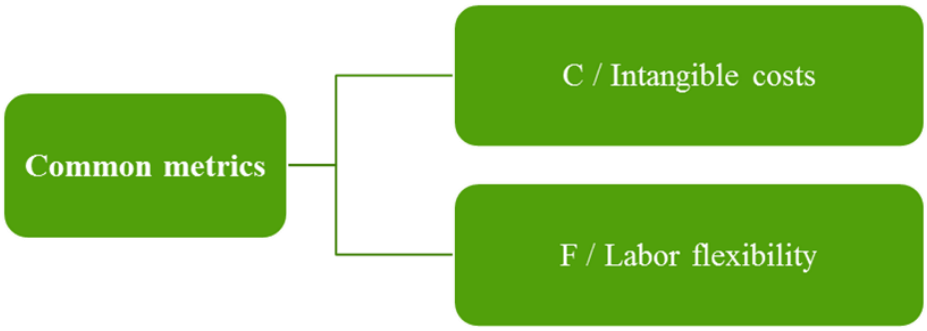


Figure 10. Common supply chain measures in pulp supply chain

Intangible costs are non-quantifiable and not associated with one particular product. These costs are closely related to employee morale, customer goodwill and research. Intangible costs can have positive or negative impact to supply chain performance. Employee morale and customer goodwill impact the company as a

whole but these cannot be counted as a cost. Customers can stop doing business with the company or employees can affect to the profitability of SC. These costs cannot be ignored but are really difficult to estimate. (Elrod 2013, p. 41, 43)

The number of tasks an employee can perform is a measure called ***labor flexibility***. People working for the successful company should be flexible and capable of performing many processes at the firm. Training and hiring new employees is a substantial cost for the firm. (Elrod 2013, p. 47)

Measures like volume flexibility, plant volume flexibility or expansion flexibility are also mentioned in the literature. The thesis focuses on company which produces commodity products with the largest possible volumes and therefore these measures are less crucial.

4.4 Benchmarking in supply chain

Benchmarking is a popular tool to improve company's performance and competitiveness. Over 70 % of managers reported using this tool. It translates into higher profitability for the organizations which practice benchmarking. Better financial results, operational and business performance and the capacity for change in strategic thinking are the benefits derived from benchmarking. (Wong 2008, p. 25-27)

There is plenty of definitions given by researchers for benchmarking. Benchmarking is defined as a continuous, systematic process for evaluating the products, services and work processes of organization that are recognized as representing best practises for continuous improvement. So it searches best practises, innovative ideas and efficiencies for improving organizations competitiveness. (Wong 2008, p. 27)

The following is a list of benefits for doing benchmarking according to Cusack (2009, p. 13-14):

- Snapshot for comparison of performance to company/industry
- Identifying best practices and key performance indicators (KPIs)
- Setting goals and objectives for organizations and employees

- Developing support for business
- Assessing improvement over time.

Benchmarking helps companies to learn quickly from others. It is based on the Deming Cycle (plan, do, check, act (PDCA)) which is a standard four phase continuous improvement cycle. Cycle is shown on figure 11. First phase "plan" focuses on selection of processes to benchmark and how to do that. Second phase "do" involves forming team for benchmarking and selection of partners. It also describes characterization of selected processes using metrics. Third phase "check" means analysis between the benchmarking company and the benchmarking partner. Fourth and the last phase "act" refers to the implementation and launching of the corrective actions to improve existing performance. (Wong 2008, p. 27-28)

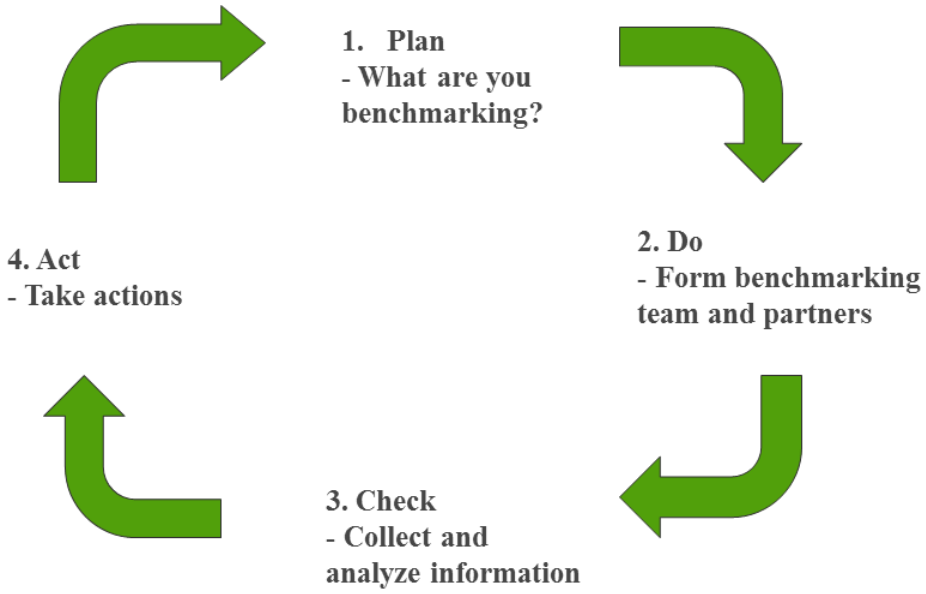


Figure 11. Demign cycle (PDCA) (Adapted from Wong 2008, p. 27-28)

Most of the literature on benchmarking of supply chain performance measures focuses on intra-organizational level. Today's trends in researches however began to focus more to inter-organizational level in benchmarking. Entire supply chain needs to be taken into consideration in this level and decision making requires a collaborative relationship. SC benchmarking is different to other fields in size, characteristics, ideals and needs. (Wong 2008, p. 30, 34)

SC benchmarking also has some serious problems in performance benchmarking. The following three points are the key problems:

1) SC is not usually shown as a whole entity in literature. It is difficult to evaluate performance because of multiple inputs and outputs to the system. Relationships between the inputs and the outputs are complex.
2) Addressing the collaborative relationship involving join decision making have failed and mathematical models are scarce.
3) SCOR need more efficient model in dynamic platform to address the integration of collaboration. (Wong 2008, p. 36-37)

5 CASE COMPANY PROCESSES

The competitive situation in pulp and paper industry in Europe is currently challenging. The competition is faced mostly between the companies but also in material procurement as well as in use of technological solutions. Companies operating in Europe are facing challenges in price war, responsiveness to the changing business and the resistance to change. The biggest threat for P&PI in Europe is the growing competition outside Europe. Also the price and the taxation of energy are very critical factors for the competitiveness. Sustainable development in BPM has an important role when thinking about the future and increasing competitiveness. Bio-economy and bio-based products can help companies to get competitive advantage.

The case company of this research is a global manufacturer of high-quality pulp products. Pulp is a raw material for many products that people use daily and it is therefore part of our everyday life. Products like paper bags, books, magazines, medical pills, clothes, household and toilet papers and food/liquid packages are usually made from pulp. The company has four modern and efficient pulp mills globally and total production capacity is over 3,5 million tons per year. Pulp products can be called as bulk or commodity products and it means products which are rapidly increasing in the markets, sold in high volumes and globally fast-growing. Company uses spruce, pine and birch in Finnish pulp mills and the origin of the wood used is always known and is mainly sourced from private land owners. In South America the company uses eucalyptus as raw material. The aim for the company is to grow as a cost competitive pulp producer with benefits from integrated full-production and versatile pulp product offering.

5.1 Supply chain process modeling

As stated before, this thesis will concentrate on processes from internal business process perspective. Next chapters models the current state pulp SC processes at two mills of the case company. Processes are divided in three different sections; production planning, warehousing and transportation. The meaning of the modeling

is to have end to end process visibility, communication and collaborate advantage, support for management needs and alignment with strategy and organizational goals. Achieving a balance between costs, times, quality and flexibility is a key to SC performance and process control. There is no need to develop the whole SC structure but focus on improving and adding value to key factors and linking SC parts together with great synergy.

