SUPPLY CHAIN IMPROVEMENT IN AN AUTOMOTIVE DOWNSTREAM SUPPLY CHAIN

A study from the Finnish automotive sector

Lappeenranta–Lahti University of Technology LUT

Master's Programme in Supply Management, Master's thesis

2023

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Examiner(s): Professor Jukka Hallikas D.Sc. (Tech.)

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ABSTRACT

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Keywords: Supply Chain Improvement, Lean, Six Sigma, Value Stream Mapping, Automotive, Downstream Supply Chain.

Supply chains have been under considerable stress during the recent years due to disturbances in global supply. In todays globalised markets, supply chain performance plays an ever-greater role in the competitiveness of companies generating growing demand for supply chain improvement.

This paper focuses on improving the less studied downstream section, of an automotive industry supply chain. A thorough and systematic two-phased data collection process is used for the empirical part of the case study. The researcher aims to highlight areas for improvement in the case company`s downstream supply chain and to contribute to existing research on downstream supply chain improvement in the automotive sector, whilst providing insight specifically related to the Finnish market.

The study utilises Lean tools, value stream mapping and 5 whys to depict the downstream supply chain in scope and to provide narrower focus for deeper analysis. Six Sigma tools, voice of process and quality function deployment are used to develop further understanding of a specific process stage, highlight what factors are important in this process stage and what should be done to improve them. The results indicate that to improve process efficiency and lead times of the downstream supply chain, greatest priority should be given to sharing final delivery information earlier and improving the reliability and quality of information.

TIIVISTELMÄ

Lappeenrannan–Lahden teknillinen yliopisto LUT

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Kauppatieteet

Daniel Iles

Toimitusketjun tehostaminen autoalan toimitusketjun alavirrassa

Tapaustutkimus Suomen autoalalta

Kauppatieteiden pro gradu -tutkielma

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Avainsanat: Toimitusketjun tehostaminen, lean, six sigma, arvovirtakuvaus, autoala, toimitusketjun alavirta.

Viime vuosina toimitusketjuihin on kohdistunut merkittävää painetta globaalien toimitusongelmien vuoksi. Nykypäivän globaaleissa markkinoissa toimitusketjujen suorituskyky on korostuneessa asemassa ja täten tarve toimitusketjujen tehostamiselle on kasvussa.

Tämä tutkimus keskittyy akateemisessa tutkimuksessa vähemmälle huomiolle jääneen autoalan toimitusketjun alavirran tehostamiseen. Työn empiirinen tutkimusosio perustuu järjestelmällisesti kerättyyn kattavaan tutkimusaineistoon. Tutkija pyrkii nostamaan esiin tehostamiskohteita case-yrityksen toimitusketjun alavirran prosesseissa ja antamaan oman panoksensa olemassa olevaan autoalan toimitusketjujen alavirtojen tehostamisen tutkimuskirjallisuuteen, lisäten ymmärrystä erityisesti Suomen markkinasta.

Tutkimus hyödyntää lean-työkaluista arvovirtakuvausta ja 5 miksi -menetelmää kuvatakseen tutkimuksen kohteena olevan toimitusketjun alavirran, sekä kohdentaakseen kattavamman analyysin tiettyyn prosessivaiheeseen. Six sigma -työkaluja prosessin ääni ja QFD-matriisi käytetään kattavamman ymmärryksen saavuttamiseksi yhdestä prosessivaiheesta sekä omaksumaan mitkä tekijät ovat tälle vaiheelle olennaisia ja kuinka niissä voi parantaa. Tutkimustuloksissa käy ilmi, että prosessitehokkuuden ja sen läpimenoajan tehostamiseksi tulisi ensisijaisesti keskittyä jakamaan lopullinen tieto toimitusajoista varhaisemmassa vaiheessa sekä parantaa jaettavan tiedon luotettavuutta ja laatua.

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I am ever so grateful to have a loving family, parents and siblings who have been very supportive and helpful throughout my life and studies, thus setting the foundation for my past, current and future achievements. A special thank you goes to my loving girlfriend and our four-legged furry friend who has been my loyal “research assistant” whilst laying down by my desk through the thesis writing process and numerous other assignments.

Thank you also to all the LUT staff members and fellow students who have made this an amazing journey. Particularly want to thank friends who have put in countless hours of work together with me in various group assignments.

Cheers to all!

