



**DETECTING AND ELIMINATING WORK TASK WASTE OF A SUPPLY CHAIN
PLANNER USING LEAN SIX SIGMA TOOLS – CASE STUDY FROM A RETAIL
COMPANY**

Lappeenranta–Lahti University of Technology LUT

Master's Thesis

Master's programme in supply management

2025

Julianna Tiirikka

Examiners: Professor Veli Matti Virolainen, D. Sc. (Tech.)

Professor Katrina Lintukangas, D. Sc. (Econ. & Bus & Adm.)

ABSTRACT

Lappeenranta–Lahti University of Technology LUT

LUT School of Business and Management

Business Administration

Julianna Tiirikka

Detecting and Eliminating Work Task Waste of a Supply Chain Planner Using Lean Six Sigma Tools – Case Study from a Retail Company

Master's thesis

2025

76 pages, 12 figures, 6 tables and 2 appendices

Examiners: Professor Veli Matti Virolainen, Professor Katrina Lintukangas

Keywords: Lean Six Sigma, Lean Management, DMAIC, Value Stream Mapping, Eliminating waste, Work task waste

Today's constantly changing external environment forces companies to continuously adapt and improve to maintain competitive advantage in addition to surviving and succeeding in the markets. Continuous improvement is one of Lean Six Sigma's core principles that aims to improve a process by eliminating its waste. Therefore, two Lean Six Sigma tools, DMAIC and Value Stream Mapping, are utilized in this thesis. This master's thesis is a case study for a company's consumable side working in the retail industry. The aim is to detect and eliminate waste from work tasks belonging to a supply chain planner.

The empirical study was conducted as qualitative research because the aim was to provide qualitative insights based on research data. The time used for each task was tracked with the help of a self-reported Excel. Each supply chain planner filled out the Excel for ten workdays during two separate weeks. Also open-ended questions were added to the end of the time tracking Excel to get more in-depth responses about experiences, opinions and feelings. The research results revealed five wastes, which are inappropriate processing, transporting, waiting, unnecessary motion and defects. They all delved from 12 inefficiencies in work tasks, to which solution suggestions were made. Also, five non-value adding tasks were found which take time but do not add value to the end customer, and therefore are seen as waste. By eliminating and decreasing the found wastes, supply chain planner could save up to 25 per cent of its daily work time and utilize it for important value adding work tasks.

TIIVISTELMÄ

Lappeenrannan–Lahden teknillinen yliopisto LUT

LUT-kauppakorkeakoulu

Kauppätieteet

Julianna Tiirikka

Hukan tunnistaminen ja poistaminen täydennyssuunnittelijan työtehtävistä Lean Six Sigma työkalujen avulla – tapaustutkimus vähittäisyrityksestä

Kauppätieteiden pro gradu -tutkielma

2025

76 sivua, 12 kuvaa, 6 taulukkoa ja 2 liitettä

Tarkastajat: Professori Veli Matti Virolainen, Professori Katrina Lintukangas

Avainsanat: Lean Six Sigma, Lean Management, DMAIC, Value Stream Mapping, Hukan poisto, työn hukka

Yritysten on pyrittävä jatkuvasti sopeutumaan ja kehittämään liiketoimintaansa pysyäkseen mukana muuttuvassa markkinassa. Lean Six Sigma tunnetaan prosessien kehitysmenetelmänä, joka pyrkii jatkuvaan kehitykseen hukan poiston myötä. Tässä pro gradu -tutkielmassa hyödynnetään kahta Lean Six Sigma työkalua: arvovirtakuvausta (Value Stream Mapping) ja DMAIC-menetelmää. Tämä tutkielma on tapaustutkimus vähittäiskaupan alalla toimivalle yrityksen käyttötavarapuolelle. Työn tarkoituksena on tunnistaa ja poistaa täydennyssuunnittelijan hukka työtehtäviä. Tutkimukseen valittiin laadullinen tutkimusote, sillä tavoitteena oli analysoida dataa havaintojen kautta. Tutkimuksen aineistonkeruumenetelmänä käytettiin kyselylomaketta Excelin muodossa, jonka avulla seurattiin työtehtäviin kuluvaa aikaa. Jokainen täydennyssuunnittelija täytti kyseiseen Exceliin jokaisen käyttämänsä 15 minuutin kymmenen päivän ajan. Lisäksi kysely sisälsi neljä avointa kysymystä.

Tutkimuksen avulla työtehtävistä löydettiin viittä eri hukkaa: liiallista prosessointia, tarpeetonta liikettä, kuljettamista, virheitä ja odottamista. Hukat löydettiin vertailemalla ajanottoja työntekijöiden kesken, tekemällä havaintoja avointen kysymysten vastuksista sekä jakamalla työtehtävät arvoa tuottaviin (VA), arvoa tuottamattomiin (NVA) ja välttämättömiin mutta arvoa tuottamattomiin (NNVA) työtehtäviin. NVA työtehtäviä löydettiin viisi kappaletta, joita pidetään suorana hukkana. Tehottomuuksia löydettiin yhteensä 12, joihin laadittiin kehitysehdotuksia. Hukkien poisto ja vähentäminen voisi säästää täydennyssuunnittelijalta jopa 25 prosenttia sen päivittäisestä työajasta.

ACKNOWLEDGEMENTS

As my thesis journey is coming to its end, so is my two-year academic path at LUT. It has been an educational yet fun experience to say the least. The amount of knowledge, memories and most importantly friends I have gained through this journey is something I will forever be grateful for.

I would like to thank all my professors during my years at LUT who have guided and instructed me throughout this path and prepared me for this thesis project. A special thank you belongs to my instructor Veli Matti Virolainen, who has been there throughout this thesis journey for guidance, support and essential feedback.

I also wish to express my gratitude to my family and friends who have stood by me through my studies and this thesis project. Your daily belief and support have kept me going even during the most stressful times.

Even though it feels wistful to wrap up my overall five years of studies, I am beyond excited to see what the world has to offer. I am excited to take on new challenges and opportunities that will help me grow both professionally and personally.

Helsinki, March 20th, 2025

ABBREVIATIONS

CSVSM	Current State Value Stream Mapping
DC	Distribution Centre
FSVSM	Future State Value Stream Mapping
LSS	Lean Six Sigma
NNVA	Necessary but non-value-adding
NVA	Non-value adding
TPS	Toyota Production System
VA	Value-adding
VSM	Value Stream Mapping

Table of Contents

Abstract

Acknowledgements

Abbreviations

1	Introduction	9
1.1.	Background, Main Objectives and Research Questions	9
1.2.	Conceptual Framework, Methodology and Limitations	10
1.3.	Defining key concepts	12
1.4.	Structure of Thesis	13
2	Lean	16
2.1.	Lean and its Purpose	16
2.1.1.	Lean Approaches	18
2.1.2.	Key Principles and Process of Lean	19
2.1.	History of Lean and Case Studies	21
2.2.	Defining Waste (Muda)	23
3	Six Sigma.....	26
3.1.	What is Six Sigma.....	26
3.2.	History of Six Sigma and Case Studies	29
4	Lean Six Sigma.....	31
4.1.	What is Lean Six Sigma.....	31
4.2.	Lean Six Sigma Case Studies and Tools	35
4.2.1.	DMAIC	36
4.2.2.	Value Stream Mapping (VSM).....	38
4.2.3.	VSM Supply Chain Planner’s Work Tasks	40
5	Empirical Findings	43
5.1.	Methodology	43
5.2.	Data collection	45
5.3.	Findings and Results	47
5.3.1.	Time Tracking.....	47

5.3.2.	Comparing results	50
5.3.3.	Open-ended questions	51
5.4.	Validity and Reliability	53
6	Analysis and Conclusions.....	56
6.1.	Discussion and Suggestions for Future Improvements and Research	56
6.2.	Answering the Research Questions	64
6.3.	Conclusions.....	67
	References.....	71

Appendices

Appendix 1. Representation of the Time Tracking Excel

Appendix 2. Comparison of the Results

Figures

Figure 1: Conceptual framework

Figure 2: Structure of thesis

Figure 3: Lean key principles

Figure 4: Lean process

Figure 5: Seven wastes

Figure 6: Link between Lean, Six Sigma and Lean Six Sigma (adapted from Snee, 2010)

Figure 7: Explanation of DMAIC

Figure 8: Meanings of VSM symbols

Figure 9: VSM supply chain planner's work tasks

Figure 10: Value Stream Map of a supply chain planner's daily work tasks

Figure 11: Work time spent during two weeks of time tracking

Figure 12: Future State Value Stream Map

Tables

Table 1: Purpose of Lean

Table 2: Purpose of Six Sigma

Table 3: Purpose of Lean Six Sigma

Table 4: Open-ended questions

Table 5: Found inefficiencies, detected wastes and suggested solutions

Table 6: Found wastes and suggestions on elimination

1 Introduction

This chapter is an introduction to this thesis. It starts with a presentation of the background which aims to clarify the relevance and significance of the research problem. After this, the main objectives and research questions are presented. The chapter continues with demonstrating the conceptual framework along with methodology and limitations of the research. After this, the key concepts are defined, and the structure of this thesis is presented to provide a clear and logical understanding on the constitution.

1.1. Background, Main Objectives and Research Questions

Companies face ongoing changes and challenges in the external environment caused by more demanding consumers than ever, increased competition and relatively unstable economic situation due to multiple various reasons. Cost reduction and ability to both rapidly change and continuously improve are core elements to survive and succeed in the market. To maintain competitive in the market, a low investment, easy to comprehend and simple approach should be used. Continuous improvement is a perfect example of this. (Drohomeretski et al. 2013). Lean Six Sigma is a common continuous improvement model, that offers a holistic, comprehensive and unitary approach due to Lean's habit of increasing process efficiency and Six Sigma's habit of detecting and defining defects from processes (Costa et al. 2021).

One of Lean Six Sigma's main aims is to eliminate waste, which is seen as an extraordinary way to improve process flow by eliminating tasks and phases that slow down operations (Costa et al. 2021). Waste can be seen as something that does not add value and therefore eliminating it is an effective way to increase a company's effectiveness (Bhamu & Sangwan, 2014; Chen et al. 2008). Also, by eliminating waste, companies are able to provide a customer exactly what they want (Womack & Jones, 2003, 15). Lean Six Sigma is nowadays used for eliminating waste in various industries due to its resilience and ease of application. A couple of well-known companies have used the mentioned methodology with great

success and therefore it has created a copycat phenomenon to many other companies and industries. (Laureani & Antony, 2012).

Time can be considered as one of our most valuable resources and therefore it should be used as efficiently as possible. This is why it is important for the case company to try maximizing efficiency time and cost wise to keep up with the constantly changing world. Many studies have been made about Lean, Six Sigma and the combination of both, Lean Six Sigma, but the retail industry has yet to fully embrace these methodologies according to the literature. Also, studies lack the perspective of utilizing Lean Six Sigma to eliminate waste regarding work tasks. Many studies focus on making processes more efficient factory or machine wise, but not many studies look at the methodology from a people-oriented approach. This thesis aims to utilize the Lean Six Sigma methodology from a practical human-centered approach.

This thesis is a case study for a company working in the retail industry. The research problem embarked from the case company's practical need to detect and eliminate work task waste to optimize resource allocation and enhance continuous improvement. The aim of this thesis is to help case company detect and eliminate work task waste of a supply chain planner mainly through work task time tracking and making qualitative insights on collected data. This thesis aims to offer practical solutions for eliminating and reducing waste by adapting a theoretical framework, Lean Six Sigma, into this pragmatic research problem.

1.2. Conceptual Framework, Methodology and Limitations

The aim of this thesis is to detect and eliminate work task waste. Three main concepts surround this topic, which are continuous improvement, detecting work task waste and Lean Six Sigma. Figure 1 is a visual presentation of these themes and their interconnection between one another. By detecting and eliminating work task waste utilizing Lean Six Sigma, continuous improvement can be achieved.

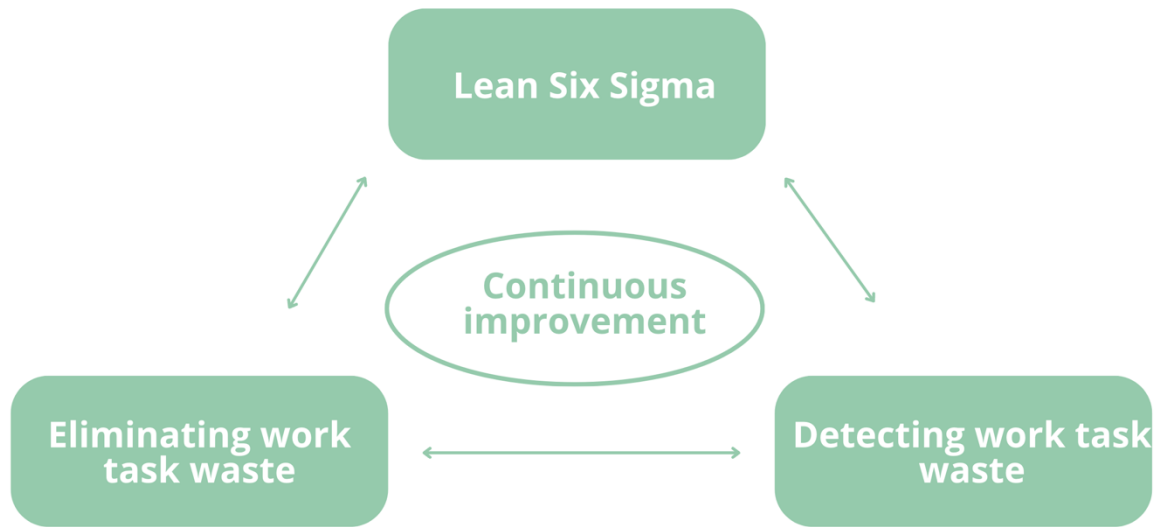


Figure 1, Conceptual framework

The aim of the thesis is to utilize Lean Six Sigma and its tools to detect and eliminate work task waste and therefore help the case company with its continuous improvement. Waste in this thesis is considered as a work task that does not add value to an end customer or takes too much time compared to other employees. The value that a supply chain planner offers to the end customer is creating a reliable and resilient process flow for products ending in the right place at the right time in right amounts. Considering the aim of this thesis, the following main research questions was formed:

How can work task waste be eliminated at case company?

In addition to the main research question, two supporting sub-questions were formed. This was done to help achieve a more in-depth answer to the main question. To eliminate waste, it first has to be found and defined. The sub-questions relate to defining the work task waste and utilizing Lean Six Sigma tools. The sub-questions are as follows:

What work tasks of a supply chain planner are considered as waste?

How can Lean Six Sigma tools be utilized to eliminate waste?

This thesis is limited to only the consumable half of the company, leaving out the grocery side. This is because the grocery side is a lot bigger and in there, one employee takes care of either store replenishment or DC (distribution center) replenishment. On the consumable

side one employee is in charge of a product family's both store and DC replenishment, which is more comprehensive. This limitation was also a wish from the case company. Both store and DC replenishments are taken into account in this thesis because it gives a holistic view of the employee's entire job description. The consumables team consists of 18 people. The entire team is chosen as a sample to get a comprehensive understanding of the team's work and to ensure justice in representation and therefore reduce risk of bias. This also obstructs possibility of missing critical observations. The time tracking data was gathered using an Excel sheet. Each employee filled out their own Excel by marking each 15 minutes spent on a compiled work task list. The data was gathered for 10 working days during two different weeks from Monday to Friday. Four open-ended questions were added to the end of the Excel survey to help receive more in-depth responses about experiences, opinions and feelings.

1.3. Defining key concepts

The key concepts of this thesis are Lean, Six Sigma, Lean Six Sigma, Muda (waste), Value Stream Mapping (VSM) and DMAIC.

Lean: Lean is a philosophy that focuses on reducing waste (Drohomeretski et al. 2013) and increasing quality and productivity by identifying and eliminating activities that do not add value to a product or to an end customer (Holweg, 2007).

Six Sigma: Six Sigma is a total quality management tool (Forrest, 2006) and a management approach that focuses on reducing faults in processes. It is a business strategy that aims to understand customer need and requirements, financial performance and business productivity. (Kwak & Anbari, 2006).

Lean Six Sigma: Lean Six Sigma is a combination of quality management methods Lean and Six Sigma. It is a methodology that strives to increase process performance and improvements, reduce waste, eliminate rework time and improve productivity. (Drohomeretski et al. 2013). It provides a holistic, comprehensive and unitary approach for continuous improvement (Costa et al. 2021).

Muda (waste): Muda is a Japanese term for waste that comprises wasted effort, materials and time (Womack et al. 2007). It can also be considered as any human activity that absorbs resources but does not create any value (Womack & Jones, 2003, 15). In this thesis waste is considered as a work task that does not bring value and takes too much time when comparing to other employees.

Value Stream Mapping (VSM): Value Stream Mapping is a tool used to illustrate all steps of a work process in a form of a map. It helps define which activities do and do not add value. (Rahmanasari et al. 2021).

DMAIC: DMAIC is a problem-solving methodology and an approach, that aims to improve process performance. It is an acronym for the words define, measure, analyze, improve and control, which describe the five steps of a process. (Vermaelen & Kovach, 2022).