These two mills of the company (which this thesis focuses on) are located quite near to each other so geographically these mills do not differ significantly. Products are manufactured based on demand forecasts and it is called as make to stock – manufacturing. Warehouses are located in both mills and in two ports in Finland. Ports have their own operators to deal with truck or train unloading and shipments. Key processes in both mills are quite similar so there is no need to separate these process models from each other. SCC's in these pulp SC's belong to the same SC team and co-operation between different mills has to be seamless. Chapters 5.2 and 5.3 explain in more detail that how these SC's differ from each other and what kind of special attention they require.

5.1.1 Production planning process

Production planning process is shown in figure 12. The process begins with sales and operations planning. Planning framework for S&OP can be divided in three parts: annual planning, monthly demand/stock balancing and weekly check. Annual planning gives sales and production forecasts for the next year and plan is usually slightly oversold. Monthly demand/stock balancing is for reviewing forecasted stock development, stock targets steering and possible mid-term sales. Updated plans for shutdowns, deliveries and checking profitability follow-up are also made in monthly balancing meeting. Weekly follow-up is organized for short-term issues in production, deliveries and sales.

Production planning process continues in the case production plants when SCC implements the plans and makes possible changes when needed. Next step is to prioritize and schedule the orders for the production. There are variables that affect heavily to the production planning, for example prioritization of the orders,

limitations/problems in production, quality requirements and delivery planning. Therefore information between sales, SCC and production needs to be seamless. All the possible problems or limitations in production need to be informed via diary, morning meetings or phone. Next step for SCC is to check stock levels and find out whether the product is ready for loading from the warehouse or need to be produced. If the product has been produced before, SCC schedules and orders the transport. If there are no right products in the warehouse, SCC makes detailed production plan according to upcoming deliveries. SCC will take daily a printed production plan to production so that they know which products and quantities need to be produced in the next 24 hours or in the next 72 hours on the weekends. Sometimes there is a need to change the production plan during weekends or outside office hours and production is being notified about the changes by phone. SCC provides information of production and delivery situation to sales for them to make actions and update the plans when necessary.

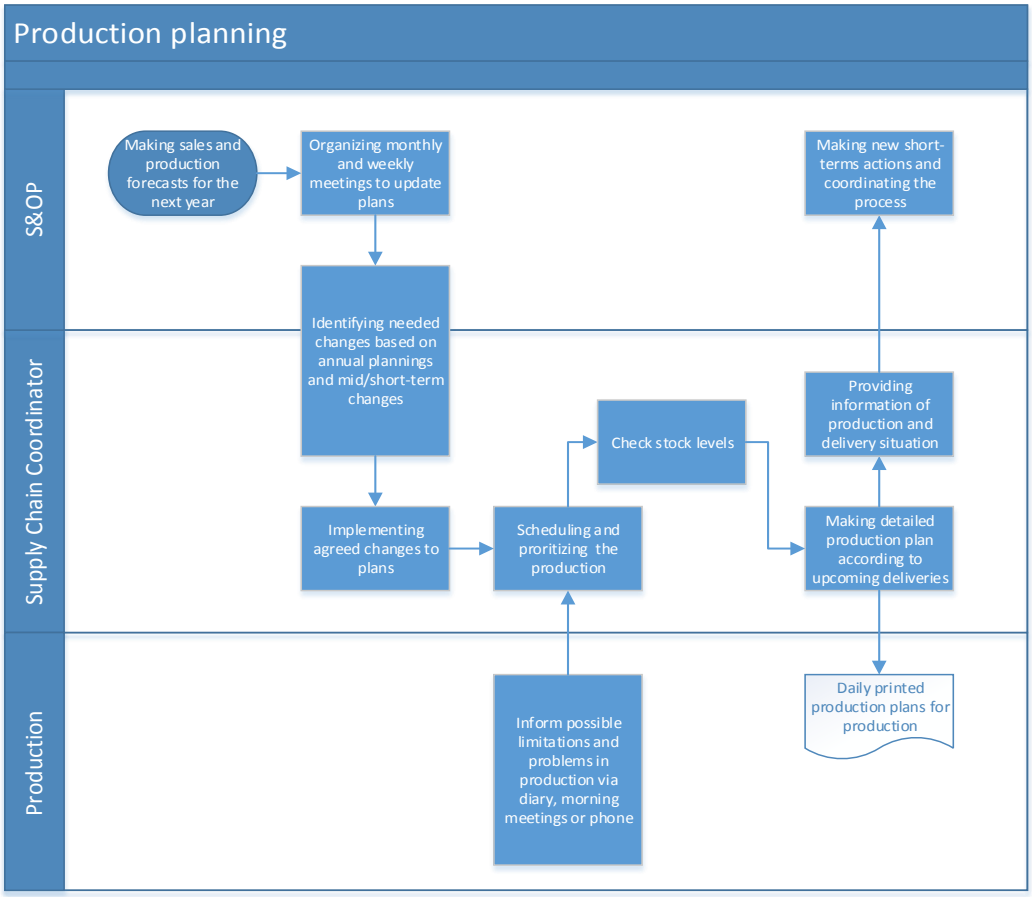


Figure 12. Production planning process in case mills

Sales make long-term and mid-term planning but SCC plays an important role for keeping these plans up to date. Communication between sales, SCC and production is a subject that needs to be developed. Current problem is the slow communication between departments and the fact that important matters are not shared with everyone concerned. All issues concerning production or deliveries to customer needs straight forward communication. It is easy to share real-time information between departments today so the only problem is to chance practices and start using them.

Product portfolio is quite limited at mills. There are under 10 different product groups that covers over 99 % of the production volumes in both mills so the variations are not large. This help production planning process significantly because there is no need to make so detailed and exact production plans for the production. Volumes are now only indicative and precise amounts are not needed at this stage.

5.1.2 Warehousing process

Warehousing at the mills and ports is a complex task. Big volumes, limited storage capacity, declassed products and fluctuations in the amounts of loadings and production cause challenges for inventory management. Making accurate plans is really difficult because unexpected changes are common. Company must be able to react quickly and adapt plans to changing environment when necessary. SCC manages warehouses and is responsible for inventory management. They manage warehouse people (although they are not managers), processes and systems and ensure that the targets of productivity are met. SCC's are working with planning, coordinating and organizing so the strategic role in warehousing and the responsibility in SCC's work is highly important for the company.

Figure 13 models the warehousing process at case mills. Processes in warehouse start when loaders store products in planned warehouse positions according to SCC instructions. There are only few different product types in mills so therefore it is quite simple to plan positions beforehand. Sometimes a lack of space in warehouses might cause some extra work but due to this inventory management is important in order to avoid such situations. Warehouses have their own layouts in IT-systems

which help to organize products to different locations in the warehouse. SCC checks the positions and quality of the products with loaders before entering the right warehouse positions for the right order. Loaders get daily (instead of weekend) loading instructions from SCC in order to know what to load, how much to load and which customer to load. Loaders collect and sort the products in the warehouse and double check the quality and products group. If the product is somehow declassed it is recycled in the production or stored separately depending on the reason for declass. SCC sends the list of declassed products to salesmen and they will find specific customers for the declassed products.

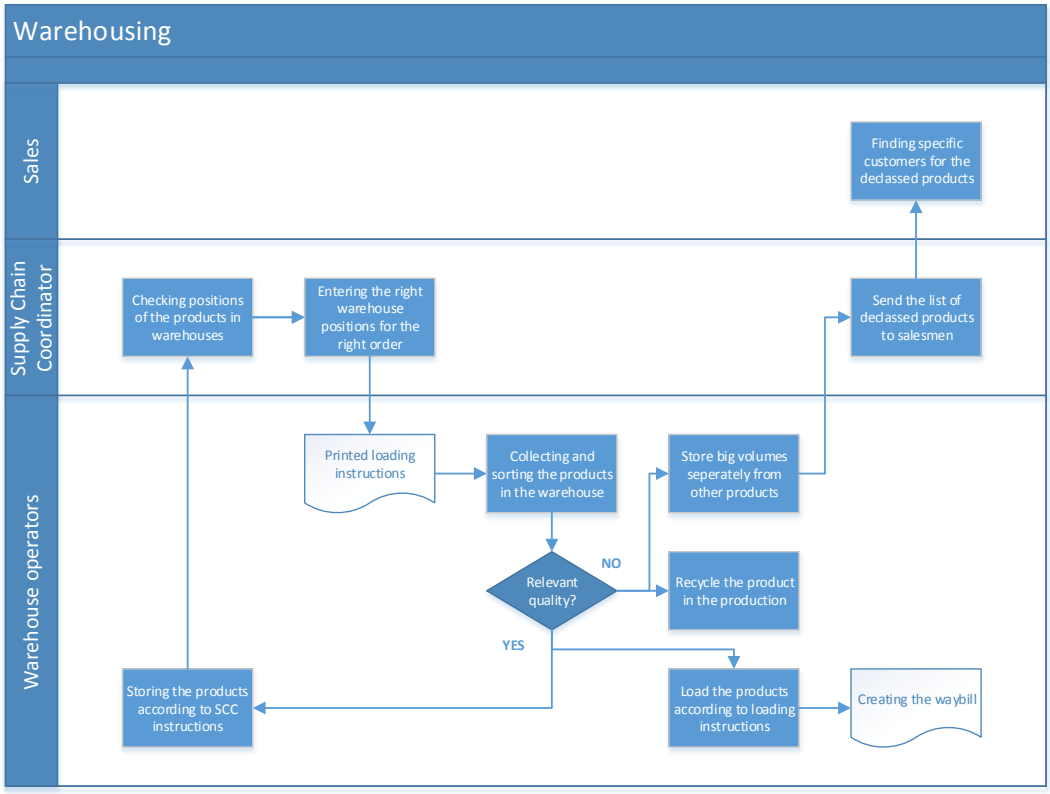


Figure 13. Warehousing process in case mills

Biggest challenge in warehousing processes is to keep it balanced. Production produces big volumes 24/7, except when there is shutdowns, investments or technical problems. Storing the products in the warehouse always generates costs for the company so that should be minimized by better planning and coordinating. A steady flow in terms of production and deliveries is the best possible option to

keep warehousing processes and levels balanced. In chapter 6.2 thesis focuses more on measures of warehousing.

5.1.3 Transportation process

Figure 14 models the transportation process. Supplier is taking care of transportation in this SC. SCC orders train carriages and trucks to the mill according to upcoming deliveries. Usual schedule is that next week's train and truck transportations are ordered till Thursday. Transportation is done by subcontractors but loadings are done by the loaders at the mill warehouses. Loaders create waybills for trains and trucks when they have loaded them with right products and with right amount. Trains go to domestic customers and also to ports from mill 2. Trucks go to domestic and export customers and also to ports. These two mills use storages in two ports and SCC send products there to wait for shipments or straight to containers. Sales give detailed schedule and amount for the shipments and SCC make the shipment instructions for the ports.

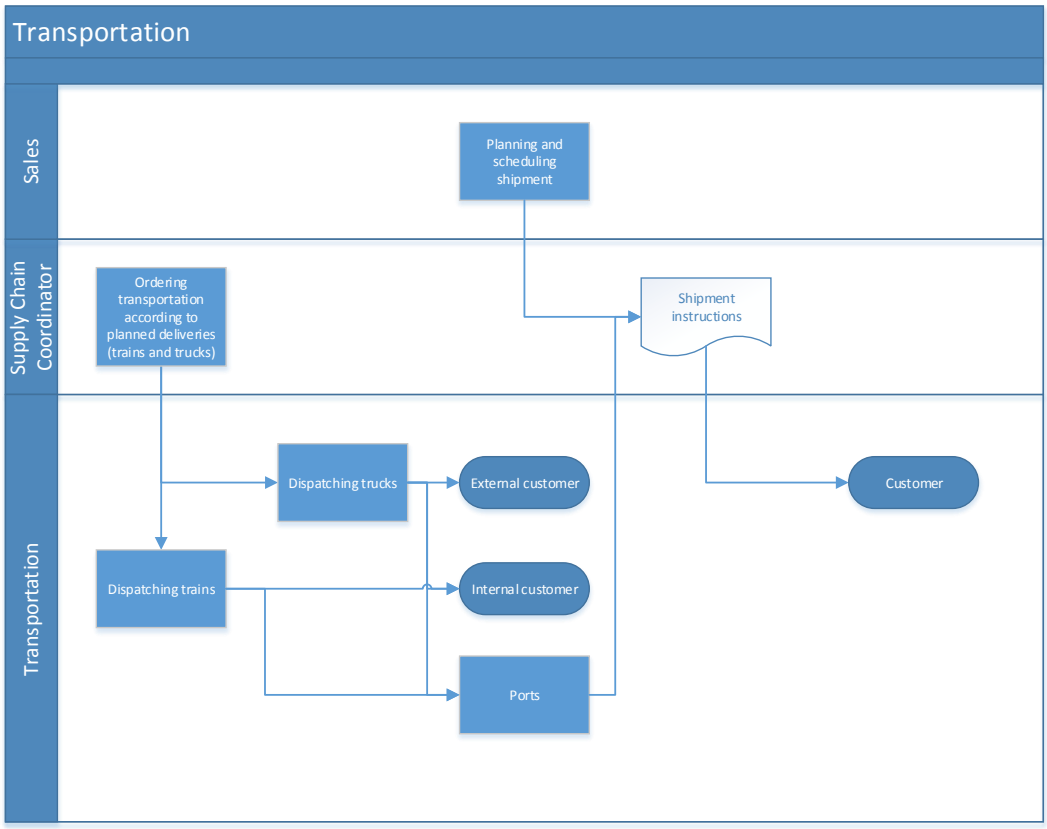


Figure 14. Transportation process in case mills

Transportation process itself is simple but there are a lot of process elements that need development. There is an opportunity to achieve significant cost savings with changing the transportation processes and developing the methods used at the moment. More of these developing points in chapter 8.1.

5.2 Unique elements at mill 1

In this chapter we concentrate on unique points in SC processes that are remarkable and need special attention in mill 1. There are some differences in planning compared to mill 2 because of different kind of customer field, delivered volumes and warehousing capacity. The bale production was 88,2 % from the total production in year 2015. The rest 11,8 % from the production was delivered straight from the production to paper mill as a slush pulp. The total bale production was three times bigger in mill 1 than in mill 2 in year 2015 so that constitutes different challenges in planning production, warehousing and transportation. The role of the SCC is emphasized because of the big volumes to store and deliver.

Mill 1 has two production lines where another produces softwood and another hardwood. Producing different product groups is therefore fast and flexible and customers have usually quite standardised quality requirements. Two production lines help production planning and if another line is having problems it will not affect totally to production volumes. Product portfolio is quite simple and do not need any special attention but customer groups are increasing all the time.

Train is a cheaper mode of transportation than truck but mill 1 is not delivering products to ports via railways. Trains go now only to domestic customers but the carriage capacity increase is possible. Increasing train deliveries is one of the targets in near future.