1.4. Structure of Thesis

This thesis consists of six main chapters, which are presented in figure 2. These chapters include introduction, Lean, Six Sigma, Lean Six Sigma, empirical findings and analysis, and conclusions. The first chapter provides an overall introduction to this thesis starting with an overview of the background, to clarify the relevance and significance of the research problem. The main objectives are also presented which give an idea of the focus in this thesis. After this the research questions are stated and the conceptual framework is illustrated and explained, to help understand the relations between the key topics. Methodology is then presented to help understand the approaches and techniques used to collect and analyze data. The chapter continues with explicating limitations and key concepts to clear the understanding and scope of this thesis. This also sets a common ground on how these concepts are viewed and understood particularly in this thesis.

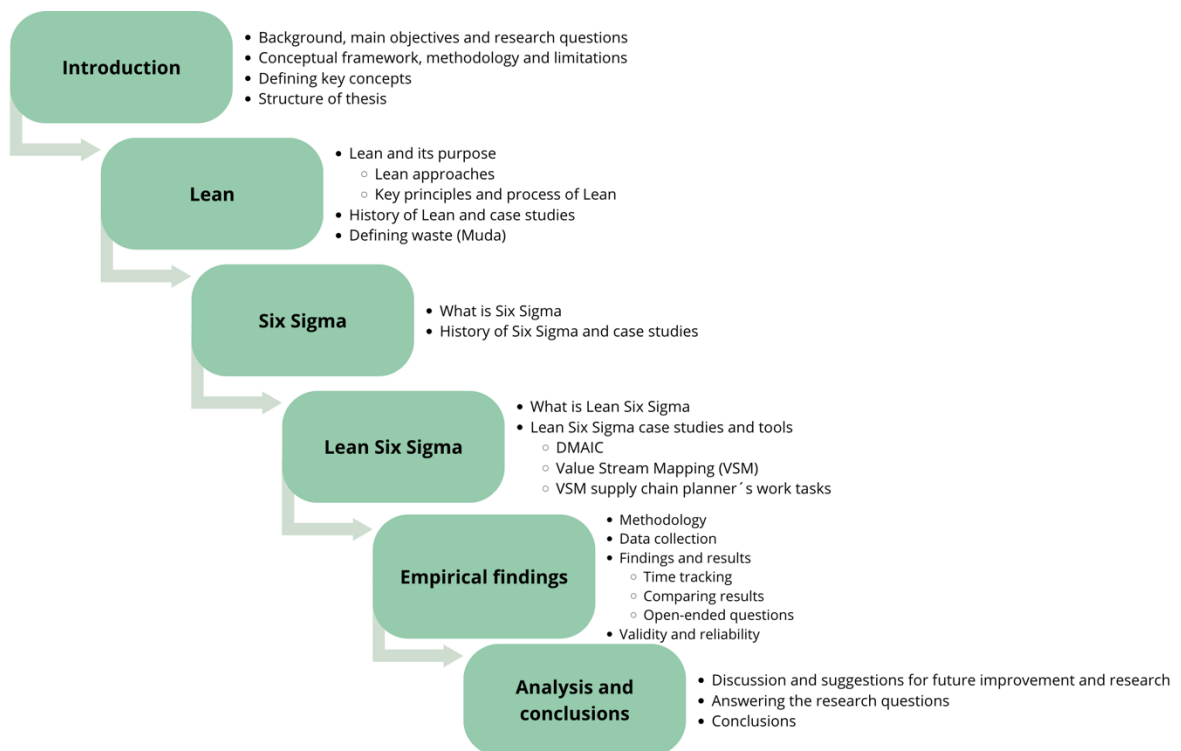


Figure 2, Structure of thesis

The next three main chapters, Lean, Six Sigma and Lean Six Sigma discuss the topics with help of previous relative academic literature. In order to achieve a high-quality research analysis, the literature review focused on peer-reviewed articles. Another main filter in choosing the scientific articles was that they have open access to the entire article. Each of these three chapters starts with an introduction to what the approach is, after which some history along with some case studies is presented. It is necessary to properly first dive into what are Lean and Six Sigma on their own, after which it is easier to understand on how they work together. This is reviewed in Lean Six Sigma chapter.

At the end of Lean chapter, waste (Muda) is explained, which is an essential part to understand in this thesis. At the end on Lean Six Sigma sub chapter two, DMAIC and Value Stream Mapping, the two Lean Six Sigma tools are presented. The latter tool is also adapted into the function of this thesis and therefore the supply chain planner's work tasks are adjusted into a form of a Value Stream Map. The empirical findings begin with an introduction of the methodology used and continues with a chapter related to the data collection. After this the results are reviewed in three different sub chapters, time tracking, comparing results and open-ended questions, to maintain easy readability. Validity and

reliability are also reviewed at the end of this chapter. Their intent is first explained, followed by a discussion on how they are applied in this thesis. The final chapter includes discussion on the findings and suggestions for future improvements. Also, suggestions for future research are made to encourage continuous improvement after this research. After all this, a conclusion sub chapter is added to encapsulate this thesis. At the very end of this thesis the references are listed, and two necessary appendices are presented.

2 Lean

This chapter discusses Lean with the help of previous relative academic literature. It starts with defining what Lean is, after which its various approaches and key principles are elucidated, and Lean process is explained. After this, the chapter discusses history of Lean and showcases some case studies from different fields. At the end of this chapter, waste (Muda) is defined to provide a deeper understanding of its meaning both in general and within the context of this study.

2.1. Lean and its Purpose

Lean is a philosophy, that aims for continuous improvement in productivity (Chen et al. 2008), with its main objective being elimination of waste (Shah & Ward, 2007; Wang et al. 2004; Bhuiyan & Baghel, 2005; Antony, 2011; Bhamu & Sangwan, 2014; Condé et al. 2023; Holweg, 2007; Womack & Jones, 2003; Ojo et al. 2022.) This can be done by reducing supply variability, processing time and demand (Shah & Ward, 2007). By eliminating waste, Lean results to time (Wan & Chen, 2008; Bhamu & Sangwan, 2014) and value (Wan & Chen, 2008; Bhamu & Sangwan, 2014; Womack & Jones, 2003) improvement. In addition to waste elimination, Lean also efforts to convert waste into value (Womack & Jones, 2003, 15).

“Lean provides a way to do more and more with less and less— less human effort, less equipment, less time, and less space—while coming closer and closer to providing customers with exactly what they want.” (Womack & Jones, 2003, 15.)

According to Chen et al. (2008), Lean can also increase competitiveness. Both Ojo et al. (2022) and Laureani & Antony (2012) concur that Lean is an advisable philosophy to use if in need of improving quality due to many reasons. For example, multiple sources state that Lean is can also reduce costs, inventory, production time, human effort and resources. (Shah & Ward, 2007; Wang et al. 2004; Wan & Chen, 2008; Bhamu & Sangwan, 2014; Antony, 2011; Laureani & Antony, 2012; Womack & Jones, 2003; Singh et al. 2010; Womack et al.

2007). Table 1 is to elucidate which sources supports which statements (see below). Only the statements that are backed up by at least two various sources are shown in the table. On the very left column are sources stating the outcomes promised when using Lean, presented on the top row.

Table 1, Purpose of Lean

	Eliminate waste	Reduce costs	Reduce inventory	Reduce production time	Reduce human effort	Reduce resources	Improve time	Improve value
Shah & Ward (2007)	x	x	x	x	x	x		
Wang et. al. (2004)	x	x	x					
Bhuiyan & Baghel (2005)	x	x						
Antony (2011)	x	x	x	x				
Bhamu & Sangwan (2014)	x	x		x		x	x	x
Condé et. al. (2023)	x							
Holweg (2007)	x							
Womack & Jones (2003)	x		x	x	x			x
Ojo et. al. (2022)	x							
Wan & Chen (2008)		x		x			x	x
Laureani & Antony (2012)		x		x				
Singh et. al. 2010)			x	x	x			
Costa et. al. (2021)								
Womack et. al. (2007)						x		

To get a more versatile understanding on Lean, it can be compared to mass production for instance. When doing this, Antony (2011) states that Lean uses less of everything mass

production does, for instance half the effort, half the investment tools, half the manufacturing space and half the production time. It also focuses on information and material flow between process steps. Womack et al. (2007) support this and note that it also aims for perfection whereas mass producers set a “good enough” goal for themselves where they settle for acceptable results.

Bhamu & Sangwan (2014) state that Lean aims to produce large quantities in the most efficient and economical way. This is supported by Costa et al. (2021), who express, that this helps improve process flow. To successfully implement Lean, Antony & Laureani (2012) emphasize how critical it is to make sure right resources are applied to the correct activities. In addition to this, Machado & Leitner (2010) state that strong commitment from employees and employers is needed. Ojo et al. (2022) concur with this view and further add that it also requires team autonomy, interest in Lean and organizational helpfulness. To indicate commitment, leaders should absorb leader role, provide needed resources and understand social and human issues. Absorbing a leader role obliges educating employees, identifying key stakeholders and collaborating with them, developing an operational plan and identifying Lean as a value. (Ojo et al. 2022).

2.1.1. Lean Approaches

According to Machado & Leitner (2010), there are three approaches to Lean. The first approach introduces Lean as a philosophy that aims to reduce waste and can be applied to not just the car industry, but also all other branches. In this approach, Lean is considered excellent for reducing waste, increasing efficiency and making things faster, cheaper and all in all better. In the second approach Lean is a system that offers a set of various tools, which all offer a specific focus. There are over a hundred different Lean tools up till this day. This approach offers a large pool of tools, from where the correct tool can be chosen to the occurred problem. In the third approach Lean is seen as an instruction manual for instance when an overall transformation plan is needed. It helps with listing different steps of the Lean transformation process, helping to understand in what order the steps should be taken, which Lean tools should be chosen and when they should be used. It also alleviates to explain which additional steps should be taken into account regarding preparation and post-processing.

Pepper & Spedding (2010) and Salah et al. (2010) agree on the second approach and compose that Lean is a holistic philosophy, that is based on a large tool pool. Ballé & Régner (2007) argue that Lean is not a toolbox but rather a system that needs to be built by employees and employers of the process. They add that Lean is primarily a learning method, because people who compose a process need to get better at what they do, for the process to perform better. Furlan et al. (2011) agree to this and state that Lean isn't simply a tool package for executing improvements, but it also requires adaptation of distinctives of an organization, suppliers and clients. Which tools to use depends on the problem occurred. Holweg (2007) on the other hand states that Lean is a model that helps organizations increase and fulfil improvement rather than being solely a package of resources.

Lean can be described from two points of view. Either from a philosophical perspective where principles are guided and goals are overarched (Womack & Jones, 2003) or from a more practical perspective where direct observation can be done to a set of management techniques, tools or practices. Lean is not just a singular, but rather a multilateral concept that embodies philosophical characteristics, which makes it harder to measure directly. (Shah & Ward, 2007). Bhamu & Sangwan (2014) reviewed 209 research papers on Lean management and Lean production. Based on these research papers they concluded that even though automotive industry was the focus for this methodology for a long time, also other industries have now adopted Lean. Fillingham (2007) agrees that Lean is a universal system, that can be applied and shaped into all kinds of forms of work.

2.1.2. Key Principles and Process of Lean

Lean includes five key principles that can be seen in figure 3. The first principle is about defining value that is desired by the customer. The second key principle is about identifying each product's or service's value stream to seek all wasted steps in the process. In this step, by identifying value stream, various work steps can be categorized into three categories: value adding (VA) steps, necessary but non-value adding (NNVA) steps and non-value adding (NVA) steps. The third key principle is about flow creation. A product or service should not have to wait or be delayed, it should flow continuously. This step can be done when the non-value adding have been removed from the process. (Machado & Leitner, 2010; Ojo et al. 2022; Womack & Jones, 2003, 16-26).

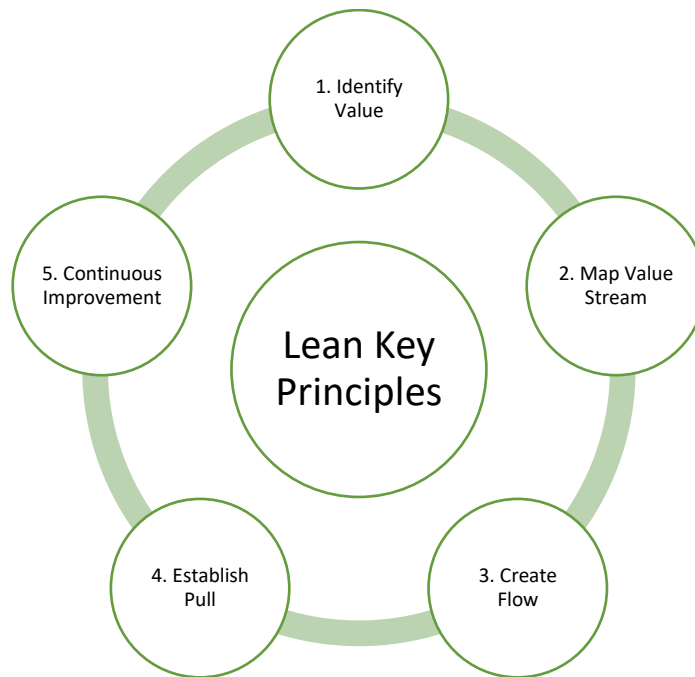


Figure 3, Lean key principles

The fourth key principle is about establishing pull, meaning the customer’s expressed needs. The flow should be based on the pull, which in this case refers to a customer “pulling” a good or service from the company instead of the company “pushing” unwanted products to the markets. The fifth and final key principle is continuous improvement, where one should constantly aim to make improvements, also known as Kaizen, and to eliminate waste. All these steps can be perceived as a circle of steps because all the steps interact with each other. Getting value flow faster reveals often waste and the harder you pull; the more flow is created. (Machado & Leitner, 2010; Ojo et al. 2022; Womack & Jones, 2023, 16-26).

These five key principles align with Machado & Leitner (2010) ’s Lean process description that include four phases, which can be viewed in figure 4. The first phase is understanding the current state. This can be done efficiently with the help of a Value Stream Map, which helps identify the value-adding, non-value-adding and necessary but non-value adding steps. The Value Stream Map is needed in the second step of a Lean process, where the future state is defined. The aim in this step is to reduce or eliminate non-value-adding steps, after which a Future State Value Stream Map (FSVSM) can be created. This illustrates how the process should look like after the Lean transformation.

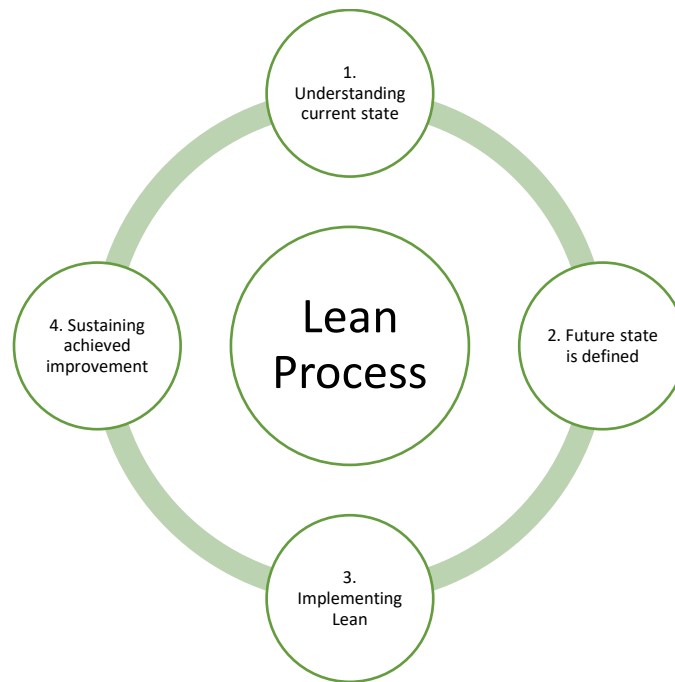


Figure 4, Lean process

Third step is about implementing Lean which aims to fulfil the FSVSM. Ongoing measurement of the Lean implementation, for example measuring customer satisfaction, cycle or lead time, is required at this stage. To succeed in Lean implementation, it is crucial to compare premeditated improvements. The fourth step is about sustaining the achieved improvements, which is often considered as an unnecessary step, but is in fact the most important and also the hardest step. It is easy to slip into old habits which is why strong commitment from employees and employers is needed. (Machado & Leitner, 2010). This continuous improvement phase can also be known as Kaizen, which is originally a Japanese concept, and refers to improving every day, everyone and everywhere (Berhe, 2022). Drohomerski et al. (2013) add that kaizen is, due to its simplicity and low investments, one of the fundamental foundations of Lean because it is also easy to understand.

2.1. History of Lean and Case Studies

Lean, also known as “Lean production” and “Lean manufacturing” (Holweg, 2007), was first pioneered in Japan after World War 2 at the Toyota Motor Company, by Eiji Toyoda and Taiichi Ohno. Lean principles were first properly established in the 1960’s. (Womack

et al. 2007). The initiative purpose was to help Japanese companies and their shortages in human resources, inventory, financial capital and materials (Tjahjono et al. 2010). What nowadays is known as Lean, was and is also known as Toyota Production System (TPS), since it is the basis of Lean. This is due to Taiichi Ohno's employment at Toyota Motor Company at the time, when Lean was first developed. (Pepper & Spedding, 2010). By 1980's, consumer demand started shifting towards new levels because vehicles started to become a new necessity for people to travel from one place to another. Consumers started appreciating more reliability and Toyota realized they no longer had to compete in price with other mass-production products. Already by 1986, Toyota realized it had indeed made a tremendous change in manufacturing and Lean could be added also to new environments. (Womack et al. 2007).