5.3 Unique elements at mill 2

Mill 2 produced three times less pulp bales than mill 1 in year 2015 but investment in production during the year 2015 increased their bale production quite heavily. In year 2016 it is still almost two times less than in mill 1 but will have strong pressure to change and develop SC planning and warehousing operations. In sales forecast

mill 2 is actually delivering more pulp to export customers than mill 1. This increase the need of developing transportation and warehousing processes at ports and also at the mill.

Storages in mill 2 are too small compared to production capacity and therefore inventory turnover must be high to keep stocks in balance. It causes extra costs when products are sent to ports without orders. The products need to be transfered between ports and it creates additional transportation and handling costs. A bigger warehousing capacity in ports is needed as renting warehouses and keeping stocks at port is expensive but at this point necessary.

Mill 2 have only one production line and it causes occasional challenges when quick reaction to changes in production volumes and deliveries is needed. Target is to maximize production volumes and produced volumes of hardwood or softwood depending on production-related issues and therefore production planning may often need revision. As there is only one production line problems will have an effect on both softwood and hardwood volumes. Production portfolio is quite limited also at mill 2 but customer portfolio has been increased notably after the investment in late 2015.

6 SUPPLY CHAIN MEASUREMENT IN CASE MILLS

Supply chain is highly important to company's success because it include a high share of cost and is also very critical for service level. Globalization opens to global SC more freedom because products can be made in several places, customers are all around the world and there is demand in new markets. Well working SC requires tools that are capable of melding together with collaborative demand management, planning and scheduling. This kind of collaboration helps to optimize production process and avoid disconnection between stakeholders.

Every company have different priorities, customer base and methods so measures for the different SC's are unique. There are hundreds of metrics for measuring SC performance but meaningful performance information is sometimes hard to find. Chapters 6.1, 6.2, 6.3 and 6.4 introduce measures that are important for performance developing of pulp SC. These are divided in four different categories: production planning measures, warehousing measures, transportation measures and common SC measures.

6.1 Production planning measures

Production planning is the core process of manufacturing and it affects to production people activities and accuracy of the deliveries. The purpose is to maximize the production capacity and reach the full potential. The main thing is to make sure that maximum capacity and also capacity restrictions are understood and monitored to all people involved in planning. All the changes in production needs to be documented to keep plans up to date. The following measures help SCM to develop SC from the production planning perspective.

FAULTY PRODUCTS / PRODUCTION ACCURACY

Faulty products or as so called declassed products are quite common in the production. Mills are producing high quality pulps for customers and that is why quality requirements are very strict. Different customers use pulp for different end products and that is why different customers might have also unique quality

standards. Mills have to differentiate products from the warehouse due to the variations in the quality and customer requirements.

Percentages of declassed bales produced from the total bale production in both mills in year 2015 are summarized in table 5. Mill 1 produced 3,8 % of declassed products from the total bale production and mill 2 only 0,8% which means a big difference between this measure. In both mills these percentages of declassed products are even higher because some of the products are classified as declassed after production and therefore these are not marked as declassed in the production volumes. The total amount of declassed is around 5 % in mill 1 and 1,5 % in mill 2. Especially in mill 1 the percentage is far too big.

Table 5. Percentages of declassed products from the total pulp bale production

	Softwood	Hardwood	Total
Mill 1	1,9 %	1,9 %	3,8 % (~5,0 %)
Mill 2	0,6%	0,2 %	0,8 % (~1,5 %)

Some of the declassed products can be recycled in the production but usually salesmen need to find a specific customer for these volumes. Declassed products make challenges for production planning and warehouse management. Inventory turnover for these products is usually slow (more of that in chapter 6.2) and therefore rearrangements in warehouse are often needed. Production is making such great volumes that the percentages of declassed actually mean thousands of tons. This makes big challenges in warehouses and have impact also for company's profit. Declassed products always cause some extra costs and company doesn't get so good margin from them. Declassed bales were sold approximately 15% cheaper than prime quality bales in year 2015. With this kind of big volumes it means the loss of around 2,4 million euros for sales in mill 1 and the loss of around 0,2 million euros for sales in mill 2.

The SCC has currently no tools for making changes to the amount of declassed products. The responsibility is fully with production so changes and improvements

need to be done there. The actions to improve quality after production notices the quality is under specifications, can take hours. SCC and production simply need to react as quickly as possible when the quality is outside of the specifications and preferably even before the quality is approaching the limit specifications. Communication between departments is extremely important that SCC can plan the deliveries and production according to up-to-date information of production.

MANUFACTURING LEAD TIME

A manufacturing company strives to enhance processes and production efficiency to improve financial performance and customer satisfaction. Minimizing manufacturing lead time improves manufacturing efficiency and commits less working capital. Sales team creates annual monthly plan by customer and product. First the plan is 5-10 % oversold because there is usually some changes and decreases in volumes in sales during the year. SCCs and sales management implement agreed changes to plans and adapt short-term actions if needed.

The pulp SC differs from most of the other SC in the fact that it does not make production against an order. Pulp mills produce big volumes with a small variety of products to the warehouse according to planned volumes and products are then delivered to customers. SCC is responsible for scheduling and planning the production so that there will be no problems or delays in deliveries to customers. Manufacturing lead time includes the time from point of order release until the order is shipped. The lead time can be less than a day but usually it is quite long and therefore it is not very agile. The volumes and shipments are planned tentatively in the annual plan so it helps to shorten lead time as production can be planned and scheduled according to the information. Manufacturing lead time is long for foreign customers because they usually take big volumes in shipments. It takes usually many weeks to deliver the whole order from the point the order is released. Safety stocks are sometimes necessary for avoiding delays in deliveries especially for domestic customers.

Manufacturing lead time is sensitive to changes and can be impacted by unexpected problems in production, transportation type, quality issues, order volumes etc. The customer base in pulp business is narrow because private people does not use raw

pulp and customers are therefore only bigger companies which process the pulp to different end products. They already know the nature of the pulp SC so they know how to prepare for long lead times. Customers give forecasts for the next year according to their needs and history data and specify the amounts closer to the time of delivery. Occasionally there could be small trial volumes or other small deliveries to customers during the year but these volumes are small and lead time is therefore fast.

CAPACITY UTILIZATION

Company make sales and production forecasts for the next year according to anticipated production volumes given by the production management. There must be also information of upcoming shutdowns and investments because these affect to the production and delivery planning and scheduling. In year 2015 production gave their estimated forecasts and sales made plans according to these volumes. Table 6 shows the percentages how real production volume differs from the estimated volumes in year 2015.

Table 6. Percentages of how real production volumes differ from the estimated volumes in year 2015

	Softwood	Hardwood	Total
Mill 1	+6,8 %	-11,8 %	-2,5 %
Mill 2	+5,0 %	+8.3 %	+7,1 %

As can be seen from the table 6 there are substantial variations in real and estimated production volumes. Mill 1 produced 6,8 % more softwood than was planned but hardwood balance was 11,8 % less than planned. Total production volume was 2,5 % less than planned so the production did not reach the total estimated volume in year 2015. That means mill 1 needed some help for the deliveries from other mills or they had to change the amounts of deliveries during the year to be able to deliver all the volumes. Production in mill 2 was 5,0 % more in softwood and 8,3 % more in hardwood and total production volume was 7,1 % more than estimated. This

number is higher than estimated because the investment shutdown went better than expected and the production was lifted to the higher levels quicker. This means they needed some extra sales during the year and they were also able to help mill 1 and deliver some of their volumes. Co-operation between different mills have to be on high level to avoid increase in warehouse volumes or problems in deliveries. This will help to keep production and deliveries balanced.

Table 7 shows how the real volume in deliveries differs from the planned volume in different customer and product groups. Annual plan is slightly oversold, so the difference in real volume and deliveries should be around -5-10%. The table shows that especially in mill 2 the delivered volumes for export customers are much higher than planned volumes. Reason for that is the well gone investment which raised the production volumes higher than expected and the change of customer portfolio. But the delivery volumes to domestic customers decreased so the total delivery volumes are only slightly more than planned. Hardwood volume for domestic customers from mill 2 is in balance but softwood volume is much smaller than planned. That could also have made export customers share higher. At mill 1 the plans were quite well in balance even though hardwood volumes for domestic customers were slightly under the plan variations.

Table 7. How the real delivery volumes differed from the plan

	Customers	Softwood	Hardwood
Mill 1	Domestic	-4,7 %	-11,5 %
	Export	+1,5 %	-2,5 %
	Total	-1,7 %	-8,0 %
Mill 2	Domestic	-36,6 %	-7,1 %
	Export	+175,0 %	+234,7 %
	Total	+0,6%	+2,4%

6.2 Warehousing metrics

The main objective of a warehouse is to provide a temporary shelter to products. To ensure customer satisfaction and cost effectiveness the performance of the warehouse needs to be measured at some level. There are a lot of warehouse data available but it is important to demonstrate the warehouses contribution to the company. Performance measurement depends on unique factors like specific customer expectations, specific processes and specific data availability.

INVENTORY COSTS

Inventory costs are divided into three part in this thesis; safety stocks, finished good stocks and warehouse costs. It is a big issue in companies that how large the safety stocks should be. Purpose is to keep inventory costs low and possible stock level decreases cannot impair the service level to customers. Safety stocks are not intended to eliminate all stockouts but the majority of them. Stockouts would mean lost sales, lost customers, backorder costs, expediting costs etc. We need to make a more detailed look for both mill separately because Mill 1 and mill 2 have quite a different kind of storage capacity and customer groups. Mill 1 produced three times more bales in year 2015 than mill 2 and it makes the whole SC different in many parts.

Table 8 shows the deliveries per year, average deliveries per day, average stock quantity, inventory turnover and stop time divided by different product groups in mill 1. Product 1 and product 4 are delivered daily to customers and cover 71 % of the all deliveries. These are the main products to focus on when thinking of safety stocks. Products 2, 3 and 5 are delivered in bigger shipments monthly and irregularly so there is no need to keep safety stocks to those. Products D1, D2, D4 and D5 are declassed products and there is definitely no need for safety stocks to these either.

Table 8. Deliveries and inventories of the products in mill 1 in year 2015

Mill 1	Delivered tons	Average delivered tons per day	Average stock quantity tons	Inventory turnover	Stop time (d)
Softwood					
Product 1	293000	802	5649	51,9	7
Product 2	16400	45	1152	14,2	26
Product 3	134000	367	19909	6,7	54
Product D1	18000	49	2712	6,6	55
Product D2	800	2	224	3,6	101
Hardwood					
Product 4	344800	945	3930	87,7	4
Product 5	33300	91	6285	5,3	69
Product D4	14300	39	1145	12,5	29
Product D5	2600	7	287	9,1	40

As said in the theory part, finished goods stocks should be as low as possible. In table 8 can be seen that average stock quantity for main product types is almost 30000 tons in softwood and almost 12000 tons in hardwood. Generic example in the figure 8 demonstrate that finished goods stock cover average 38% of total logistical costs so it is remarkable cost for the whole SC. At least in softwood the finished goods stock levels are too big compared to the deliveries so there are some possibilities to decrease these levels. This is the biggest function of the logistical costs and therefore need actions to better company's profitability.

Deliveries, stock quantities and inventory turnover rates from the last four months in year 2015 from mill 2 are summarized in table 9. These numbers are after the big investment and are therefore more close to reality than numbers of the whole year.

Table 9. Deliveries and inventories of the products in mill 2 in last 4 months of the year 2015

Mill 2	Delivered tons	Average delivered tons per day	Average stock quantity tons	Inventory turnover	Stop time (d)
Softwood					
Product 1	14500	120	2130	6,8	54
Product 2	40500	338	11945	3,4	107
Product D1	738	6	0	-	
Hardwood					
Product 4	20400	170	1940	10,5	35
Product 5	24600	205	10617	2,3	159
Product D4	275	2	98	2,8	130

As can be seen from the table above, the average stock quantities (finished good stocks) are mainly too big compared to delivered volumes. Therefore inventory turnover rates are at a worryingly weak level when comparing to industry average. Higher turnover would decrease finished good stocks remarkably and inventory costs could be decreased significantly. In chapter 8.1 are made suggestions that how inventory costs could be decreased.

Both mills have warehouses next to the mills and the costs are fixed regardless of how many products they contain. Company has also rent warehouse capacity from ports and these costs can be minimized with better planning and scheduling. Port 1 loads pulp to containers and are usually planned for shipments outside Europe. Mill 1 do not use this port as a warehouse although the company has rent space from

there. Mill 1 delivers products straight to the containers which reduces costs from warehousing and processing times. Problem for this process is that containers are ready for shipments only a short time before the delivery date. Therefore big volumes need to be delivered to the port in a relatively tight schedule. Transport capacity is however sufficient and does not cause any problems even with the delivery of bigger quantities. This kind of processes also need a lot of warehouse capacity at the mills. Therefore mill 2 cannot plan the deliveries to port in the same way. Limited warehouse capacity with big production volumes force them to keep stocks at port and deliver products there even without an order. This brings additional costs for the company because of the increased need of warehouse capacity and slow turnover rate. This also affect to the quality of products because of the increased need of handling with bales. Port 2 load pulp to ships without containers as a break bulk and pulp needs to be already waiting at the port when ship arrives. Warehouse capacity at the port is therefore necessary and that help mills in planning and scheduling the deliveries.

INVENTORY TURNOVER

Inventory turnover varies significantly by every product. Company produces two main product categories in both mills, softwood and hardwood. Both of them have only few different bale types or quality requirements so the production mix variety is very limited. There are two types of customers, domestic and export. Inventory turnover to domestic customers is usually much faster than to export customers because of the relatively stable daily inland deliveries. Production need to be scheduled quite early and inventory turnover rate decrease because export customers take bigger shipments for example once in a month or in a quarter.

Table 8 shows that the inventory turnover rates for products 1 and 4 in mill 1 is in a quite good level. Products 2, 3, 5, D1, D2, D4 and D5 have slow inventory turnover rate and that means bigger average stock quantities. One of the reason for the slow rate is the bigger unstable shipments for export customers which force mills to raise their stock quantities. Table 9 shows that the inventory turnover rates for every product in mill 2 are way too slow. Turnover rate can be also measured by time and the statistic is called as stop time. Stop time varies from 4 days to 159

days. The shorter the stop time is, the less capital is tied up in the stock. Target levels for inventory turnover and stop time rates are set in conclusions chapter.

In table 10 can be seen how delivery volumes in domestic and export customer groups differentiate in both mill.

Table 10. Domestic and export deliveries

	Softwood	Hardwood	Total
Mill 1, year 2015			
Domestic	29,9 %	37,7 %	67,6 %
Export	25,2 %	7,2 %	32,4 %
Mill 2, year 2015			
Domestic	12,6 %	18,6 %	31,2 %
Export	37,4 %	31,3 %	68,7 %
Mill 2, year 2015 after investment			
Domestic	9,3 %	13,1 %	22,3 %
Export	38,7 %	38,9 %	77,6 %

There was a big investment in mill 2 and their production growth in the end of 2015 was remarkable. That is why numbers after that investment are more realistic although it looks a shorter time interval (only 4 months). As can be seen from the table 10, the deliveries seems to focus more on export customer and there is a difference between the numbers of the whole year 2015 and the last four months of 2015. There is no decrease in the delivery volumes to domestic customers but the increased volumes after investments are sold to export customers and therefore the percentage of domestic volume is smaller. As said earlier in this chapter, inventory turnover for export customers is bigger and therefore stock levels have increased after investment.