In the late 1990's the focus was on quality, cost and delivery and from 2000's onwards focus has been also on customer value. Nowadays, Lean aims to optimize value to customers by either adding features or removing waste. (Hines et al. 2004). Bhuiyan and Baghel (2005) state that Henry Ford was the one to systemize Lean and execute the concept of mass production in his factories in the early nineteenth century. In the early days of Lean, before 1990's, Lean had an automotive manufacturing-based view that did not take into account human aspects, nor did it take into account variability in demand. The focus was then solely on quality. Since then, it has evolved also into the western world in various sectors and so has become a more practical methodology.

Fillingham (2007) slightly questioned this and examined if Lean could be adapted from the automotive industry to the healthcare industry to save lives. The study was located at Bolton Hospitals and lasted for eighteen months. This study was divided into four steps. First step was trying to understand what brings value to a customer, which in this case was a patient. Using observation, interviews, focus groups, questionnaires and patient diaries, he was able to separate the non-value adding work from the value adding work and therefore eliminate some of the non-value adding steps. The second step was to observe the entire patient care journey with the help of value stream analysis and identify waste work tasks that could be removed to make the journey more efficient. (Fillingham, 2007).

Third step included execution of a future state vision by the team, and the fourth step was about ensuring changes are put into practice and benefit is truly being delivered. Tremendous achievements were made in just nine months. For instance, paperwork reduced by 42 per

cent, total length of patient stay reduced by 33 per cent, mortality reduced by 36 per cent and time taken to get patients into operating room with a fractured hip reduced by 38 per cent. With the help of Lean, Bolton Hospitals was able to make their work process more efficient. (Fillingham, 2007). Also, other studies have managed to implement Lean for improving efficiency. For example, in Chen et al.'s (2008) study, a company was able to improve its quality and improve their processing time using Lean.

Lean has also been added to replenishment in some case studies including Sharma & Kulkarni (2016) 's, where lean was used in spares replenishment in an army. It is crucial to have and maintain proficient replenishment in an army for them to be prepared to accomplish missions at any time. Stocking of spares was first done with just in case philosophy which ensued in large inventories and expensive costs. Lean was added to the system during peace time to make the supply chain more efficient and save costs.

2.2. Defining Waste (Muda)

Muda is a Japanese term for waste that comprises wasted effort, materials and time (Womack et al. 2007). Bhamu & Sangwan (2014) concur and state that waste is defined as activities that do not add value in a production process. Therefore, according to Bhuiyan & Baghel (2005), waste is something that a customer has no interest in paying for. According to Hines & Rich (1997), there are seven wastes that are known as more common than others, that well from the TPS. These seven wastes are overproduction, waiting, transporting, inappropriate processing, unnecessary inventory, unnecessary motion and defects. These wastes are also shown in figure 5.

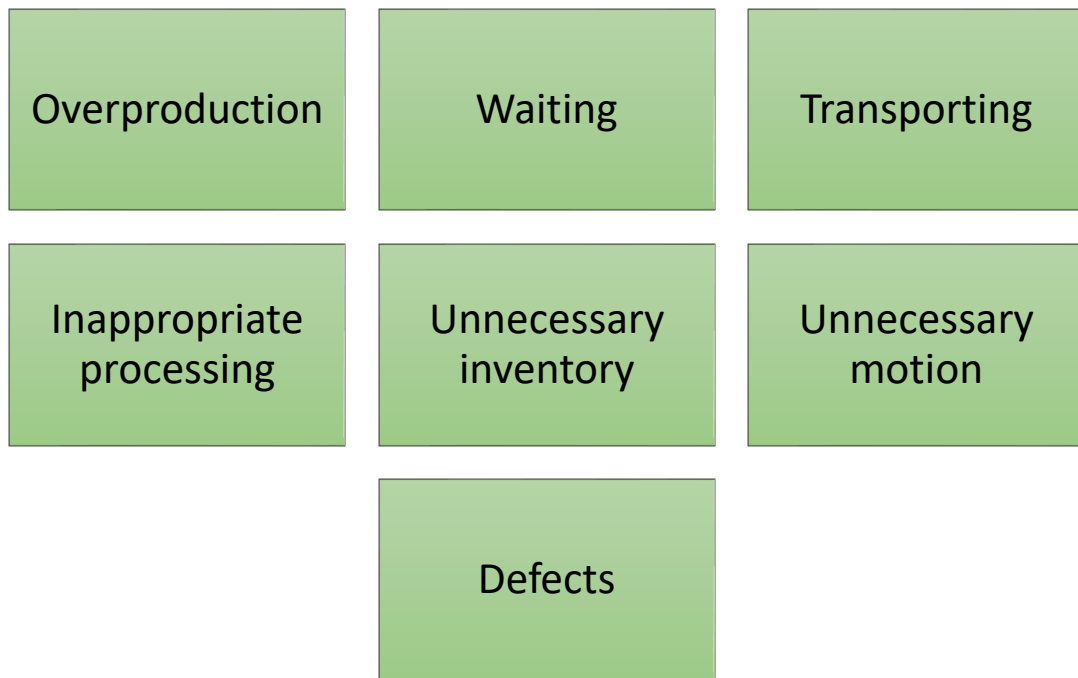


Figure 5, Seven wastes

Overproduction can lead to excessive lead and storage times, costs and unfinished stocks for instance. Waiting may emerge when goods are still or not being worked on, which makes employees wait. This benefits no one and effects both employees and the goods. Transporting can emerge when for instance shipping routes are not planned well. It is crucial to minimize transporting to the bare minimum, to prevent damages, poor communication and deterioration. Inappropriate processing may occur when complex solutions are used instead of simple ones, for example using large and expensive machinery when smaller ones would serve the same way. This can lead to additional transport and poor communication. It may also occur when unnecessary work is required.

Unnecessary inventory can often increase both storage costs and lead time. This often hides problems and therefore obstructs prompt recognition of problems. It also increases lead time and costs. Unnecessary motion includes steps where employees are required more than necessary and stretching to capabilities above them. This exhausts the employees and increases risk of quality problems. Defects are often seen as direct additional cost that should be cut out immediately but should also be seen as improving opportunities rather than something you should get rid of. From these seven wastes, overproduction is considered as

the most serious waste because it threatens a smooth flow of goods and services which could lead to faulty productivity and quality. It also causes superfluous storage and lead times which can consequently cause flaws in products. (Hines & Rich, 1997).

According to Womack & Jones (2003, 15), waste can also be for instance products or services that don't meet with customer needs, mistakes that need repairing, products which don't sell that cause excess inventory, additional processing steps which aren't actually needed, unnecessary movement of employees or goods and unnecessary waiting by for example downstream activities due to upstream activities not delivered on time.

3 Six Sigma

This chapter focuses on relative academic literature about Six Sigma. First, Six Sigma is explained thoroughly after which some history is presented. At the end of this chapter some case studies are presented to get a better understanding on what is possible with the utilization of Six Sigma.

3.1. What is Six Sigma

Six Sigma can be viewed from two perspectives, statistical and business viewpoint (Kwak & Anbari, 2006). When talking as an indicator, Six Sigma technically means that no more than 3,4 defects out of a million opportunities should be detected (Hahn et al. 2012; Kwak & Anbari, 2006). From a business viewpoint, Six Sigma is viewed as a business strategy that is used to improve business profitability in addition to efficiency of operations (Kwak & Anbari, 2006). In this thesis, the focus is on the business viewpoint of Six Sigma because it is not used as a measuring tool but rather a business improvement strategy. One of Six Sigma's main benefits is detecting and minimizing defects (Bhuiyan & Baghel, 2005; Antony, 2011; Hahn et al. 2012; Kwak & Anbari, 2006; Laureani & Antony, 2012; Mahanti & Antony, 2009; Snee, 2010). In addition to this, Six Sigma can also eliminate root causes of a problem and prevent defects. (Tjahjono et al. 2010). According to Antony (2011) & Snee (2010), Six Sigma is also about increasing capability and stability of a business process.

One of Six Sigma's main functions is to create robust products and processes (Antony, 2011; Kwak & Anbari, 2006; Laureani & Antony, 2012; Mahanti & Antony, 2009; Salah et al. 2010; Tjahjono et al. 2010). Laureani & Antony (2012) add that the aim of Six Sigma is to accomplish stable and predictable process results. By improving products and processes, Six Sigma utilization also enhances quality (Antony, 2011; Mahanti & Antony, 2009; Salah et al. 2010), improves profitability (Condé et al. 2023; Tjahjono et al. 2010) and saves costs (Baya, 2017; Mahanti & Antony, 2009; Salah et al. 2010). Kwak & Anbari's (2006) study supports the last stated benefit. The study folded a table of multiple companies and their

reported benefits from using Six Sigma. Over half of the companies were able to reach financial savings when implementing Six Sigma in their process improvement.

Laureani & Antony (2012) state that Six Sigma is about precision, accuracy and ensuring work is done already during first try. According to Antony (2007), Six Sigma can improve bottom-line results and achieve high quality products and services and therefore also increase shareholders' wealth. Antony (2011) adds in a later published article that Six Sigma is especially useful in detecting process steps that perform value poorly. Tjahjono et al. (2010) on the other hand state that Six Sigma can help strengthen product development and process design, and reduce manufacturing process cycle time by shortening product lead times. To clarify which sources support which claim concerning the outcomes of utilizing Six Sigma, a table has been made. In table 2, the very left column shows sources stating the outcomes presented on the top row. An "X" is marked to each row that supports the outcome. Only the statements that are backed up by at least two various sources are shown in the table.

Table 2, Purpose of Six Sigma

	Detect and minimize defects	Increase capability and stability	Create robust products and processes	Enhance quality	Save costs	Improve profitability
Bhuiyan & Baghel (2005)	x					
Antony (2011)	x	x	x	x		
Laureani & Antony (2012)	x		x			
Kwak & Anbari (2006)	x		x		x	
Hahn et. al. (2012)	x					
Mahanti & Antony (2009)	x		x	x	x	
Snee (2010)	x	x				
Salah et. al. (2010)			x	x	x	
Tjahjono et. al. (2010).			x			x
Baya (2017)					x	
Condé et. al. (2023)						x

Six Sigma can also be an extremely successful improvement method from human (motivation, teamwork and customer focus for instance) and process (process improvement, analysis and control) aspects (Antony, 2007). The use of Six Sigma can for example increase customer satisfaction (Mahanti & Antony, 2009) and lower inventory (Wei et al. 2010). The journey of utilizing Six Sigma is stated by Mahanti & Antony (2009) as follows: Six Sigma

starts with a practical problem and is then translated into a statistical domain where it works out a statistical solution after which it translates back into a practical solution. Costa et al. (2021) & Tjahjono et al. (2010) add that Six Sigma is a structured problem-solving framework that uses statistical tools to achieve desired results.

Six Sigma is also known as a quantitative and disciplined improvement approach which can be utilized in different fields such as manufacturing, finance and service processes, that is based on specified metrics. Some of the most crucial elements to successfully implementing Six Sigma, are selecting and training the right people, continuous top management support. In addition to this, enthusiasm, valuing and understanding customer needs, clear performance metrics and strong leadership are required. (Hahn et al. 2012). Wang et al. (2004) agree that effective and committed leadership along with combining the right tools, right people and right projects are the key factors of Six Sigma's successful implementation.

Since Six Sigma has been a continuously growing approach, its experts are increasing and are also known as black, green or yellow belts. The black belts are top experts that train the most, green belts train slightly less and yellow belts train the least. (Hahn et al. 2012). According to Laureani & Antony (2012), previously also white belts have been added to the list. Their job is a lot narrower compared to the black belts and they focus within a specific work cell.

3.2. History of Six Sigma and Case Studies

It is said that Motorola was one of the first companies to successfully implement Six Sigma in the 1980's, when the company was about to lose its business to other Japanese competitors. After this, multiple other companies have started applying it to their company processes. (Hahn et al. 2012). Antony (2007) divides the history of Six Sigma into three separate generations. The first generation was from years 1987-1994 and it focused on reducing defects. The second generation, 1994-2000, focused on reducing costs. The third generation which happened from 2000 onwards, concentrates on adding value to the customer.

Anand et al. (2010) concur that in 1986, when six sigma was first originated, its original purpose was to improve production processes minimizing variation and therefore reducing

defects. These required solid metrics and precise measurement. Since then, Six Sigma's goals have broadened and nowadays they include objectives such as developing closer relationships with suppliers and increasing customer satisfaction. Six Sigma was first used in the manufacturing fields but since then, other industries have noticed its perks, and it has also been used in purchasing, servicing, marketing and engineering for instance (Kwak & Anbari, 2006). During the last few decades, Six Sigma has also been implemented in service industries in the context of supply chain (Wei et al. 2010). Six Sigma has also been added to local government, public sectors and healthcare for instance (Tjahjono et al. 2010).

Six Sigma is considered as one of the main reasons for Samsung's tremendous success in the 1990's. Six Sigma was applied in their entire business process, but also specifically in supply chain. This resulted in increasing quality, developing new innovative products and increasing customer satisfaction and profits. Since then, Six Sigma in supply chain management has become a unique tool of Samsung's strategy in continuous and systematic improvement. Samsung had two steps in implementing supply chain management six sigma, which were education and application to practice. (Yang et al. 2007).

Wang et al. (2004) utilized Six Sigma for supplier development. They measured performance scores for 25 suppliers to define supplier network optimization and supplier development program resource allocation. With this listing their aim was to categorize suppliers so that the suppliers with top scores would be prioritized as first tier group for long-term relationship. The suppliers with lower results should upgrade their capabilities and the suppliers with the lowest scores should be eliminated from the supplier base. Mahanti & Antony (2009) found, based on their survey, that applying Six Sigma helped multiple Indian software companies produce better quality software, increase their productivity, reduce costs and most importantly, increase customer satisfaction.

Six Sigma was also added to a Portuguese company NutriSoil as a strategy aiming to retain profitability by reducing production costs. Six Sigma helped NutriSoil improve its competitive advantage and save considerable amounts of costs. Annual savings of 700 000 euros and 4,74 per cent increase in sales value per product were achieved. A key indicator for the pleasant results was management's thorough education. Six Sigma turned out to be an effective way to improve a production process that helped the company achieve an enormous saving in costs in addition to reduction in absenteeism, turnover and work-related accidents. (Baya, 2017).

4 Lean Six Sigma

This chapter includes reviewing the definition of Lean Six Sigma and introducing some case studies related to the topic, with the help of relative academic literature. Also, the LSS practices and tools used in this research, DMAIC and Value Stream Mapping, are introduced on a deeper level. At the end of this chapter, supply chain planner's work tasks are presented in the form of a Value Stream Map.

4.1. What is Lean Six Sigma

Lean Six Sigma is a combination of Lean and Six Sigma. They have both been used separately for multiple years but have only been used together since 2000's. (Laureani & Antony, 2012; Antony et al. 2012). Due to Lean's habit of increasing process efficiency and Six Sigma's habit of detecting and defining defects from processes, LSS provides a holistic, comprehensive and unitary approach for continuous improvement (Costa et al. 2021). According to Bhuiyan & Baghel (2005), Six Sigma brings a statistical control to Lean and on the other hand Lean can help Six Sigma reduce invested capital and improve process speed. In short, Lean and Six Sigma should be used together to get the full potential because they both complete each other. (Salah et al. 2010). Costa et al. (2021) support this and state that LSS offers an exceptionally powerful tool for process improvement when both Lean and Six Sigma are merged.

Antony (2011) also agrees that alone, Lean and Six Sigma are unable to reach improvement rates that LSS alone is able to. For example, Six Sigma alone cannot reduce invested capital or improve a process on its own and Lean cannot put a process under statistical control (Bhuiyan & Baghel, 2005). Pepper & Spedding (2010) agree and add that Six Sigma without Lean offers a broad toolbox for an improvement team to utilize but no structure or strategy to proceed. LSS also helps face problems that occur when both Lean and Six Sigma are used individually, as they complete one another. Both of these methodologies together help increase improvement. (Salah et al. 2010; Bhuiyan & Baghel, 2005; Antony, 2011). The reason why Lean and Six Sigma can easily be combined, is because they share the same

principles, goals and objectives. Lean and six sigma should be used simultaneously rather than in parallel to leverage their synergy and get the most benefit. (Salah et al. 2010). Both Six Sigma and Lean share similar commonalities such as focusing on continuous improvement, involving staff, customer satisfaction and searching for root causes and defects (Laureani & Antony, 2012). These tools used simultaneously can help access root causes of poor process performance (Salah et al. 2010; Snee, 2010).

Even though there are a lot of similarities, some qualities also differ when comparing Lean and Six Sigma. Antony (2011) conducted a research together with other researchers and professionals regarding differences between Lean and Six Sigma. They found that Six Sigma requires longer training time and larger investments than Lean. Pepper & Spedding (2010) add that in a process, Six Sigma strives to improve effectiveness whilst Lean aims to reduce inefficiency. Using both continuous improvement methods Lean and Six Sigma together, finding the correct balance between the two is required. This avoids a too lean of an approach that might result in a starch response to the market. An incorrect amount of balance between the two could also result in wasting unnecessary resources if focus from the customer needs is strayed.