STOCK ACCURACY

Accuracy of physical stock compared to what is in the database should match as closely as possible. Visibility through SC is a key to have a high-performing warehouse but there are always a disparity in these kind of big warehouses. There are distortions in the warehouses because of there are problems in bale registration to systems or errors in loadings. Amounts in stocks and systems may not be balanced because loaders can also make mistakes. This is a daily problem and people need to do inventories regularly.

Regular checks against database and stocks improve inventory accuracy. At the moment the company do not have any unique identification system for the products and the only way to trace bales is the production lot number painted on the side of the pulp bales. Inventories are almost impossible because there are thousands of tons of products in the warehouses and the production lots can be seen usually only from the bales in front of the storage locations. Occasionally customers inquire why bales marked in the delivery report differs from the reality. Inventory controlling should be a priority and stock accuracy is fully dependable on the responsibility and professionalism of the loaders.

STORAGE UTILIZATION

Storage utilization is one aspect in warehouse management. Big volumes of products need large warehouses and that makes planning challenging. Mill 1 has two production lines and both lines have their own warehouse. Line 1 produces softwood and line 2 produces mostly hardwood. Sometimes line 2 produces also small volumes of softwood. Line 1 has warehouse capacity for around 20700 tons and line 2 have capacity for 13800 tons. Mill 2 has only one production line and the total warehouse capacity is only around 6800 tons.

Storage usage of mills and ports are seen in table 11. The table covers whole year 2015 but with mill 2 only last 4 months of year 2015 after the investment. Mill 1 has big and good storages on site and full warehouse can cover an average of 15 days of deliveries. Mill 1 used the storage capacity of an average 48% in year 2015. As said earlier, mill 2 has a limited storage capacity on site and therefore storage

usage at the mill is around 90 %. If there are shutdowns in paper machines at mill 2 and no need for slush pulp the whole production is made in pulp bales and the storage is fully covered in matter of days.

Table 11. Storage usage in mills and ports

	Mill	Port 1	Port 2
Mill 1	48 %	~0 %	70,6 %
Mill 2	90 %	68,2 %	56,5 %

The company has rent storage capacity from port 1 and the storage is not separated between the mills. Both mills use the same storages but actually mill 1 does not use port 1 as a storage because they deliver pulp mostly straight to containers. Mill 2 uses an average 68,2 % of the total storage capacity and the figures are substantial because of the limited capacity at the mill. There is a big opportunity to decrease this number but it needs investment in warehouse capacity at mill 2. The company has rent storage space also from port 2 and is not officially separated between two mills but mills have their “own” warehouse lots there. The storage utilization is in good balance and there is no need to increase or decrease capacity in port 2 at the moment.

6.3 Transportation metrics

Performance of transportation provides an information that how successful the SC is at providing products to the customer. Delivery performance need to meet customer expectations in order to have a well performing SC.

DISTRIBUTION COSTS

Distribution costs are a big cost for the SC. Company does distribution by train, truck and ship. The aim is to create a synergy between these logistical functions and make it work as well as possible with as low costs as possible. Geographical location of customers and ports reflect on distribution costs. When compared internationally the costs are high in Finland especially due to the long distances.

There is no need to calculate exact costs for the whole transportation structure. Better option is to separate transportation types and find possibilities to reduce costs or change the transportation method. There are many things that affect to distribution costs like distance, volume, size, quality, loading times, markets etc. Tendering or changing the delivery forms is not a simple project and requires a lot of attention. This thesis focuses only on truck and train deliveries and leave ship deliveries out from the topic.

Distribution costs are already taken into account very well but there are still some scopes that could be developed and save costs. Synergy between different transportation methods are in good balance but possible big developments in the near future are railroad deliveries to ports from mill 1 and container loadings at the mills. Table 12 shows the average percentages of delivery shares from the mills by truck and train in the beginning of year 2016.

Table 12. Transportation types variations from the mills

	Train	Truck
Mill 1	58 %	42 %
Mill 2	62 %	38 %

Storages for the products are located in connection with the mills. Company has also rent storage capacity from the ports to help the upcoming shipments. Both mills are located quite close to the ports so moving big volumes by trucks and trains is fast and flexible. Locations for the storages are also planned well so there is no need to make any changes to this.

Train is slightly inflexible but the cheapest way to move products inland. As mentioned earlier mill 1 is delivering big volumes of pulp to domestic customers and train is the best option there. Truck is an easy way to move products fast to customers or ports because it is more flexible but more expensive than railroad deliveries. If the railway carriage capacity is already used fully there is sometimes a need to replace transport by trucks. Ship will not wait for products at the port so

good planning and scheduling is highly important. It need weeks of planning to get ready for shipments because these can be thousands of tons of pulp.

ON TIME DELIVERY

Customers' satisfaction is one of the key elements in business and these measures have a big impact on it. Customers give to SCC a schedule with reference regarding to previous agreements. SCC schedules the production and deliveries according to this information. On time delivery has been handled in the case company very well and problems are relatively rare. There might be some delays because of the hauliers but the company will never be able to get completely rid of these. There can be problems in availability of railway carriages, trucks can break down or there can be communication errors. Also delays in the arrival of ships are relatively common. Sometimes big problems in production can cause further problems and then there might be need to make special arrangements. This means deliveries from the other mills of the company or a different kind of product deliveries. Deliveries were on time over 99 % certainty in year 2015 and this also reflects the fact that production and deliveries are well planned and scheduled.

ERRORS IN SHIPMENTS

A lot of people are able to influence the SC and compared to this errors in shipments are relatively rare. Errors can begin from the production if quality controlling is done carelessly or completely neglected. Sometimes loaders load bales straight from the production so they need to have updated information of the quality. Loaders can also make mistakes because of hurry and human errors. Hauliers need to also have good instructions to where they are going and what to load in trucks.

There has been some errors in shipments in both mills during year 2015 but it is still only marginal from the total volumes shipped. Only way to get rid of them is to improve quality control, add diligence in warehouse operations and give more detailed instructions and plans. The objective is to reduce the errors to a minimum and an identification system for the products is also needed. These errors in shipments always cause unnecessary extra costs for the company and they also affect to customer satisfaction. In the two mills there are only few different product

groups and a relatively small number of customers which make transportation process easier.

DELIVERY FLEXIBILITY

Deliveries in short term are not very flexible but long term deliveries are usually more flexible. Customers know the nature of the pulp SC and they know how to prepare for the long delivery times. Short term actions in deliveries are sometimes hard to implement because of big volumes and confirmed plans. Long term deliveries are easier to plan because production can be scheduled more in line with the quantities to be delivered.

Transportation types also affect to delivery flexibility. Trucks are the most flexible type of transportation because transportation companies are able to respond to changes very quickly. SCC can make changes to delivery plans daily only announcing the transportation company and giving new instructions for warehouse operators. Trains are also quite flexible but there are some constraints like railway carriage capacity and destination. It also takes a slightly more time that these changes affect at the customers because of longer delivery time. Ships are the least flexible transportation type and there is often need for balance the shipments between different customers. Ships require the most planning and preparedness beforehand.

6.4 Common metrics

This chapter focuses on common measures related to SC performance. These measures are unquantifiable but must be taken into account when considering the performance of the SC processes.

INTANGIBLE COSTS

Intangible costs include expenses such as lack in customer goodwill, decrease in employee morale or losses in productivity. These costs are unquantifiable but there is still a need to estimate the impact because they have a significant effect on company's performance. Intangible costs may occur after new practices or policies. If the company for example cut employee benefits it is likely the employee morale

will drop. This can also affect negatively to productivity. Customers can be disappointed with a decline in service or product quality.

After the company's intangible costs are incurred, they can absorb the costs or act to eliminate them. Informational meetings with employees to reduce discontent can be arranged, alternative ways of working found and public relations improved to keep customers goodwill. Rate of productivity increases significantly when people feel valued by the business.

LABOR FLEXIBILITY

This means the ability of employee to change tasks and be multi-talented. SCC is a key person to keep things simple and effective in pulp SC. Coordinating the SC requires a lot of flexibility from the SCC because changes are relatively common. Sometimes working outside office hours is needed for keeping things updated. Flexibility is also needed from other people related to SC processes because keeping plans balanced requires cooperation with many different departments.

7 BENCHMARKING CASE

Benchmarking in this case can be said as process and internal benchmarking. Benchmarking of processes is usually done in top performing companies in other industry sectors but in this thesis benchmarking is done in the same organization other business unit. The purpose is to get information for adjusting performance goals, achieving improvements in key processes and spreading expertise and best practices throughout the organization quickly. Benchmarking includes visits, interviews and data collecting at mill 3. Internal benchmarking advantages are the easy data access, standardised data available, less time and fewer resources needed and implementation of practices are easier in general across the same organization. However by internal benchmarking it is not necessarily possible to find innovative or entirely new models for process development.

The SC at mill 3 differs from mill 1 and mill 2 SC in many different ways. Mill 3 is located by the sea so this alone brings a significant advantage in terms of warehousing and transportation while it reduces distribution costs and the need for planning the train and truck deliveries notably. This also means better controlling and handling in port operations which reduces errors in shipments, quality problems, inventory levels and need for different warehouse locations. Mill 3 has been longer a major supplier of export bales for overseas customers and therefore their SC planning has better experience and tools. They also have significantly more different product and customer groups and that gives more challenges in coordinating the whole SC.

Mill 1 and 2 are relatively new suppliers in export markets with big volumes so there are still a lot of things to learn. SC is organized and managed better at mill 3 and therefore mill 1 and mill 2 should find the best practises to take advantage of their own activities. Mill 3 makes more long-term production and transportation planning than mills 1 and 2 and they manage better the whole SC and are able to plan production month ahead. This means better planning in shipments, better communication with sales and port operators, better predictability and better history data utilization. SCC use their time better in the activities that plays an important role in coordinating the SC and not for the time consuming unnecessary things.

There are designated people in the warehouse operation that are mostly responsible for inventory management. SCC use also more efficiently production planning tools and have made also their own tools to improve planning. They have implemented production schedules in company systems which help updating and sharing the real time information through the organization.

Next are listed the main results of this benchmarking case:

- More versatile utilization of company systems
- More long-term planning in production and deliveries
    - At least one month ahead
- SCC are the main coordinators for the whole SC
    - More communication between sales and ports
    - More coordinating role for the SCC
- SCC are able to focus on major issues of the SC
    - Sharpen the responsibilities in SC
- Communication between sales needs to be seamless
- Improve the transparency of the supply chain

These things listed above reflect many performance metrics in SC. Following these things will lead to better levels in inventory turnover rates, stock levels, on-time deliveries, distribution costs, inventory accuracy and manufacturing lead time. Many things affect many different aspects in SC and therefore you need to improve other processes to achieve results in others.

8 CONCLUSIONS

This chapter contains analysis of results, benefits of findings, limitations and future research opportunities for the case company. The purpose is to bring together all the topics that this thesis raised and make conclusions based on the results of the findings.

8.1 Analysis of results and benefits of findings

After analysing pulp SC processes, there is no need to make big changes or add processes in the current SC. Pulp SC processes are already well organized but there are still processes that need to be developed. Focus need to be on developing current state processes and getting processes to support each other better.

PRODUCTION PLANNING

Production planning and scheduling have tools to be effective but sometimes the use of these tools is not sufficient. Long-term planning needs more focus in the future from the SCC in order to improve the predictability. The whole SCM entity will have benefits from it and it affects many issues, such as inventory levels and customer satisfaction. The main thing is also that SCC can focus on coordinating the process and therefore some old-fashioned methods need to be changed to meet the modern world. Production plans need to be implemented to the current systems where it can be updated in real time and production figures can be monitored through the organization. Mill 3 already use systems for production planning and mill 1 and 2 need to implement this in the near future.

Declassed products are quite harmful because of irregularity, heavy effects for planning, slow inventory turnover and lower gross margin. One of the main thing in the production should be to avoid producing declassed products. Percentages of declassed products produced from the total production is far too big at the moment, especially at mill 1. The target level should be to get the percentages down to less than 1 %. This means over 2 million euro increase in profits from the sales with the same volumes as in 2015. In order to achieve this level it requires much from the production. First of all, the quality of raw material has to be good so that the finished

product complies with the quality requirements. Also communication between different production departments need to be seamless and the flow of information must be real-time in order to be able to react on changes. The development of production processes and quality controlling will lead mills to better results in production efficiency and the whole SC will also receive benefits from increased quality at the mills.

Manufacturing lead time can be reduced by planning and controlling the whole SC better. SCC needs to take more role in coordinating SC processes because that will improve SC efficiency. At the moment sales make the plans of shipments with shipping controllers but the responsibility needs to be fully on SCC. SCC will plan the shipments and deliveries with shipping controllers and ask then confirmation for the volumes from sales. This kind of change in planning will help to forecast and plan production and deliveries for a longer period compared to current situation. The planned orders should be shipped in a month from the day they are produced so manufacturing lead time target should be set for one month (30 days). That will also affect positively on inventory turnover rates and better warehouse controlling.

Production capacity utilization indicates the total manufacturing output capacity utilized at a given time. The better the capacity is forecasted, the better production, warehousing and deliveries are in balance. Big changes in estimated volumes bring several challenges in warehousing and deliveries. Stores can run out or overload, inventory turnover rates increase, planned shipments be postponed or new customers need to be found. Of course “overproduction” is much better option than “underproduction” but however the best is if forecasts are as accurate as possible to achieve efficient SC. Updating forecasts at regular intervals is highly important.

WAREHOUSING

SCC can be called as a warehouse operation manager although it is not formally part of their job description. They manage with instructions, inventories, bugs and damage reports, take care of human resources and send waybills to customers. There are a lot of issues that warehouse management must deal daily so there is an opportunity to automate some of the tasks and rely on the correct software. Instructions need to be moved to automated systems for an easier update and

control. Part of the warehouse operations need to be also moved to the responsibility of warehouse operators (loaders) such as waybill sending to customers and inventories at warehouses. With these new arrangements SCC can focus on actual planning and coordinating and not use the time for the time-consuming activities which do not coordinate the process.

There are big possibilities to reduce inventory costs. One thing is to define safety stock levels for products that are delivered daily from the mill 1. Mill 2 do not deliver any products daily but more or less irregularly. Table 8 shows the average stock quantities and average deliveries per day and there product 4 is at the best level. Average stock quantity should cover at least 3 days but max 5 days deliveries of the daily products so table 13 shows the targets for safety stock levels at mill 1. The purpose is to keep stock near the minimum target level and maximum level not to be exceeded. Of course the use of common sense is allowed when there is shutdowns or other specialties coming. This will reduce the capital tied up in warehousing significantly. If the company is able to reach the target minimum level it means annually over million euros less in capital tied up in warehouses.

Table 13. Safety stock levels for mill 1

Mill 1	Target min level	Target max level
Product 1	2400 tons	4050 tons
Product 4	2700 tons	4500 tons

One possibility for inventory cost savings is to reduce warehouse capacity from port 1 but that means increased need for capacity at mill 2. If the company can reduce the warehouse capacity by half in port 1 it results to over 100 000 euros saving in rental costs annually and also substantial savings from handling costs at port 1. Other benefits for increasing warehouse capacity at the mill 2 are improved delivery planning possibilities (better customer service), decreased handling amounts (better quality) and possible direct loading to containers at the mills. Warehouse capacity increase at mill 2 is necessary because of increased bale production volumes and

significant benefits in company profits. This requires investment in warehouses but the saving are so significant that it is definitely needed investment.