Lean Six Sigma (LSS) is mainly used to eliminate waste from a process (Costa et al. 2021; Salah et al. 2010; Bhuiyan & Baghel, 2005; Drohomeretski et al. 2013). It also improves quality (Salah et al. 2010; Laureani & Antony, 2012; Bhuiyan & Baghel, 2005), reduces costs (Salah et al. 2010; Bhuiyan & Baghel, 2005; Laureani & Antony, 2012) and identifies customer desires (Costa et al. 2021; Salah et al. 2010). In addition to this, it also increases customer satisfaction and therefore simultaneously maximizes shareholder value by achieving rapid improvements in all capital investing, cost, quality and process speed (Laureani & Antony, 2012; Salah et al. 2010).

As seen in chapters 2.1. and 3.1., a table helps visualize and perceive which sources support which statements and therefore one has also been made to this chapter. In table 3 (see below), the very left column shows sources stating the outcomes presented on the top row. Also in this table, only the statements that are backed up by at least two various sources are shown.

Table 3, Purpose of Lean Six Sigma

	Eliminate waste	Improve quality	Reduce costs	Identify customer desires	Increase customer satisfaction
Bhuiyan & Baghel (2005)	x	x	x		
Laureani & Antony (2012)		x	x		x
Costa et. al. (2021)	x			x	
Salah et. al. (2010)	x	x	x	x	x
Drohomeretski (2013)	x				

According to Drohomeretski et al. (2013), Lean Six Sigma is a methodology that strives to increase process performance and improvements, eliminate rework time and improve productivity and company performance. It also strives to achieve better financial results (Bhuiyan & Baghel, 2005) and helps reduce cycle time by eliminating non-value adding tasks (Costa et al. 2021).

“Lean Six Sigma is a business improvement methodology that aims to maximise shareholders' value by improving quality, speed, customer satisfaction, and costs: it achieves this by merging tools and principles from both Lean and Six Sigma.” (Laureani & Antony, 2012.)

“Lean Six Sigma is a business strategy and methodology that increases process performance resulting in enhanced customer satisfaction and improved bottom line results.” (Snee, 2010.)

From figure 7 (see below), you can see the link between Lean, Six Sigma and their combination Lean Six Sigma. Whilst Lean focuses on minimizing waste, reducing non-value-adding activities and cycle time, Six Sigma aims on improving business profitability and operation efficiency, minimizing defects and creating robust products and processes. When these two methodologies are combined, process performance and improvement can

be increased and also process variation, waste, non-value adding work and instability can be reduced. (Snee, 2010; Kwak & Anbari, 2006; Laureani & Antony, 2012; Bhuiyan & Baghel, 2005; Costa et al. 2021).

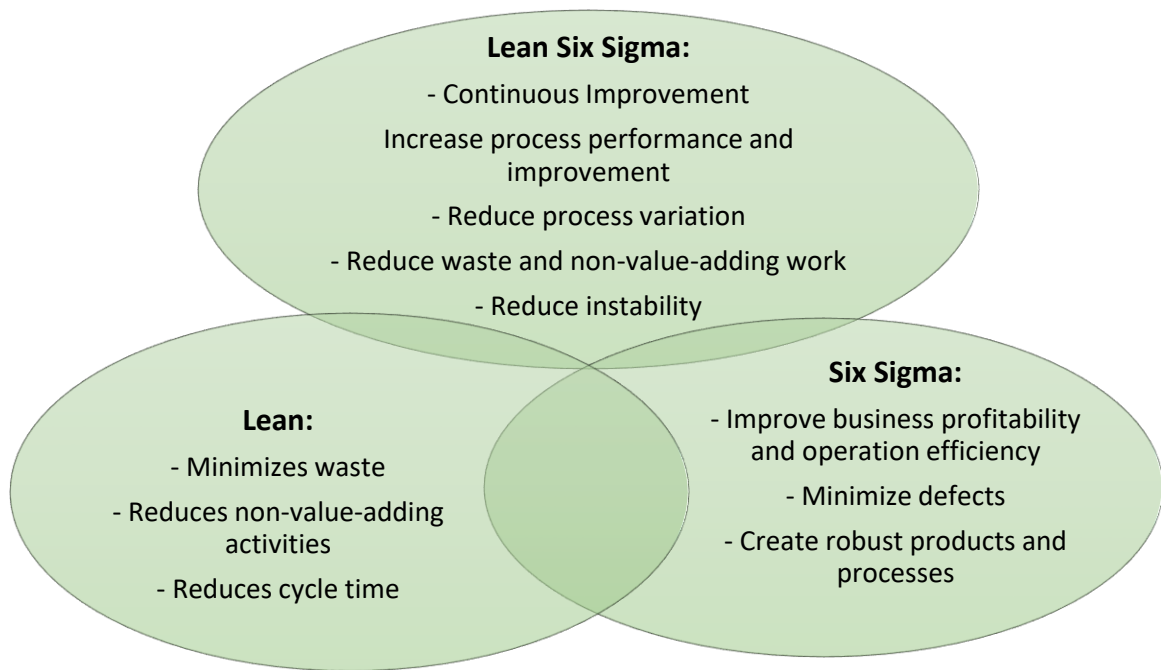


Figure 6, Link between Lean, Six Sigma and Lean Six Sigma (adapted from Snee, 2010)

According to Hilton & Sohal (2012), leadership and communication are critical factors for successfully implementing LSS. Also, LSS education and training are important as well as having LSS experts such as project management and project improvement teams. In addition to all this, performance evaluations are a critical factor, which are often based on data, invested capital, measurement and quality criteria. Adding to this, Netland (2016) states that managers should create a long-term plan and follow it up on a daily basis. Managers should also make sure to apply Lean techniques and tools and commit and take an active part in the LSS program and commit to it. Without commitment and support from the management, it is a waste of time and energy to even launch a LSS initiative. Also, effective communication is vital for composing a common language for improvement and change in a company. This also increases employee's engagement in working with problem-solving scenarios and work better as a team. (Antony et al. 2012).

4.2. Lean Six Sigma Case Studies and Tools

Vermaelen & Kovach (2022) used LSS to achieve better work practices and changes, that aim to reduce time required for a certain task, in this case meetings. Using DMAIC as a LSS tool, the company was able to reduce and improve the quality of the meeting minutes, making the meetings more efficient. Lean Six Sigma tools have also been applied in other cases to improve efficiency. For example, Tagge et al. (2017) utilized DMAIC to increase efficiency in an operating room. Sharma et al. (2021) on the other hand used DMAIC and other LSS tools, such as VSM, to reduce defect rate by 53 per cent and increase simultaneously production rate and therefore increase efficiency. Laureani et al. (2010) wanted to examine the power of LSS on company performance and explore how well it can be applied to other than manufacturing operations. The study results show that LSS helped them reduce annual turnover by ten per cent and reduced additional costs related to hiring process and training by 1.3 million US dollars per year.

Antony (2007) claims that LSS could only be applicable to manufacturing operations, but Vermaelen & Kovach (2022) disagree stating that LSS has spread to many other various industries, with the second largest industry being service industries. Also, studies prove that LSS can be applied to various industries. Drohomerecki et al. (2013) made a study in southern Brazil for multiple large companies representing in a wide variety of industry sectors to examine the effect of using Lean, Six Sigma or LSS in their organization. The study results state that the application of LSS helps a company find more broad competitive priorities compared to when using Lean or Six Sigma on their own. LSS enables an organization to have exceptional quality, offer higher reliability in products and services, have flexibility in serving customers, make an organization work faster and reduce costs. Also, Costa et al. (2021) studied if and how LSS could be applied in the food industry. Conclusion was that LSS helped identify possible improvement opportunities which then helped enhance firms' performance and competitiveness.

4.2.1. DMAIC

DMAIC is a disciplined systematic improvement approach (Snee, 2010) that is originated in Six Sigma but can be used also as a comprehensive framework generally for process improvement (Salah et al. 2010). It is a process that cuts out unproductive procedures (Kwak & Anbari, 2006). Bhuiyan & Baghel (2005) state that DMAIC was first developed to define opportunities, measure performance, analyze opportunities and improve and control performance. DMAIC has been used for instance in service operations such as government, education, healthcare and banking to achieve prominent performance improvements. Tjahjono et al. (2010) scoped multiple publications and based on these suggest that DMAIC is one of the two most common methodologies for implementing Six Sigma.

DMAIC is an acronym that stands for the words define, measure, analyze, improve and control (see figure 8). In the define phase, a customer's value is defined and understood. A problem is also created, and a project team is gathered. Also defining project boundaries and mapping the process flow are important steps in this phase. In the measuring phase, a data collection plan is developed, and current data is collected to view the current phase. Improvement suggestions are made at this phase, which often starts the analyzing stage. These improvement suggestions often reveal root causes of the defined problem. The analyze phase includes phases such as finding potential waste, estimating potential impact of the waste to the process and estimating how often it might occur. (Salah et al. 2010; Vermaelen & Kovach, 2022; Kwak & Anbari, 2006).

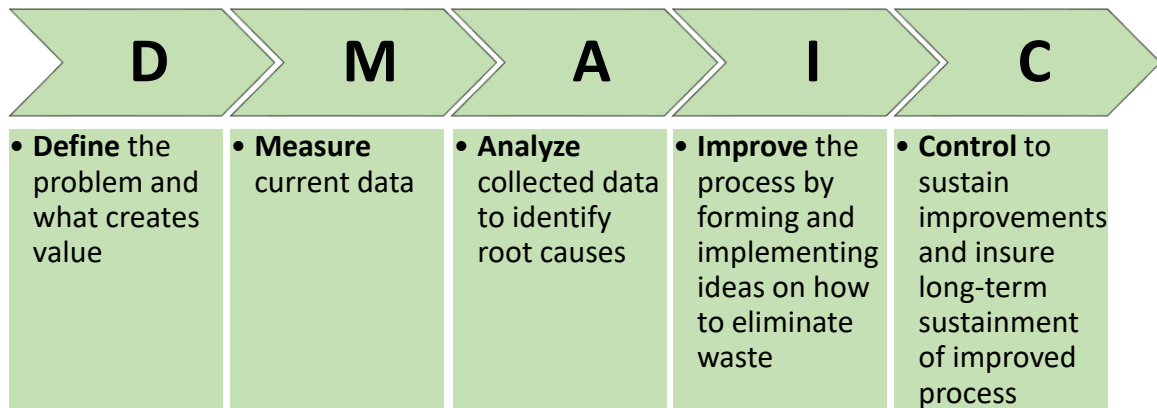


Figure 7, Explanation of DMAIC

The improve phase is for making value flow better in addition to forming and implementing ideas on how to eliminate waste. The control phase is for controlling the results and ensuring that the improvements stay, and they are continuously revised. These are simple steps to successfully implement a process, but not every step needs to be used every single time to improve a process. For instance, sometimes only the analyze step is needed to conceive a future state, or defining the current step can be done by using only the measure phase. (Salah et al. 2010; Vermaelen & Kovach, 2022; Kwak & Anbari, 2006).

Mast & Lokkerbol (2012) state that DMAIC can be studied from two perspectives: from a descriptive accounts point of view, such as practitioners applying the methodology in improvement projects, or from a prescriptive accounts point of view, such as textbooks and courses. This thesis will focus on descriptive accounts focusing literature on case studies. Some prescriptive methods like textbooks are used to clarify the meaning of some theories and methodologies. Salah et al. (2010) recommend using DMAIC as a core structure when using both Lean and Six Sigma together. Forrest (2006) on the other hand claims that when using Six Sigma, each project should utilize DMAIC for financial improvement.

Mast & Lokkerbol (2012) concluded in their article that DMAIC can be applied to a wide range of well- and semi-structured problems. It is also stated that DMAIC is better suited for

problems with a viewpoint of multiple subjective rather than problems that primarily value subjective conceptions, human dynamics or personal values. According to Laureani et al. (2010), using DMAIC as a LSS tool, identifying true value adding activities and eliminating waste, significant improvements in customer service and decreasing costs can be achieved. Pranckevicius et al. (2008) on the other hand used DMAIC to improve a manufacturing process of a plastic cup. The tool helped retrace and repair problems in the production process. Wei et al. (2010) used DMAIC to improve replenishment process of a logistic center in Taiwan. This resulted in reducing the replenishment frequency, decreasing costs in delivery and shortening the replenishment planning time for instance.

Condé et al. (2023) used DMAIC to detect root causes of faults and tried providing solutions to reduce and eliminate them in a car part supplier company. This LSS tool helped them achieve their project goal. Othmane (2022) applied Lean manufacturing and specifically DMAIC tool to improve and optimize its replenishment process and flow. The aim was to mitigate and eliminate all sorts of waste to increase efficiency. They divided replenishment steps into value-adding and non-value-adding operations to identify waste that needs to be eliminated. Conclusion was that in this case, replenishment could be automatized to save costs and improve efficiency.

4.2.2. Value Stream Mapping (VSM)

Value Stream Mapping (VSM) is defined as a set of all the procedures required to develop a specific good or service. Identifying a full value stream is an important step of Lean thinking and almost always unveils massive amounts of waste. (Womack & Jones, 2003). VSM is a reliable qualitative analysis tool that also provides, if used correctly, a current and wanted future state definition of a process (Pepper & Spedding, 2010). Lean consists of multiple tools but for it to truly work, Pepper & Spedding (2010) claim that VSM should be applied before any other Lean tools. According to Antony et al. (2012), VSM helps everyone in a company understand the entire process and perceive which steps add value and which do not. A VSM shows both the elapsed process time, which shows the sum of duration of all steps and actual required work time which shows the sum of duration and of all value adding steps. Elapsed process time should be aimed to reduce whilst actual required work time should remain the same because all the steps add value, and their needed time cannot be

decreased due to the fact that there is no waste to eliminate. (Machado & Leitner, 2010). According to Rahmanasari et al. (2021), VSM is often used to improve productivity, product quality and on-time delivery.

VSM is one of the most common LSS tools. Machado & Leitner (2010) studied which Lean tools were used in twenty-four health care case studies the most. The most used tool was a Value Stream Map, which was used eleven times. Sometimes you can solve current problems just by creating a Value Stream Map. It helps give a more in-depth understanding of a current work process. Only by understanding the whole process, including your own and others' work tasks, you can identify value steps and waste of the whole process. To create a Value Stream Map, a multidisciplinary set of people that are closest to the work, such as staff or in health care objective patients, should be gathered (Machado & Leitner, 2010). Rahmanasari et. al (2021) state that Current State Value Stream Mapping (CSVSM) and Future State Value Stream Mapping (FSVSM) are Value Stream Mapping types that represent different tenses as their names suggest.

One of the most crucial parts in making a Value Stream Map is dividing the actions and steps of a process into three different categories; value-adding steps (VA) which create value to the company or customer, necessary but non-value adding steps (NNVA) that don't bring value but are necessary to the process and therefore cannot be removed, and non-value adding steps (NVA) that do not bring value and could therefore be removed. NNVA tasks are also known as type one Muda and NVA is known as type two Muda. For the process to create flow, establish pull and achieve continuous improvement (see figure 3), it needs to eliminate the NVA steps. (Womack & Jones, 2003, 38)

Fillingham (2007) used VSM to spot excess waste in work tasks. A group of employees from the hospital focused on mapping the entire patient's journey which led to finding an enormous amount of waste, duplication and error. After performing VSM, a doctor stated that because of not having seen the whole process of patient care and only focusing on his own part of the job, he had not realized how poor the whole journey was and how much waste and extra work it included. Therefore, it is important to visualize the entire process and scrutinize it from a broader point of view. Singh et al. (2010) utilized VSM to identify improvement areas in their production industry, and the results were extensive. Lead time was reduced by 83 per cent, processing time was reduced by almost 13 per cent, work-in process inventory was reduced by 89 per cent, manpower requirement was reduced by 30

per cent and productivity per operator was raised by 43 per cent. Rahmasari et al. (2021) on the other hand utilized VSM to map where waste was detected in their production. With the help of VSM, they were able to decrease waste and increase unit production.

4.2.3. VSM Supply Chain Planner's Work Tasks

Figure 8 demonstrates meanings of the symbols in the Value Stream Map illustrated in figure 9. Each green rectangle stands for a process step that belongs to a supply chain planner. An entirely green circle stands for a process step that belongs to someone else than a supply chain planner. A circle with green frames but a white content stands for something that should be taken into account. A pink square represents a decision or outcome that effects the process' progression. A grey rectangle represents tasks that happen continuously along the process and don't have a specific spot when to perform them.