Inventory turnover target rate should be over 12 which means less than 30 days stop time for the products in the warehouse. If the company is able meet the targets, the inventory level changes using the 2015 values are shown in table 14. At mill 1 this means that on average over 3 million euros less capital is tied up in the warehouses and at mill 2 over 5 million euros. Numbers for mill 2 are slightly distorted because of big increases in delivery volumes and customer fields in year 2015 which especially in the beginning raised inventory levels higher than expected. But however if the company can decrease the inventory levels to meet target rates of inventory turnover it will have major impact on company's profitability.

Table 14. Inventory level changes after meeting the targets for inventory turnover

	Softwood	Hardwood	Total
Mill 1	-34 %	-31 %	-33 %
Mill 2	-67 %	-70%	-69 %

To keep warehouses more accurate there is a need to invest in a system that track products accurately throughout the SC. Controlling pulp movements and stock levels increase the correctness of the shipments to customers and customers can track pulp as it is being consumed. Other benefits for tracking systems are for example knowing correct stocks and consumption in real-time, loading accuracy and the total operational performance increases and errors in shipments decreases. One possible option for tracking is radio frequency identification (RFID) systems which are a growing element in SCM. RFID uses tags to receive and transmit information that can be used to identify the item through radio signals. Tags are positioned in the side of the bales and readers can read many tags at the same time and do not require a straight line of sight access to be able to read tags. Automatic scanning and data logging can increase productivity by decreasing manual work and improving visibility and planning. This kind of identification system would help to manage the whole SC. There is also pressure from customers and also from

authorities to develop monitoring the product through the lifecycle. This investment is relatively expensive for the company and also challenging to determine the payback time. Although the company itself would invest in the RFID system they must also ensure that the customers and the ports will be able to read and handle these systems as to achieve its full benefits. The use of the RFID is becoming more common all the time and it certainly creates pressure to ports and customers to acquire readers if they do not already have it.

TRANSPORTATION

Transportation at case mills is a quite simple process. They use three types of transport and have limited number of product groups and customers, although number of customers has been increasing. The customer base have been changing a lot recently and that seems to be the trend in the near future too.

Distribution costs can be minimized by maximizing train deliveries and tender out transport companies thoroughly. Mill 1 is able to increase the volumes in train deliveries but is limited by the capacity of the carriages. The company needs to negotiate with the transport company whether there is any possibility to increase volumes delivered via railways. Deliveries via railway instead of trucks to port 2 could decrease the logistical costs around 200 000 euros a year. Mill 2 already deliver volumes to port 1 via railways but there could be discussions to which port is more reasonable to deliver.

Stuffing containers at the mills is one of the developing points. This will bring many advantages like better quality of products, better handling and coordinating, and reduced transportation costs. Then there are also no need for having storages at the port 1 which will reduce rent costs. If the company does not need to rent warehouse capacity from port 1 at all, it means almost 0,5 million euros savings in rental costs annually. Of course moving stuffing operations from port to mills is not easy and mills need to do some investments, changing in practices and organize trainings but nevertheless the advantages are so significant that this need more investigations.

On time deliveries, errors in shipments and delivery flexibility are all in a good level at the moment and do not need special actions. It is not important to measure

these in percentages because we discuss about individual cases in these metrics. If problems occur, the cause of problems should be thoroughly investigated and documented as to better predict and prevent such incidents in the future. Improving planning tools, keeping manufacturing lead time in targets, increasing warehouse capacity at mills and container loading at mills will together improve these measures.

COMMON

These are unquantifiable measures but still important for SC performance. Sharing information and clear definition of responsibilities help the company to avoid intangible costs. Feeling valued and satisfied motivates employees and will increase productivity. Managers have an important role to keep relationships between management and employees on a good level. A good working environment also increases the flexibility of workers and increasing responsibility is then possible.

8.2 Limitations

This thesis focuses on gathering information from case mills and benchmarking is done for one of the company's mills. Benchmarking cases could have been done from literature or other businesses but due to the lack of time and limited literature material this thesis is based on only inside of the company operations. It would have been helpful and interesting to find examples from the literature or do the benchmarking outside of the company boundaries.

Numbers used in this thesis are indicative and may not always be entirely accurate.. This does not affect the conclusion and is not essential because the purpose is to give a broader perspective of the processes and developing points. Some of the data was hard to clearly differentiate from other material and there was a need to make assumptions or simplifications. Mill 2 had big investment in 2015 and therefore thesis uses mostly the data from the last 4 months of 2015 after investment. Percentages gives good direction for the results but of course do not accurately reflect, for example, the impact in euros.

This study will not provide any exact numbers or non-public information because the company does not want to show detailed data or numbers publicly. Therefore some of the figures are distorted. The study is done within the limits the company gave and accepted during the study. During this study many interesting details that was excluded from this thesis were found and shared only with the company's management.

8.3 Proposals

This chapter brings together all the proposals that are based on the findings in the case company. These proposals will develop SC to be more effective and help people to understand how SC is working or should work.

- Better use of the production planning tools to make production planning processes more effective and better controlled
- SCC take more role in coordinating SC processes and less important time consuming tasks will be transferred to other people involved in the processes
- Manufacturing lead time target level one month (30 days)
- Start following more closely the safety stock levels at mill 1
- Increase inventory turnover rates to target level
- Warehouse capacity increase at mill 2 and warehouse capacity decrease at port 1
- Start traceability project to improve SC controlling and increase customer satisfaction
- Increasing volumes for railway transportation at mill 1
- Research the opportunity of container loadings at mills

Findings are so remarkable that there are very good arguments to improve the facts above. These all together require a lot of planning and behavioral changes in operations. All the changes cannot be made quickly because they require extensive cooperation with different departments and a lot of research. It will take months to develop all changes suggested but some of them can be made in a short time frame.

8.4 Possibilities for future research

It is difficult to forecast accurately all the things that could arise in the future. The company should always be prepared to adapt to changing environment for example in the role of government, the increasing participation of third parties, and the impact of new technologies. A quick reaction to environmental changes gives the company a competitive advantage. Changes in customer portfolio and general economic situation can lead to a need to change the structure of supply chain.

This study aimed to provide insights of the SC processes current state at the case mills. Study found processes that need to be developed and monitored more closely. When the proposals made in chapter 8.3 are cleared and settled through projects, some new possibilities for future research might be found. One of the main future researches is finding a suitable traceability system and begin container loadings at mills. A lot of detailed investigations and planning is needed before these projects can be implemented.

9 SUMMARY

The competitiveness of the company is more and more dependent on the competitiveness of the whole supply chain. Therefore supply chain process management and performance measurement have been popular subjects in the SC literature recently. The main objective of this research was to model current state of pulp SC processes at case mills and find KPIs to measure its performance and find the development points. The purpose is to develop existing current state processes to be more efficient and not to change the whole process structure.

A changing world and environment creates pressure for the development of SC. Developing SC process management and measurement will bring significant benefits in manageability, efficiency and costs. Many people just think SCs for granted and do not understand what development possibilities can be found. As this study itself shows, in already well-functioning SC can be found significant improvements and cost savings. Big volumes of products and global environment will give many different possibilities to develop SC processes and achieve competitive advantage.

The findings of this thesis provide the case company information of SC processes which need development and more detailed research. Processes itself might be working well, but with small changes and improvements in processes, surprisingly great benefits might be achieved. Like calculations showed, there are many values that can be developed, and by doing so, make the whole SC chain more efficient.

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