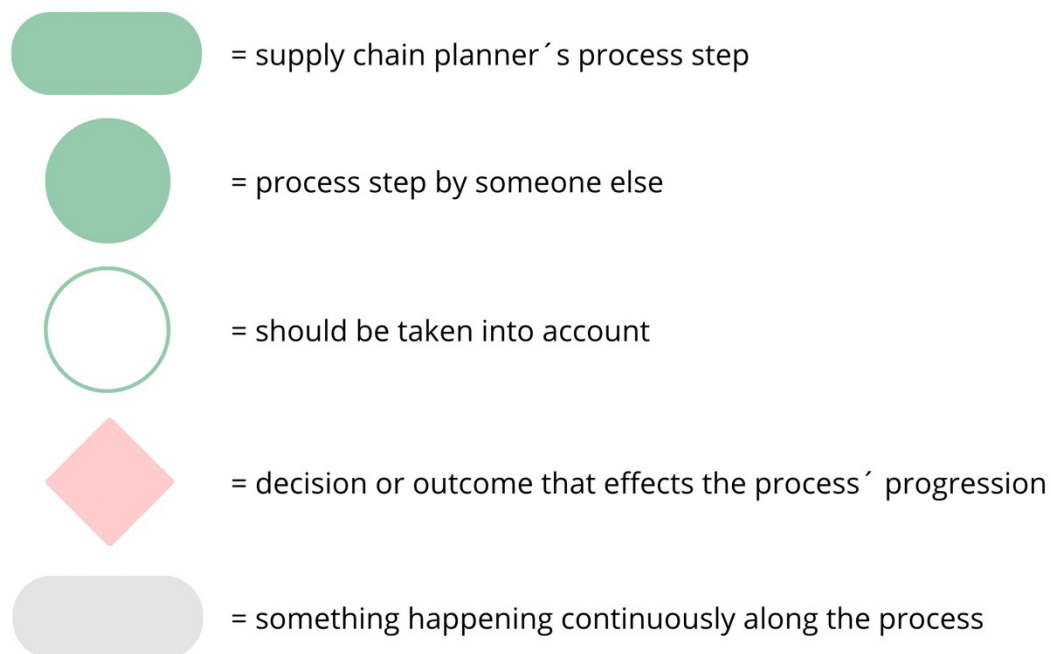


Figure 8, Meanings of VSM symbols

Figure 9 demonstrates supply chain planner's work tasks in the form of a Value Stream Map. This was made to get a deeper understanding on the entire work task process of a supply chain planner. This VSM was scrutinized on a more detailed level but due to the case company's confidential information, it is presented mostly on a category level in this thesis.

The amount of work tasks belonging to the category and whether the task belongs to either a VA, NVA, NNVA or a mixture of these classes is mentioned under each category. This is to demonstrate how many tasks are included in a category. Apart from a couple of work tasks being mentioned, that are considered as general and do not give detailed information on specifically the case company's work tasks. Green shapes represent the actual process of a supply chain planner's work tasks, and grey shapes represent constantly ongoing work tasks, that are not a part of just one category in the process. Because the categories in the grey shapes are not something that are included in the actual process, they are considered as something that should not take too much time.

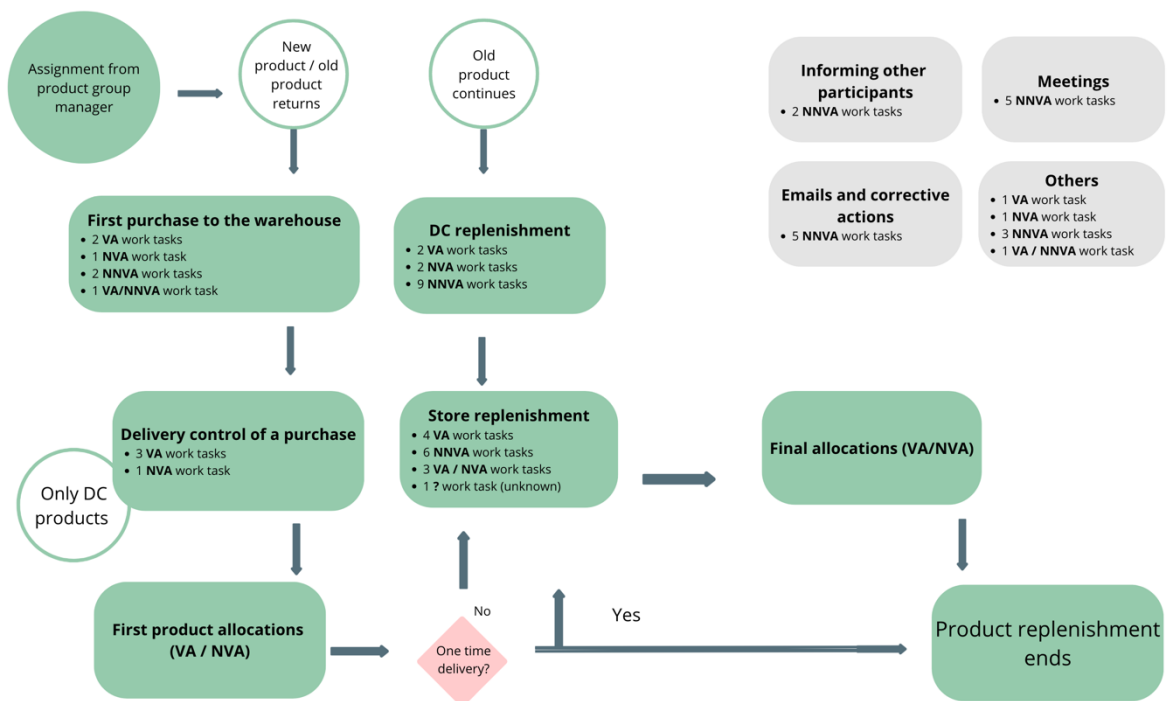


Figure 9, VSM supply chain planner's work tasks

If a new product emerges or an old product returns, the assignment wells from a product group manager after which first purchases to the warehouse are made. This step includes six more specified tasks that include one NVA and one VA/NNVA task and two VA and NNVA tasks. After that the DC product purchase requires delivery control. There are four detailed steps from which one is NVA and the three rest are VA tasks. After the first product allocations are made, depending on whether the product is a one-time delivery product or not, different steps are taken after that. If the product is a one-time delivery, it is replenished to the stores and after that the replenishment is ended. If the product is not a one-time

delivery, the next step is store replenishment. This step includes the most, 14, work tasks which divide as follows: four VA, six NNVA and three VA/NVA tasks. One task was filled in the time-tracking but was forgotten to specify so it could not be categorized.

If an old product's replenishment continues, the process is a bit simpler. The product is replenished to the distribution center which consists of 13 tasks. Two VA, two NVA and nine NNVA tasks. After that it continues to store replenishment, after which the process is the same whether the product was originally new, an old product was returning or an old product continued its replenishment. The next process step is the product's final allocations, which is both a VA and NVA step in this process. After this the product replenishment ends.

Tasks that happen continuously along the process and don't have a specific spot when to perform them include task categories such as "meetings", "emails and corrective actions", "informing other participants" and "others". "Informing other participants" include two NNVA work tasks and both "meetings" and "emails and corrective actions" consists of five NNVA work tasks. The "others" category includes one VA, one NVA, one VA/NVA and three NNVA tasks.

5 Empirical Findings

In this chapter the empirical findings of this research are reviewed. First, the methodology is presented, after which the data collection method is explained. The third section is about findings and results, which are explained in three separate parts: time tracking, comparing results and open-ended questions. At the end of this chapter, reliability and validity of the research are discussed.

The case company is a large Finnish enterprise working in the retail industry. This thesis focuses on the supply management department's consumable side, which consists of 18 employees. The company's most important customers are consumers, to whom the value is aimed to target at. The company is currently one of the biggest players in the Finnish market but to stay competitive it needs to continuously improve its operations.

5.1. Methodology

The approach of this thesis was a case study. According to Farquhar (2012), a case study uses familiar research methods for data collection and is most commonly used to collect and analyze data. When limiting the research to a particular company, it is easier to achieve an in-depth understanding on the topic. A case study is able to bring a lot of value to a company by allowing a researcher to investigate a problem on a practical real-life situation.

“A case study is an empirical inquiry that investigates a contemporary phenomenon in depth and within a real-life context.” (Farquhar, 2012).

The aim of this research was to detect, understand and eliminate waste that appeared in a supply chain planner's work tasks. After measuring the time spent on work tasks, it was necessary to analyze the results and acquire a more in-depth understanding. Therefore, a qualitative approach was chosen. Qualitative research is an interpretive and naturalistic approach that aims to capture deep understanding from human perspectives. It gives an opportunity to investigate on a comprehensive level. (Taylor, 2010, 62). Also, a good reason for using a qualitative approach was that the research questions could not be answered

numerically. The main research question “How can work task waste be eliminated at case company?” required in-depth analyzing.

This part of the thesis was based on the DMAIC’s measure phase. It measured the defined research problem before the data could be analyzed (see 4.2.1.). The aim was to measure work tasks to understand what the waste is. The data collected was primary data, composed by a self-made survey. The survey form in this thesis was a structured Excel survey. Structured survey is a convenient way to scrutinize the results also from a quantitative approach and help compare the results (Hirsjärvi & Hurme, 2000, 45). It also helps standardize the research results, but this requires keeping all survey questions formatted similarly, so that each respondent understands them the same way and no one is treated differently (Hirsjärvi et al. 2009, 193). In addition to this, four open-ended questions were added at the end of this Excel. Open-ended questions help receive more in-depth responses about experiences, feelings, opinions and observations (Taylor, 2010, 63).

The research was made online to make it easier to fulfil the Excel. Therefore, it was also easy for the employee to fill it regardless of whether the employee was at the office or working remotely from home. It was performed in Finnish because all the employees’ native language is Finnish, and it is also the work language. This was also found best because this way the employees could fully understand the questions and work tasks and interpret them similarly. The data was analyzed from three perspectives: measuring time tracking, comparing results and analyzing open-ended questions. The time tracking phase was analyzed with the help of a pie chart (see figure 11) and a Current State Value Stream Map (see figure 10). A table was made whilst comparing the results to help illustrate the similarities and differences in time used for various work tasks (see appendix 2).

The research was conducted in the most ethical way possible. The results were analyzed anonymously, and this was emphasized to the employees. This was to increase reliability and reduce bias of any kind. The Excel sheets were kept and filled out only on the employees’ work desk to ensure confidentiality. After fulfilling the Excels they were sent back directly to me, with no intermediaries viewing the results. With the exception of open-ended questions, results were not viewed individually to prevent identification of responses. Even though the answers to the open-ended questions were viewed individually, they were analyzed anonymously.

5.2. Data collection

This research used purposive sampling, and the sample was limited to the employees of store and DC replenishment of case company's consumables side. Purposive sampling is a non-probability sampling method where participants are intentionally selected. This gives an opportunity to best fit the sample to the research aim. This way it ensured that everyone who could have impact on the end results were included. (Campbell, 2020). The chosen sampling seemed self-evident since the research was about the work task waste of a supply chain planner on the consumable side of the company. All the employees were chosen to get a holistic understanding of the supply chain planners' work and to eliminate the possibility of missing critical observations. The Excel sheet was sent to all 18 employees, but only 17 Excels were sent back due to one employee not working at the time.

A research presentation was held on the 21st of November, which included presence of the employees and their chiefs, besides myself. The aim was to present the idea of this research and motivate the employees to answer the survey as well as possible. Also, the instructions for filling the survey were reviewed to ensure everyone understood them similarly. To mitigate risk of oblivion, misunderstanding and confusion, the instructions were also added into the survey, so that the employees could review them whilst filling out the survey. The research was sent to the employees after this presentation and the execution of the study was conducted for ten working days during two separate weeks; 25.11.-29.11.2024 and 9.12.-13.12.2024, from Monday to Friday. One week was purposely kept in between to scatter possible work task accumulation.

The needed data for this research was time tracking of work tasks, which was gathered using an Excel sheet. Each employee filled out their own Excel sheet after which it was sent back after filling it out. The Excel included a separate sheet for each day (25.11.-29.11.2024 and 9.12.-13.12.2024) including work tasks belonging to the employees. The time tracking was executed by tracking each 15 minutes of the day. Some work tasks might have taken only a little while at a time and therefore the time tracking was set so small. Five minutes was also thought about but considered too small to constantly mark. Appendix 1 represents the time tracking Excel. As said previously, it is in Finnish due to clarity and understandability for the employees. The categories are marked with orange cells on the left of the table and included work tasks are marked with white cells on the right side of the category. The work

tasks were removed from this picture due to confidentiality. Under each category were separate “other” cells where an employee could write another task related to that specific category but was not already on the Excel sheet. It was emphasized to the employees to aim add other tasks under an already existing category rather than the “others” category. It was necessary that tasks belonging to a category were in the correct place because results were viewed on a category level. In total 14 “other” work tasks were added which are taken into account in Value Stream Maps but not in comparing results since only the employees that added them could see them.

The third column in appendix 1 was to write any additional information that came to mind about the specific task. For example, an explanation could be written if a task took a lot longer that day than usually. The next tiny columns were for time tracking. An “X” represented 15 minutes and was to be marked when the mentioned time was used for a task. The real Excel Survey contained 32 boxes which add up to eight hours so a little more than a normal 7,5-hour work day, just in case of some overtime. The column on the right was a total time used on a task, that was automatically calculated with an Excel formula. The employees were instructed to only make changes to the yellow cells.

No challenges, for instance technical difficulties, were faced during the data collection phase and all 17 surveys were received on time. A couple of surveys were missing some needed information, which were inquired subsequently. One employee did not remember afterwards asked what the work task was she had added in one category. This was luckily only a 15-minute task and was marked in the correct category. Also, five surveys in total were missing all answers to the open-ended questions. These were not inquired afterwards because it may be that there was simply nothing to add to the topic and these questions were not compulsory. The time tracking with the help of the Excel survey was used as a measurement tool to get quantitative results on how much each work task took time to implement. This helped identify inefficiencies in work and offered an opportunity to compare if some tasks took a lot longer with some employees than others. This helped detect and eliminate waste which aligned with the goal of this research. More on the comparisons in chapter 5.3.2.

5.3. Findings and Results

The time tracking was measured on a deeper level, but the results were viewed on a category level due to confidentiality. This was a request from the case company. The categories, to which the work tasks were divided into, were inspired by a Value Stream Map (see 4.3.5.). Each work task was divided into value-adding (VA), necessary but non-value adding (NNVA) and non-value adding steps (NVA). This division was made together with a representative from the company to ensure the work tasks were categorized correctly and to support Machado & Leitner's (2010) claim that the closest people to the job should be gathered when creating a Value Stream Map. The work tasks categorized as NVA tasks, were automatically considered as waste. The NVA tasks took all together 49,5 hours from all 17 employees during the two-week tracking. For one employee it made 17 minutes per day.

5.3.1. Time Tracking

Employees were asked to fill every 15 minutes spent on a work task in the Excel. This means that breaks, sick leaves or other time spent away from the computer were not taken into account. This is an important matter when addressing the final results. Each day did not add to the regular 7,5-hour workday and the research contained some days when not all employees were working. This is why the total results were calculated as a quotient of the total work time amount during the two-week time tracking period by 17 employees.

Figure 10 shows a Value Stream Map of the work task categories, and how much time they took per one employee per day. First purchase to the DC took 27 minutes, delivery control of a purchase took 18 minutes, first product allocations took 15 minutes, DC replenishment took 45 minutes, store replenishment took 2 hours and 8 minutes, final allocations took 7 minutes, informing other participants took 3 minutes, meetings took 1 hour 10 minutes, emails and corrective actions took also 1 hour 10 minutes and others took 30 minutes. All together these tasks took in average six hours and 53 minutes per employee per day.

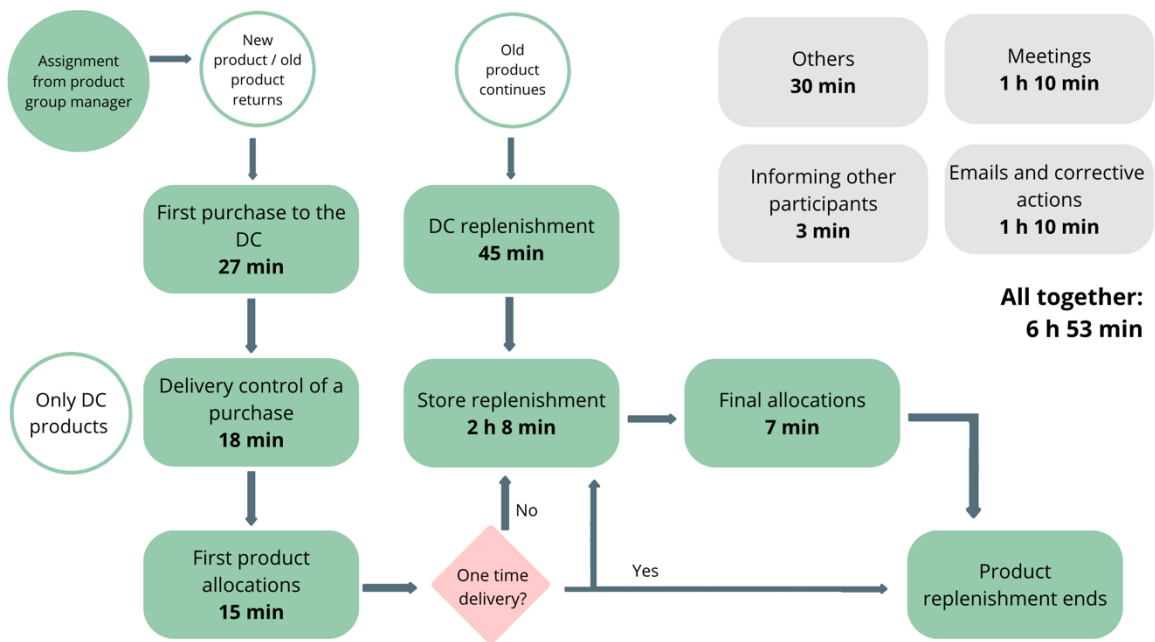


Figure 10, Value Stream Map of a supply chain planner's daily work tasks

The time was calculated by adding the total minutes spent on one task. This time was then divided by 17 (the amount of people included in the research), divided by ten (the number of days the time tracking was for) and multiplied by 60 to get the answer in minutes. All this was done to get a clearer understanding on how much time one work task requires per employee per day. The Value Stream Map in figure 10 shows clearly what categories were part of the actual process, the green shapes, and which were the constantly ongoing tasks, the grey shapes. Green categories took in total 4 hours, which is 58,1 per cent per day, and grey categories took in total 2 hours and 13 minutes, which is 41,9 per cent of the day. Even though the green categories are the actual process, the difference between these and the ongoing tasks did not differ significantly.

Figure 10 and figure 11 show quite similar results in different visual ways. Figure 10 shows how many minutes was spent on one category. It also shows which categories were a part of the actual process and which ones are constantly ongoing. Figure 11 on the other hand provides a clear, more visual, representation of the same information but in a form of a pie chart. This helps to help perceive the big picture more easily and view the time spent in a form of per centages. As the pie chart in figure 11 shows, "store replenishment" took 31 per cent of the day. Both categories "meetings" and "emails and corrective actions" took 17 per cent of the day. Considering these two categories are not in the actual process, this is

considered as quite a lot. “DC replenishment” took 11 per cent of time per day and “others” category took seven per cent of work time. “First purchase to the warehouse” category took 6 per cent and both “delivery control of a purchase” and “first product allocations” took four per cent. “Final allocations” category took two per cent and “informing other participants” took the least amount of time, just one per cent, of an employee’s time.

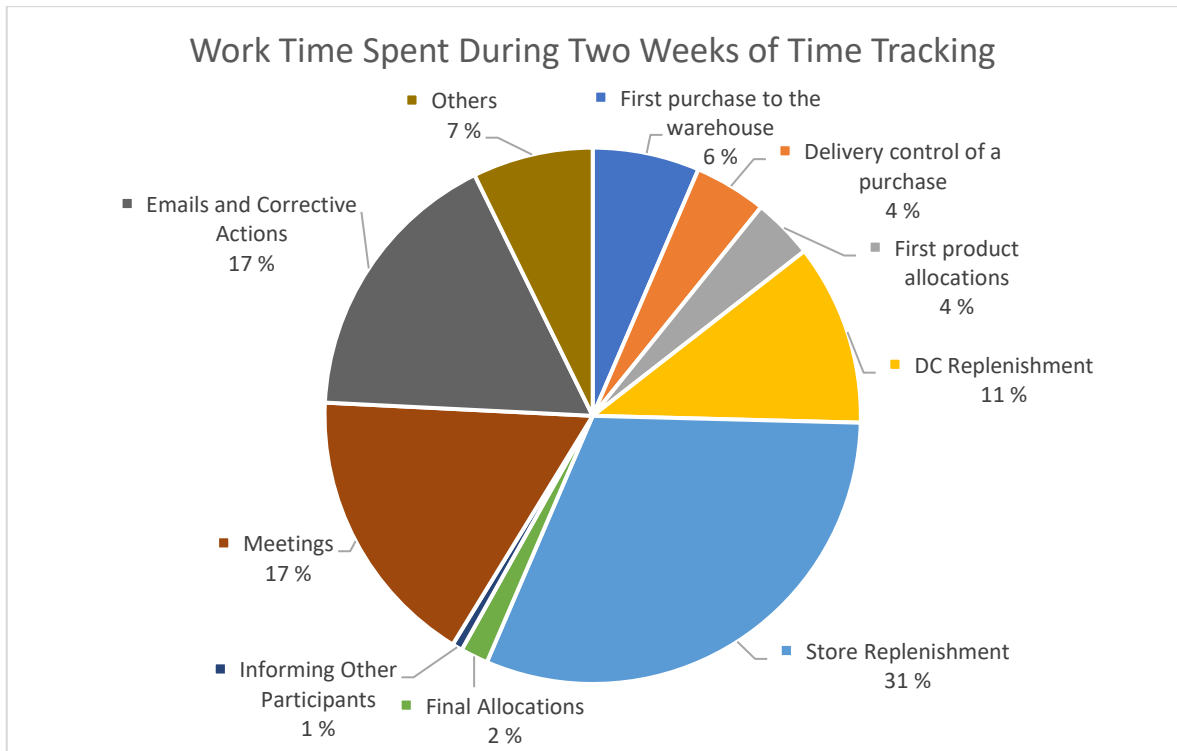


Figure 11, Work time spent during two weeks of time tracking

“Others” category took seven per cent of the entire day, from which “additional sorting out” work task took around 44 per cent. Another major work task in the mentioned category was “double work”, which included for instance double checking and re-doing work tasks. This took around 31 per cent of time. Together these two work tasks took around 74 per cent of the entire “others” category. Especially double work listed as a NVA task, it took quite a lot of time to execute. Out of the “emails and corrective actions” category, “message exchange between a supply chain planner and a supplier” took about 44 per cent out of the entire category. Though this is an essential part of a supply chain planner’s work, taking about 7,5 per cent of the entire day is quite a lot to use for communication. Both “emails and corrective actions” and “meetings” were not included in the actual process as seen in figure 10. They

still took 17 per cent, together 34 per cent of the entire day. No other than “store replenishment” took as much as 17 per cent per day so this can be considered as a lot of time.

5.3.2. Comparing results

The most hours worked during the two-week time period was 87.25 hours, and the least amount was 36 hours. In addition to this, only two other employees worked less than 64 hours, and the average of working hours was 69 hours per two weeks. Therefore, the minimums scrutinized in this chapter came from employees who worked above the average. This ensured that comparisons were not made between employees with immensely different working hours. The average between the difference of maximum and minimum time spent on a task was 5.8. Because of this, if the maximum and minimum differed from each other more than six hours, it was scrutinized on a deeper level. In total, there were nine of these tasks.

Appendix 2 illustrates the findings related to comparison. The table only consists of the core work tasks which were gathered before the survey together with the representative from the case company. This means that none of the subsequently added tasks by the employees were attached. This was because these “other” tasks were not available to all employees since added only to their own Excel surveys during the research. Each category was presented, and the number of work tasks included were shown as well. The columns in orange are employees that worked under the average, 64, hours, which means minimums were not taken from these employees. The rows in yellow represent the employees whose maximum’s and minimum’s difference was more than six, the average. At the bottom row of this table, the total amount of working hours is shown per each employee. Next some key findings of this table are presented.

In the “first purchase to the warehouse” category, two work tasks stood out from the results. Both of the tasks had a minimum of zero hours and a maximum of 9.25 hours. A work task in the “DC replenishment” category required time from 0.75 hours to 13.75 hours. The employee that used 0.75 hours worked 87,25 hours during the two weeks whilst the 13.75 hours worked 76 hours. This stood out due to the fact that an employee who worked more hours in total took less time to finish this task than the employee who used maximum

working hours for a task. One singular work task in the “store replenishment” category required between 2.75 and 22.5 hours from various employees, which makes the difference up to 19,5 hours. The extremities from this range worked in total almost the same time, 75.5 and 76 hours, during the entire two weeks.

Another sub task in the same category took zero hours from some employees and 11 hours from some. When comparing the minimum from employees that worked above the 69-hour average, a minimum for one work task in the “meetings” category was zero and the maximum was 6.5 hours. Another task in the previously mentioned category took in minimum zero hours and in maximum 6,75 hours. The largest minimum by far is in the “meetings” category, with a digit of 4,75. A work task in the “emails and corrective actions” category took in minimum 2,75 hours whilst the maximum time spent on this task was 11 hours. In the “Others” category, double checking and redoing a work task took in minimum zero hours and in maximum 6.25 hours.

Employees were able to add additional comments to their daily work tasks on the Excel. This was recommended if something unusual happened for instance some work tasks took more or less than usually. In total 21 additional comments were written, from which five explained which meeting an employee attended and four related to Christmas season. Two related to substitution and the rest were explanations on what was done that day or untypical matters that effected the time used for a work task. The amount of these additional comments was considerably low, and therefore these comments were not taken into consideration when analyzing the total results but kept in mind when analyzing why big differences were perceived in consumed times.

5.3.3. Open-ended questions

Four open-ended questions were asked to deepen understanding on work tasks and to make sure every employee had the chance to state if they had something still on their minds about the topic. These questions were placed at the end of the Excel survey. Five Excels were returned where none of the open-ended questions were answered. Either these employees had nothing to add, or it might also be possible that the filling out was forgotten. The answers to the open-ended questions involved detailed information about work tasks and systems,

and therefore are not attached in this thesis due to confidentiality. You can see a list of the open-ended questions in table 4 (see below).

1. Are there any work tasks on your mind that feel unnecessary and time-consuming? If yes, which one/ones?
2. Did you do any work tasks that took under 15 minutes and are therefore not seen in the time tracking?
3. Which work tasks require excessive time due to waiting?
4. Is there still something on your mind related to this topic?

Table 4, Open-ended questions

The first question was “Are there any work tasks on your mind that feel unnecessary and time-consuming? If yes, which one/ones?”. This was asked to get an employee’s view of what might feel time-consuming which might not appear in the research results. This question received nine answers. Three answers related to being an intermediary between e-mails and having to send them forward to the correct team. Multiple answers related to double checking, editing, and solving which require a lot of manual work and therefore time. In addition to this, doing tasks that would or should belong to someone else take excessive time. Also, an observation was made about information not flowing from one system to another and having to wait for that.

The second open-ended question was “Did you do any work tasks that took under 15 minutes and are therefore not seen in the time tracking?”. This was asked to make sure no task is ignored or left out because it does not appear in the survey. This question received seven answers. Two answers mentioned that due to having so many different systems, seeking information takes a lot of time. Also, many of these systems have pages that need checking every once in a while because no notification is received if it needs actions. Also phone calls and answering questions from various people in addition to small necessary work tasks take time, but not a lot at once.

The third open-ended question was “Which work tasks require excessive time due to waiting?”. Waiting is considered as one of the main seven wastes (see 2.2.) but was found difficult to include in the survey. This question was kept important to get an understanding on the work tasks that require waiting. This question received the most, 10, answers. In six of these, insufficient and incorrect information was mentioned. Correcting them, asking for correct information and then waiting for answers delay the supply chain planner’s work. Four answers contained complaints about the information not flowing rapidly enough from

one system to another, which causes excessive waiting. Also defects in work tasks interrupt finishing other tasks and therefore cause waiting.

The final open-ended question was “Is there still something on your mind related to this topic?”, and it received seven answers. This question was an important one to ensure every aspect is taken into account. A good observation, that emerged in the answers, was to keep in mind that many tasks are divided into multiple systems and can’t be marked in just one category. One answer adjusted the issue of remembering to mark the time tracking. It was also brought up to attention that the supply chain planner’s job is a downstream job. This leads to most questions and sorting out ending up on supply chain planner’s desk which takes away time from their routine work. A mention about weather conditions effecting work amount was also disclosed. During the first time tracking week, snow had reached the whole country and therefore a peak in snow equipment was reached, which eventually added workload. Each supply chain planner has their own product categories, which means this only affected some of the employees.

5.4. Validity and Reliability

Taylor (2010, 63), states that there are some ways of improving validity in qualitative research. These ways include for instance using multiple sources to verify data and attempting to keep an unbiased approach on interpreting the results. According to Newman & Benz (1998), you must remain neutral in the research questions. For instance, no bias can emerge and original data should be available to the public. The research should also last for a long enough time-period and be well documented so that another researcher could replicate it. The research should also be replicable so that the results could be repeated if the same circumstances were to happen (Kirk & Miller, 1986, 50-55).

To ensure validity in this research, the results were addressed anonymously which obstructs a bias point of view. The open-ended questions were formed in a neutral way avoiding leading and restrictive questions in addition to offering multiple variables to answers and not just one. Other than the names of sub work tasks, everything else is available to the public, and the research was documented as well as possible for other researchers to replicate. If the same circumstances were to happen, a strong belief emerges of the possibility to replicate

this study. The research lasted for just two weeks, which might have an influence on the results. A longer lasting study could have offered a more representative sample of work tasks. Also, the fact that each employee has a different personal product category might affect the validity. Some employees could have for instance snow shovels and some summer products that could include products like swimwear. The employees with non-seasonal winter products might have more time to concentrate on routine work tasks whilst employees with winter products might have to use more time on work tasks related to arranging these products.

Such a short time period could exclude some work tasks entirely that might occur on a different time or only occasionally. The short time-period also eliminates long-term trends such as seasonalities. Also, time of the research might affect the results. The research was conducted in December, near Christmas, which means Christmas season was already ongoing and this might have required more time with unusual work tasks. In addition to all this, changing weather conditions, for example snow, might have an influence on workload. To ensure validity and that all tasks are included, all work tasks were gathered with the help of a representative from the case company. The representative also helped separate the tasks to VA, NVA and NNVA tasks, to make sure they were categorized correctly.

Research can be considered reliable if the data gathered can be replicated by another researcher (Taylor, 2010, 64). Also, one way to determine reliability is if people interpret the questions similarly. For this to happen, a clear sample has to be selected, and questions need be formatted clearly. (Hirsjärvi & Hurme, 2000, 186). Walker (2011, 1-2) adds that simplicity is a way of ensuring reliability. Yet it is often well understood but not executed because many inexperienced researchers, especially in university environments, form research on a general level rather than tailoring it to a specific task. Hirsjärvi et al. (2009, 195) add that the respondents' missing motivation and negative attitude can affect the validity of the research results.

A clear sample was chosen for this study. This involved all supply chain planners working in the consumables side of the case company. A research presentation was held to make sure all employees got a thorough understanding on instructions related to filling out the survey. In this research, employees were in charge of marking their time spent on work tasks. It was emphasized that results are addressed anonymously, and no names are revealed at any time

to anyone. Yet there is a possibility of employees feeling the need to forge results to make it look like they have done more work than they actually have.

Because the data is self-reported, there is also a possibility of some work tasks marked wrong in case of a hurry for instance, or a simple oblivion. Also, there is a possibility of employees not taking this research so seriously, although it was emphasized to them how the results found in this research can only make their work easier. The survey was kept as simple as possible for readability and understandability. This way each employee could understand the questions similarly. In addition to simplicity, this research was also customized entirely for the case company and specifically for this research problem. The literature gathered to work as a basis for this thesis used only peer-reviewed scientific articles to increase the reliability of them.

6 Analysis and Conclusions

In this chapter, discussion is formed related to the previous literature review and research results made in this thesis are discussed. Some future improvement ideas are shared as well as ideas for future research. After this, the research questions of this thesis are answered in a separate subheading for clarity. To summarize the purpose and findings of this thesis, a conclusion subchapter is added to the end.

6.1. Discussion and Suggestions for Future Improvements and Research

Reviewing the results, waste can be identified but the total elimination is not always easy and should not be the only option. Waste can be seen as something that takes too much time but cannot necessarily be eliminated. In this case, it would be advisable to aim reduce the time spent on these kinds of tasks. As seen from the results chapter (5.3.), some work tasks do take significantly more time to complete when comparing employees. There are multiple reasons why this could happen, for instance work experience might influence. For some employees who have worked at the company for longer, a task might be routine work whilst for someone who is rather new to the company it might take a lot longer. Also, training and its amount could vary. It is important for everyone to get similar and the same amount of training.

Between employees, there were nine tasks with a time difference of more than six hours when comparing the maximum and minimum spent time on a certain task (see 5.3.2.). These tasks should be further investigated on why the time difference is so significant. A list of these tasks was additionally sent to the company but are not listed here in detail due to confidentiality. Three of these work tasks took over ten hours more from some employees, with the largest difference reaching to almost 20 hours between the most and least spent hours. This is an enormous number of hours spent on a work task whilst not all employees need it. It could be further examined whether additional training should be held on these tasks to even out the amount of time spent on performing them.

All the employees have different product categories, which might affect the time difference. Some product categories might require more time on certain tasks due to a broader selection or due to the requirement of more detailed work. If some product categories are a lot more burdensome, some evening out could come in handy. Also, a common instruction from the case company to the employees could be shared, regarding which tasks should be prioritized. There is a slight chance of some employees struggling to perceive how much time should be spent on a work task. As seen in figure 10, the actual process took 4 hours, and the constantly ongoing tasks took almost 3 hours of the day per employee. The actual process is the priority where a supply chain planner should be putting its focus on. Even though the ongoing tasks support the accomplishment of the actual process, prioritizing should be on the actual process illustrated in green. Categories “emails and corrective actions” and “meetings” took together 2 hours and 20 minutes per day per an employee, which can be considered as quite a lot especially not being a part of the actual process.

Broström’s article states that up to four out of five employees experience meetings as a waste of time due to their irrelevance and ineffectiveness. Often meetings are arranged even though the leader lacks clear vision on what wants to be achieved, how much time should be reserved and who should be invited. In 2015, it was estimated that in Finland, a middle-sized 50-person company wastes up to 500 000 euros per year due to worthless meetings. According to the article, 80-90 per cent of meetings could be elided. A meeting is only justifiable if it requires presence of all the participants for enhancing common understanding, sharing expertise, exchanging opinions or finding solutions to common problems for instance. (Broström, 2024).

As the results show (see figure 10), meetings took a lot of time per employee per day, on average of 1 hour and 10 minutes, which means 18 per cent of the entire day. For some employees this might turn out to be a needed pause from personal tasks, but for some it may be plainly an interruption that disturbs the flow of accomplishing other work tasks. To prioritize time for value-adding tasks in case company, meetings should be either reduced or enhanced. Each meeting should be re-estimated whether it is necessary or not. It is crucial to consider carefully whether the meeting is something that requires presence of all participants or is something that could be dealt via an email or group chat for instance. If the problem is one-way, a meeting might not be necessary. Also, a clear target should be set and it should be clear to both the leader and the participants. In category “emails and corrective

actions” the correspondence between a supply chain planner and a supplier took in average 44 per cent of the entire category. It should definitely be scrutinized whether all this communication is necessary or whether it is due to bottlenecks such as wrong or missing information as mentioned previously in the chapter.

When looking at open-ended questions, clear frustration seemed to appear regarding a couple of topics. An issue that came up a couple of times in answers for open-ended question number one, was missing information and incorrectly filled up forms. This interrupted the work of a supply chain planner and required additional time when correcting the information or asking for it subsequently. This could easily be fixed by negotiating with the other end about the issue and asking them to pay attention to the necessity and clarity on wanted information. This discussion should of course take place in a good peaceful time to make sure everything is thoroughly covered all at once. Also, automatization could be utilized in filling information to minimize manually made mistakes. Another issue that emerged was being an intermediary in specifically emails and other messages. A solution should be figured where the people sending messages and emails would know who to directly contact. For example, the case company could compose a brief newsletter that contains a list of issues and who to contact if the issue appears. This could then be sent back every time an incorrect email is received to prevent the same mistake from occurring.

An important factor to keep in mind is that the minimum time spent on a work task was 15 minutes for it to be noticed. In the open-ended questions the second question gave a chance to mention any work task that does not show in the results. One recognition regarded phone calls and brief questions from colleagues. These kind off short tasks are difficult to track but should be kept in mind. Additionally, some systems reputedly require check inspections once in while just in case there is something to take care of. An external professional, consultant or an in-house IT support team could check if notifications could be added to these systems. This way unnecessary time taking checkups could be avoided.

An issue of the number of systems a supply chain planner needs to perform its work tasks appeared in the answers to open-ended question number two. These systems could be mapped and analyzed if all of them are necessary and if some tasks could be done in other systems to eliminate the amount to the minimum or alternatively merge systems, if possible. Also, the flow of information transferring from one system to another was questioned. This should definitely be taken care of. In a modern world that we live in with newest technologies

and systems, no work task should take more time because an employee needs to wait for information transferring from one system to another. A professional could be hired to investigate if the systems are used as should and manufactured to best fit the need in the case company. Systems could also be put out to tender to see if other systems could perform information transfer as desired.

Double-checking, editing, redoing and sorting out tasks appeared in multiple answers in the open-ended questions. Sorting out and double work were tracked in the survey separately and they took together around 22 minutes per employee per day. “Others” category took seven per cent of the entire day, from which “additional sorting out” work task took around 44 per cent. Another major work task in the mentioned category was “double work”, which included for instance double checking and re-doing work tasks. This took around 31 per cent of time in the “others” category. Together these two work tasks took around 74 per cent of the entire “others” category, which means 22 minutes from the entire day. Double-checking, editing, redoing and sorting out require a lot of extra time and could be prevented with caution and attention.

One answer for open-ended question number three estimated that about half of the work tasks require waiting. A couple of answers disclose that work tasks especially in category “first purchase to the warehouse” require waiting due to false information, and data transferring between systems. The waiting could be prevented by setting clear deadlines and instructions for needed information. Also, what could be considered, is sharing certain files with concerning individuals for those to check needed information themselves rather than waiting for responses. Waiting is one of the seven most common wastes (see 2.2.). Time is one of the most valuable yet restricted resources, which is why all waiting should be cut to the minimum. Work tasks that require waiting prolong the time it takes to finish a task and therefore the waiting should definitely be eliminated or at least reduced. Waiting was challenging to measure in the time tracking survey, so an additional open-ended question was added as a third question to the end. This question received quite similar answers to the previous open-ended questions. Waiting for incorrect information to be corrected and waiting for answers to additional sorting out requires a lot of waiting.

Information should be written and shared correctly in the first place to avoid waiting for it to be corrected. This requires meticulousness and vigilance. In addition to this, information flow from one system to another required waiting. This also increases risk of using outdated

data, which is a huge risk in a fast-paced environment such as a retail industry. To make information flow better between systems, an external professional or in-house IT support should be hired. Bottlenecks need to be identified, and a solution needs to be found. This way efficiency could be enhanced, and delays could be prevented.

Table 5 demonstrates the reviewed inefficiencies and solutions in this chapter. The left column represents the inefficiency discussed and on the right a solution or solutions are offered. In the middle of this table, the wastes the inefficiency causes are categorized. All together there were 12 inefficiencies, from which double-checking, editing, redoing and sorting out are in the same row due to them sharing same solutions and creating similar waste. All together five wastes were found.

Table 5, Found inefficiencies, detected wastes and suggested solutions

Inefficiencies	Waste	Solution
Some tasks taking a lot more time from some people	- Inappropriate processing	- More training to unify knowledge - Even out burdensome - Instructions on what to prioritize
Meetings taking so much time	- Unnecessary motion	- Reduce the amount - Enhance them by setting a clear target - Ponder on whether the meeting is necessary
Missing and incorrect information	- Defects	- Meeting with the other end about necessity and clarity on wanted information - Automatization
Being an intermediary in messages and emails	- Waiting - Transporting	- Newsletter that states if a certain issue emerges, who to contact
Unnecessary system check-ups	- Unnecessary motion - Inappropriate processing	- External professional, consultant or in-house IT expert to solve this - Notifications
Number of systems	- Inappropriate processing - Transporting	- External professional, consultant or in-house IT expert to see if some could be merged
Information not flowing from one system to another	- Transporting - Waiting	- Identify bottlenecks - External professional, consultant or in-house IT expert to solve this
Double-checking, editing, redoing, sorting out	- Defects - Inappropriate processing	- Caution and attention
Waiting	- Waiting	- Future research - Clear deadlines and instructions - Sharing files with concerning individuals

As seen in table 5, five wastes out of the seven most common ones (see 2.2.) were detected. “Some tasks taking a lot more time from some people” can be considered as inappropriate processing because it might include doing more work than actually needed, and therefore taking excessive amount of time when comparing to others. “Meetings taking so much time”

on the other hand led to unnecessary motion due to constantly been drawn away from normal tasks and interrupting the focus on them, causing unnecessary mental motion. Additional energy is needed to refocus switching from one work task to another. Also, if these meetings are on spot and not online, unnecessary physical motion is needed to transfer from one place to another.

“Missing and incorrect information” cause point-blank defects and should be eliminated right away. “Being an intermediary in messages and emails” causes waiting and transporting because additional steps are required which easily leads to delays. In addition, it requires unnecessary transporting of information. “Unnecessary system check-ups” cause both unnecessary motion and inappropriate processing waste because unneeded additional motion is required. “Excessive number of systems” results in inappropriate processing in addition to transporting waste. The latter waste is also built up from “information not flowing from one system to another”, in addition to waiting. Defect and inappropriate processing are found in all “double-checking, editing, redoing and sorting out” due to correcting mistakes and using additional time to finish these tasks. “Waiting” obviously causes waiting waste due to its inefficiency.

When comparing the ongoing tasks to the actual process itself, “emails and corrective actions” and “meetings” took a huge amount of time from the day (see figure 10). Together these categories took up to 34 per cent of the entire day (see figure 11) which is a lot since the focus should be the actual process. The tasks in these categories are important for a supply chain planner from communication, problem-solving and decision-making viewpoints, but should take less time to complete. These tasks cause wastes such as unnecessary motion, waiting and transporting, also covered previously in this chapter. It would be important to reduce the time spent on these categories and tasks.

As Costa et al. (2021) state, that LSS is a holistic, comprehensive and unitary approach for continuous improvement. Because this thesis used such a common methodology, Lean Six Sigma, it can easily be applied to various industries due to its resilience and ease to apply. In fact, a few well-known companies have used the mentioned methodology with such great success that it has created a copycat phenomenon to many other companies and industries. (Laureani & Antony, 2012). DMAIC is according to Bhuiyan & Baghel (2005) used for multiple functions in various environments and is therefore quite generalizable. Due to all this, the findings of this research could be partly generalized to other industries and

companies. However, it must be taken into consideration, that the generalizability could be limited to some factors such as company environment. The industries and companies should share similar organizational structure, work tasks and should operate in the same market to ensure similarities with case company. This research could at least serve as a pioneer and an example to other retail companies when detecting waste by tracking work task time and utilizing Lean Six Sigma from a human-centered approach.

Even though the used data collection method, time tracking, is quite common and could be utilized and customized to other industries and companies with similar other factors, the main issue for generalizing the findings of this research is the specifics of research data. This research was specifically customized for the case company's research problem. The work tasks measured are so designated and fit to the role of a supply chain planner in this specific case company, that it could be problematic to fit to a different company or role with various work tasks. Also, organizational culture affects the generalizability. For a role that has similar features, such as stationary working on computer all day, a similar task time tracking could be possible. But for a more physically active hands-on role, for example a warehouse worker moving throughout the day, it would be more difficult to track each 15 minutes of a day. The supply chain planner's work tasks are also quite predictable so the findings could not be generalized to a job such as an event planner or police officer, whose work tasks differ depending on the day. Also, as the case company is considered as a large enterprise, the generalizability of the findings can be difficult if not impossible to adjust to small and medium sized enterprises.

Future research could examine the reasons to notable time differences for completing work tasks between employees. Finding answers to why some employees take significantly more time in some tasks than others. Is it due to work experience, task complexity or simply inefficiencies in finishing tasks. Another future research could relate to waiting between or during work tasks. One answer regarding the open-ended questions estimated that about half of the work tasks require waiting. This could be examined, which work tasks actually require waiting and how much. Also, why they require waiting and how could it be optimized. This thesis' research could also be redone during different time of the year and possibly for a longer time period to strengthen the repeatability of this study.

6.2. Answering the Research Questions

The main research question was “How can work task waste be eliminated at case company?”. Sub-questions “What work tasks of a supply chain planner are considered as waste?” and “How can Lean Six Sigma tools be utilized to eliminate waste?” were formed to get a more in-depth answer to the main research question. The sub-questions are answered first to get a thorough understanding on the answer to the main research question.

What work tasks of a supply chain planner are considered as waste?

Tasks that take a lot more time from some employees are considered as inappropriate processing because they probably could be done slightly faster if the difference is so big and some employees do not need as much time as others. These tasks can be seen as waste that should be reduced but cannot be totally eliminated. There were in total nine of these tasks. One of these tasks is a NVA tasks and can therefore be totally eliminated. The other tasks are either VA or NVA tasks and cannot be totally eliminated but the time spent on the could be reduced. All work tasks were categorized to value-adding (VA), non-value adding (NVA) and necessary but non-value adding tasks (NNVA). As Womack & Jones (2003, 38) state, NVA tasks need to be eliminated to create flow, establish pull and achieve continuous improvement. In conclusion, five NVA tasks were found in this thesis, which can be directly eliminated.

In addition to this, time tracking data and qualitative insights made from answers to open-ended questions revealed some key inefficiencies in workflow. There were in total 12 of these tasks, which were the following: some tasks taking a lot more time from some people, meetings taking so much time, missing and incorrect information, being an intermediary in messages and emails, unnecessary system check-ups, number of systems, information not flowing from one system to another, double-checking, editing, redoing, sorting out and waiting. All these cause five various wastes, which are inappropriate processing, unnecessary motion, defects, waiting and transporting. Therefore, these tasks can also be considered as waste in this thesis and should be reduced, if not entirely eliminated.

How can Lean Six Sigma tools be utilized to eliminate waste?

Lean Six Sigma helps identify inefficiencies in a process and therefore helps eliminate waste (see 4.1.). Two Lean Six Sigma tools were utilized in this thesis which are DMAIC and

VSM. DMAIC framework helped split the waste elimination process systematically into five steps (see 4.2.1.). First the research problem was defined which was the case company's practical need to identify and eliminate work task waste to optimize resource allocation and enhance continuous improvement (see 1.1.) The measure phase was seen in chapter 5.2. where data collection of the research was explained and where the work time was tracked and measured. The analyze phase was seen in all chapters 5.3.1., 5.3.2., 5.3.3., which covered the findings and results of the research in addition to chapter 6.1., which discussed the findings on a deeper level.

Improve phase was seen in chapter 6.1., where future improvements were suggested and 6.2., where future research ideas were proposed. The final phase of DMAIC, control phase, was seen in chapter 6.3., where future suggestions were made. These steps also relate to a typical Lean process (see figure 4) and adjust to Lean's key principles (see figure 3), which prove the effectiveness of these steps. In addition, Fillingham (2007) also defined what brings value to the customer, made a value stream analysis and a future state vision, and was able to improve its process efficiency significantly, which supports the efficiency of following these steps. VSM helped visualize the entire current state of work task flow of a supply chain planner (see 4.2.3.). This way it was easier to identify additional steps, in this case work tasks, that take a long time to finish and tasks that do not add value. VSM helped understand the process efficiency and what should be improved. Later in this thesis a Future State Value Stream Map is created where the wastes mentioned in the previous sub-question are eliminated and reduced to see how much time could be saved.

How can work task waste be eliminated at case company?

The aim of this thesis is to answer the main research question "How can work task waste be eliminated at case company?". By analyzing the data collected with time tracking and identifying bottlenecks, which are in this thesis known as waste, this thesis aims to offer practical solutions to eliminate and reduce waste. The first and most important step is to identify the waste for it to be eliminated. For this, Lean Six Sigma and its tools were utilized because in previous studies they have helped for instance eliminate waste and therefore improve quality of meeting minutes and helped work faster and more efficiently (see 4.2.). Time tracking data and qualitative insights made from answers to open-ended questions revealed some key inefficiencies in work flow, which were the following: some tasks taking a lot more time from some people, meetings taking so much time, missing and incorrect

information, being an intermediary in messages and emails, unnecessary system check-ups, number of systems, information not flowing from one system to another, double-checking, editing, redoing, sorting out and waiting. These are tasks that need to be eliminated or at least reduced.

Table 5 presents key solutions to these inefficiencies which include for instance increasing training, adding company instructions on what tasks to prioritize to strengthen understanding on what the focus should be, and what tasks should not take long. Also reducing and enhancing meetings in aim to cut out the time spent on them, clarifying with other participants what information is needed and when to prevent missing and false information and then having to wait for the correct information, or alternatively automatize information to prevent manually written mistakes. A document could be formed where the correct contact personnel are listed with example issues of when to contact them. This way when an email arrives to an employee to whom it does not belong to, the document could be sent back so that next time a similar issue appears, the sender knows directly who to contact to avoid intermediaries and speed up the process.

Either in-house or external IT professionals or consultants should be hired to check some of the issues concerning systems, for example adding notifications to avoid unnecessary system check-ups. A lot of additional caution and attention is required from all employees and their co-working partners to avoid silly mistakes that afterwards require double-checking, editing, redoing and sorting out. Clear deadlines and instructions could prevent waiting. Also, sharing files or access to systems could avoid additional waiting. Time spent on the nine work tasks taking a lot longer to accomplish by some employees, should be reduced as well. These tasks are not mentioned due to confidentiality but are sent to the case company for them to know exactly where to put the focus on.

As Drohomeretski et al. (2013) state, continuous improvement is vitally important to succeed in the market, which is why the next step for the company is to set targets regarding the improvement suggestions to ensure their initialization. Firstly, the NVA tasks should be removed since they take time but do not add value. In addition to this, an easy start would be picking for example three improvement suggestions, taking action on them and setting a goal of six months for them to be implemented. After this, case company could choose three improvement suggestions to start with and make a clear goal of reducing time spent on them by 25 per cent in the next six months. Also, reducing time used to accomplish the nine earlier

mentioned tasks marked in yellow (see appendix 2) should be instituted with the help of improvement suggestions (see table 5), to even out the time taken to accomplish them. To conclude, a clear time period, couple of improvement suggestions and a per centage of how much time is aimed to reduce should be chosen. The suggestions for this are six months as a time frame, a 25 per cent time reduction for three improvement suggestions chosen by the case company. These improvement suggestions depend on to the case company's vision on what are the most important ones for them at this time.

6.3. Conclusions

This thesis aimed to detect and eliminate work task waste of a supply chain planner at case company. Time used for various work tasks was tracked with the help of an Excel survey and two Lean Six Sigma tools: DMAIC and Value Stream Map. In total five wastes were identified which are summarized in table 6 (see below). The left column states the waste found and the right column represents the key solutions to eliminate or reduce the waste. The five found wastes are inappropriate processing, unnecessary motion, defects, waiting and transporting. These wastes delve from 12 inefficiencies found through analyzing and making qualitative insights of collected time tracking data and answers to open-ended questions.

Table 6, Found wastes and suggestions on elimination

Waste	Key solutions for reducing or eliminating
Inappropriate processing	<ul style="list-style-type: none"> - More training to unify knowledge - Even out burdensome - Instructions on what to prioritize - External professional, consultant or in-house IT expert to solve this - Notifications in systems - Caution and attention
Unnecessary motion	<ul style="list-style-type: none"> - Reduce the amount - Enhance them by setting a clear target - Ponder on whether the meeting is necessary - External professional, consultant or in-house IT expert to solve this - Notifications in systems
Defects	<ul style="list-style-type: none"> - Meeting with the other end about necessity and clarity on wanted information - Caution and attention
Waiting	<ul style="list-style-type: none"> - Newsletter that states if a certain issue emerges, who to contact - Clear deadlines and instructions - Sharing files with concerning individuals - Future research
Transporting	<ul style="list-style-type: none"> - Newsletter that states if a certain issue emerges, who to contact - Identify bottlenecks - External professional, consultant or in-house IT expert to see if some could be merged

Reviewing the results, waste can be identified but the total elimination is not always easy and should not be the only option. Waste can be for instance something that takes too much time and therefore should be reduced but cannot necessarily be eliminated. Figure 12 (see below) is a Future State Value Stream Map (FSVSM) that represents what the Value Stream Map could look like in the future and how much time would be spent if suggested improvements are made. In this FSVSM, the NVA tasks are entirely eliminated, and the time spent on “emails and corrective actions” and “meetings” categories is reduced by a quarter. In addition to this, the nine tasks mentioned that take extensively various amounts of time to complete by different employees (see 5.3.2.) are also reduced each by a quarter. All this is done to perceive how much time could be saved when waste is eliminated or reduced.

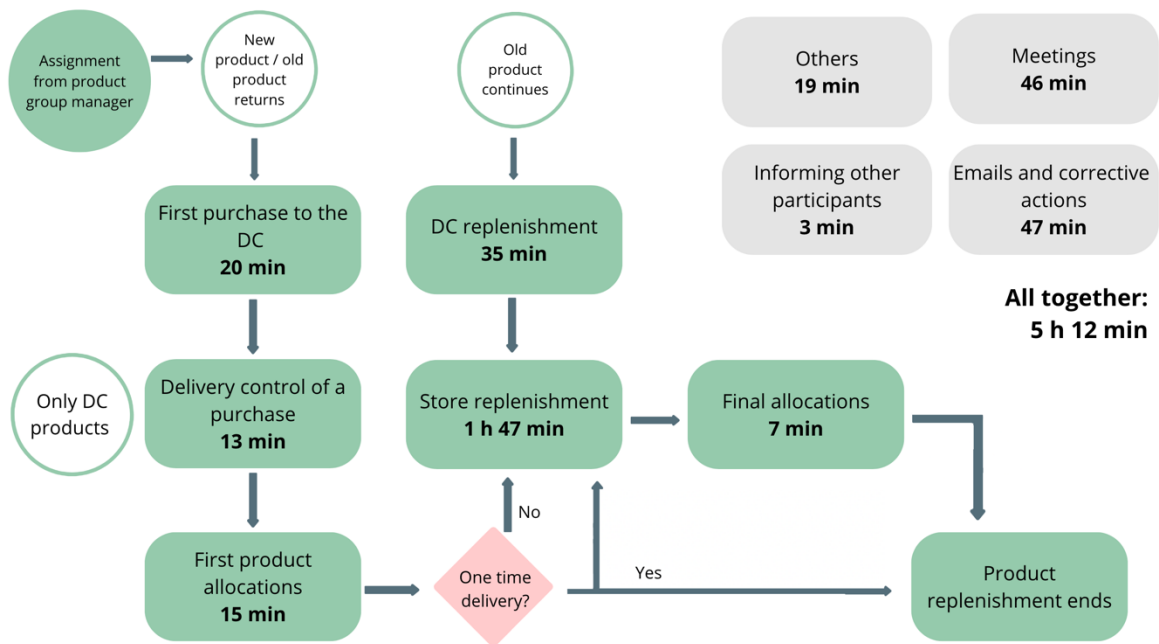


Figure 12, Future State Value Stream Map

By eliminating the NVA tasks and decreasing time spent on both the nine work tasks mentioned in chapter 5.3.2., and the categories “emails and corrective actions” and “meetings” by a quarter, the time spent on these tasks per day can be reduced by almost 25 per cent. The original time spent on these tasks was 6 hours and 53 minutes (see figure 10) and the new time could be to 5 hours and 12 minutes with the needed eliminations and reductions (see figure 12). With these improvements the case company can save time, which is the most valuable yet restricted resource, and employees could focus more on the value-adding tasks.

To make sure improvement stays continuous after this study, it is recommended that the case company firstly makes sure that both employees and the employer are strongly committed. This is a key factor for the continuous improvement to succeed (Machado & Leitner, 2010). Secondly, communication between management and employees must be effective, and this should be taken care of. This way better teamwork and commitment can be achieved as Netland (2016) and Antony et al. (2012) state. Also, it would be advisable to take the elimination of NVA tasks as a top priority since they take time but do not add value. After this, reduction of time accomplishing the nine earlier mentioned tasks (see 6.1.) should be instituted with the help of improvement suggestions (see table 5). The time tracking should not be left here. The improvements should be taken into action and another time tracking

should be held for example in a year to re-examine possible progression, and to fulfill the 5th step of Lean's key principles (see figure 3). As said in chapter 6.1., follow-up research could focus on examining why some work tasks take longer from some employees in addition to what tasks require waiting and how much.

References

- Anand, G., Ward, P. T. & Tatikonda, M. V. (2010) Role of explicit and tacit knowledge in Six Sigma projects: An empirical examination of differential project success. *Journal of operations management*. [Online] Vol. 28, no. 4, p. 303–315.
- Antony, J. (2007) Is six sigma a management fad or fact? *Assembly Automation*. [Online] Vol. 27, no. 1, p. 17–19.
- Antony, J. (2011) Six Sigma vs Lean. *International Journal of Productivity and Performance Management*. [Online] Vol. 60, no. 2, p. 185–190.
- Antony, J., Krishan, N., Cullen, D. & Kumar, M. (2012) Lean Six Sigma for higher education institutions (HEIs): Challenges, barriers, success factors, tools/techniques. *International journal of productivity and performance management*. [Online] Vol. 61, no. 8, p. 940–948.
- Ballé, M. & Régnier, A. (2007) Lean as a learning system in a hospital ward. *International journal of health care quality assurance incorporating Leadership in health services*. [Online] Vol. 20, no.1, p. 33–41.
- Baía, A. P. (2017) Achieving Customer Specifications Through Process Improvement Using Six Sigma: Case Study of NutriSoil - Portugal. *The Quality management journal*. [Online] Vol. 22, no. 2, p. 48–60.
- Berhe, H. H. (2022) Application of Kaizen philosophy for enhancing manufacturing industries' performance: exploratory study of Ethiopian chemical industries. *The International journal of quality & reliability management*. [Online] Vol. 39, no. 1, p. 204–235.
- Bhamu, J. & Sangwan, K. (2014) Lean manufacturing: literature review and research issues. *International journal of operations & production management*. [Online] Vol. 34, no. 7, p. 876–940.
- Bhuiyan, N & Baghel. A. (2005) An overview of continuous improvement: from the past to the present. *Management decision*. [Online] Vol. 43 no. 5, p. 761–771.
- Broström, N. (2024) Suodata turhat palaverit pois. *Ekonomi magazine*. 3/24. p. 8-13.

Campbell, S., Greenwood, M., Prior, S., Shearer, T., Walkem, K., Young, S., Bywaters, D. & Walker, K. (2020) Purposive sampling: complex or simple? Research case examples. *Journal of research in nursing*. [Online] Vol. 25, no. 8, p- 652–661.

Chen, J. C., Li, Y. & Shady, B. D. (2008) From value stream mapping toward a lean/sigma continuous improvement process: an industrial case study. *International journal of production research*. [Online] Vol. 48, no. 4, p. 1069–1086.

Condé, G. C. P., Oprime, P. C., Pimenta, M. L., Sordan, J. E. & Bueno, C. R. (2023) Defect reduction using DMAIC and Lean Six Sigma: a case study in a manufacturing car parts supplier. *The International journal of quality & reliability management*. [Online] Vol. 40, no. 9, p. 2184–2204.

Costa, L. B. M., Filho, M. G., Fredendall, L. D. & Ganga, G. M. D. (2021) Lean six sigma in the food industry: Construct development and measurement validation. *International journal of production economics*. [Online] Vol. 231.

Drohomeretski, E., Gouvea da Costa, S., Lima, E. & Garbuio, P. (2013) Lean, Six Sigma and Lean Six Sigma: an analysis based on operations strategy. *International Journal of Production Research*. [Online] Vol. 52, no. 3, p. 804-824.

Farquhar, J. D. (2012) *Case study research for business*. Los Angeles, [Calif.] ; SAGE.

Fillingham, D. (2007) Can Lean Save Lives? Leadership in Health Services. [Online] Vol. 20, no. 4, p. 231.

Forrest, G. (2006) Six-Sigma and the Revival of TQM. *Total Quality Management & Business Excellence*. [Online] Vol. 17, no. 10, p. 1281-1286.

Furlan, A., Vinelli, A. & Pont, G. (2011) Complementarity and lean manufacturing bundles: an empirical analysis. *International journal of operations & production management*. [Online] Vol. 31 no. 8, p. 835–850.

Hahn, G. J., Hill, W. J., Hoerl, R. W. & Zinkgraf, S. A. (2012) The Impact of Six Sigma Improvement-A Glimpse into the Future of Statistics. *The American statistician*. Vol. 53, no. 3, p. 208–215.

- Hilton, R. & Sohal, A. (2012) A Conceptual Model for the Successful Deployment of Lean Six Sigma. *International Journal of Quality & Reliability Management*. [Online] Vol, 29, no. 1. P. 54-70.
- Hines, P., Holweg, M. & Rich, N. (2004) Learning to evolve: A review of contemporary lean thinking. *International journal of operations & production management*. [Online] Vol. 24, no. 10, p. 994–1011.
- Hines, P. & Rich, N. (1997) The Seven Value Stream Mapping Tools. *International Journal of Operations & Production Management*. [Online] Vol. 17, no. 1, p. 46.
- Hirsjärvi, S. & Hurme, H. 2000. *Tutkimushaastattelu: Teemahaastattelun teoria ja käytäntö*. Helsinki: Yliopistopaino.
- Hirsjärvi, S., Remes, P. & Sajavaara, P. 2009. *Tutki ja kirjoita*. 15. edition. Helsinki, Tammi.
- Holweg, M. (2007). The Genealogy of Lean Production. *Journal of Operations Management*. [Online] Vol. 25, no. 2, p. 420-437.
- Kirk, J. & Miller, M. L. (1986) *Reliability and Validity in Qualitative Research*. Beverly Hills, Calif; SAGE.
- Kwak, Y. H. & Anbari, F. T. (2006) Benefits, obstacles, and future of six sigma approach. *Technovation*. [Online] Vol. 26, no. 5, p. 708–715.
- Laureani, A. & Antony, J. (2012) Standards for Lean Six Sigma certification. *International journal of productivity and performance management*. [Online] Vol. 61, no. 1, p. 110–120.
- Laureani, A., Antony, J. & Douglas, A. (2010) Lean six sigma in a call centre: a case study. *International journal of productivity and performance management*. [Online] Vol. 59 no. 8, p. 757–768.
- Machado, V. C. & Leitner, U. (2010) Lean tools and lean transformation process in health care. *International journal of management science and engineering management*. [Online] Vol. 5, no. 5, p. 383–392.
- Mahanti, R. & Antony, J. (2009) Six Sigma in the Indian software industry: some observations and results from a pilot survey. *TQM journal*. [Online] Vol. 21 no. 6, p. 549–564.

Mast, J. & Lokkerbol, J. (2012) An analysis of the Six Sigma DMAIC method from the perspective of problem solving. *International journal of production economics*. [Online] Vol. 139, no. 2, p. 604–614.

Netland, T. H. (2016) Critical success factors for implementing lean production: the effect of contingencies. *International journal of production research*. [Online] Vol. 54, no. 8, p. 2433–2448.

Newman, I. & Benz, C. R. (1998) *Qualitative-quantitative research methodology: exploring the interactive continuum*. Carbondale: Southern Illinois University Press.

Ojo, B., Feldman, R. & Rampersad, S. (2022) Lean Methodology in Quality Improvement. *Pediatric Anestheisa*. [Online] Vol. 32, no. 11, p. 1209-1215.

Othmane, B. (2022) Improving Replenishment Flows Using Simulation Results: A Case Study. *Logistics*. [Online] Vol. 6, no. 2, p. 34.

Pepper, M. P. J. & Spedding, T. A. (2010) The evolution of lean Six Sigma. *The International journal of quality & reliability management*. [Online] Vol. 27, no. 2, p. 138–155.

Pranckevicius, D., Diaz, D. & Gitlow, H. (2008) A Lean Six Sigma Case Study: An Application of the “5S” Techniques. *Journal of Advances in Management Research*. [Online] Vol. 5, no. 1, p. 63-79.

Rahmanasari, D., Sutopo, W. & Rohani, J. (2021) Implementation of Lean Manufacturing Process to Reduce Waste: A Case Study. *IOP Conference Series. Materials Science and Engineering*. [Online] Vol. 1096, no. 1.

Salah, Rahim & Carretero (2010) The integration of Six Sigma and lean management. *International journal of lean six sigma*. [Online] Vol. 1 no. 3, p. 249–274.

Shah, R. & Ward, P. W. (2007) Defining and developing measures of lean production. *Journal of operations management*. [Online] Vol. 25, no. 4, p. 785–805.

Sharma, A., Bhanot, N., Gupta, A. & Trehan, R. (2021) Application of Lean Six Sigma framework for improving manufacturing efficiency: a case study in Indian context. *International journal of productivity and performance management*. [Online] Vol. 71, no.5, p. 1561–1589.

- Sharma, P. & Kulkarni, M. (2016) Framework for a dynamic and responsive: Time separated – lean-agile spare parts replenishment system in army. *International journal of productivity and performance management*. [Online] Vol. 65, no. 2, p. 207–222.
- Singh, B., Garg S. K., Sharma, S. K. & Chandandeep, G. (2010) Lean implementation and its benefits to production industry. *International journal of lean six sigma*. [Online] Vol. 1, no. 2, p. 157–168.
- Snee, R. D. (2010) Lean Six Sigma - getting better all the time. *International journal of lean six sigma*. [Online] Vol. 1, no. 1, p. 9–29.
- Tagge, E. P., Thirumoorthi, A. S., Lenart, J., Garberoglio, C. & Mitchell, K. W. (2017) Improving Operating Room Efficiency in Academic Children’s Hospital Using Lean Six Sigma Methodology. *Journal of pediatric surgery*. [Online] Vol. 52, no. 6, p. 1040–1044.
- Taylor, G. R. (2010) *Integrating Quantitative and Qualitative Methods in Research*. 3rd edition. Lanham, MD: University Press of America.
- Tjahjono, B., Ball, P., Vitanov, V. I., Scorzafave, C., Nogueira, J., Calleja, J., Minguet, M., Narasimha, L., Rivas, A., Srivastava, A., Srivastava, S., Yadav, A. (2010) Six Sigma: a literature review. *International journal of lean six sigma*. [Online] Vol. 1, no. 3, p. 216–233.
- Vermaelen, N. & Kovach, J. V. (2022) Driving meeting effectiveness through organizational process improvement—A Lean Six Sigma case study. *Organizational dynamics*. [Online] Vol. 51, no. 2, p. 100827.
- Walker, I. R. (2011) *Reliability in Scientific Research: Improving the Dependability of Measurements, Calculations, Equipment, and Software*. 1st edition. [Online]. Cambridge: Cambridge University Press.
- Wan, H-D. & Chen, F. (2008) A leanness measure of manufacturing systems for quantifying impacts of lean initiatives. *International journal of production research*. [Online] Vol. 46 no. 23, p. 6567–6584.
- Wang, F-K., Du, T. & Li, E. (2004) Applying Six Sigma to Supplier Development. *Total Quality Management*. [Online] Vol. 15, no. 9-10, p. 1217-1229.

Wei, C.-C., Sheen, G.-J. Tai, C.-T. & Lee, K.-L. (2010) Using Six Sigma to improve replenishment process in a direct selling company. *Supply chain management*. [Online] Vol. 15, no. 1, p. 3–9.

Womack, J. P., Jones, D. T. & Roos, D. 2007. *The machine that changed the world*. New York: Free Press.

Womack, J. P. & Jones, D. T. (2003) *Lean thinking: banish waste and create wealth in your corporation*. London, Simon & Schuster.

Yang, H. M., Choi, B. S., Park, H. J., Suh, M. S. & Chae, B. (2007) Supply chain management six sigma: a management innovation methodology at the Samsung Group. *Supply chain management*. [Online] Vol. 12, no. 2, p. 88–95.