Sincerely,

Daniel Iles

ABBREVIATIONS

5S	Sort, straighten, scrub, standardise and sustain
C2C	Cash-to-cash
COVID	Corona virus disease
CTQ	Critical to quality
DMAIC	Define, measure, analyse, improve, and control
DOE	Design of experiments
DSC	Downstream supply chain
DMS	Dealer management system
ETA	Estimated time of arrival
FMEA	Failure mode and effects analysis
JIT	Just-in-time
LCV	Light commercial vehicle
PC	Passenger car
PDCA	Plan, do, check and act
PDI	Pre-delivery inspection
PDSA	Plan, do, study and act
PPO	Post production option
QFD	Quality function deployment
RQ	Research question
R&D	Research & development
SC	Supply chain
SCI	Supply chain improvement
SIPOC	Supplier, input, process, output and customer

SQ	Sub-question
TPS	Toyota production system
USC	Upstream supply chain
VoP	Voice of process
VSM	Value stream mapping

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1. Introduction

The rise and vast development of globalisation has opened new business opportunities for organisations around the world, however it isn't all record breaking sales and endless success as it also poses fierce competition and slimmer margins as behemoth companies apply economies of scale in the attempt to squash smaller players and outperforming rival industry giants. Somewhat obviously this has led to a greater and greater need for efficiency gains, cost reduction, especially in the relation to supply chains (SC), which play a critical role in running successful businesses. A common view is that the quality of goods and services correlate with the cost of producing them and vice versa. However, this isn't always the case as there are methods for promoting quality whilst reducing costs: Lean and Six Sigma. As a cause of the COVID pandemic and war in Ukraine both global and local supply chains have been under an unprecedented strain due to scarcity of components and rising costs. Such crisis increases the need for further improving supply chains to be more efficient, robust, agile etc. in order to not only remain competitive, but to upkeep business operations running close to normal.

Chapter one introduces the field of research that this paper focuses on, provides insight on the authors motivation for his work, covers the objectives of this study, the research problem, research questions, limitations and finally the overall structure of this thesis.

1.1 Area of research

This paper focuses on supply chain improvement (SCI) via Lean and Six Sigma methodologies. The previously mentioned topics are discussed both from a broader perspective and from the point of the automotive industry, which is the specific field of industry for this paper. In addition, certain focus is given specifically for downstream SCI as the empirical part is conducted on automotive downstream supply chain improvement.

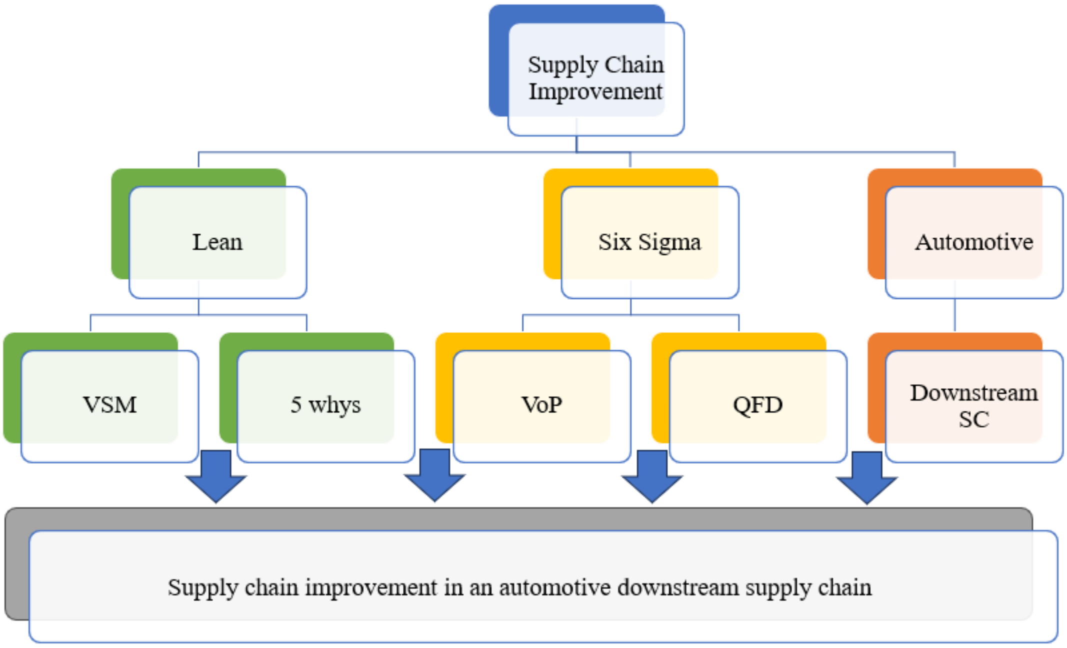

Figure 1. Conceptual framework / theoretical background.

Figure 1 displays the conceptual framework and theoretical background for this paper. As indicated in figure 1, the connecting concept is SCI. Both Lean and Six Sigma are the key methodologies of SCI studied. Value stream mapping (VSM) and 5 whys being the Lean tools of focus. For Six Sigma the tools of focus are voice of process (VoP) and quality function deployment (QFD). Automotive industry acting as the selected industry and downstream supply chain the process focus point for empirical research. Ultimately all coming together as supply chain improvement in an automotive downstream supply chain.

1.2 Objectives of the study

SCI is in no shape or form an under studied field as there is an extensive amount of research conducted on the topic dating back several decades. SCI being a key contributor in seeking efficiency gains, process improvements, cost reduction and overall competitiveness, its significance and importance are well known and should be a matter of interest to organisations that are looking to succeed and remain competitive. The automotive industry has been a rather popular industry of focus for this field of research. This is likely to do with the fact that many SCI theories/tools stem from automotive manufacturing. However, most of the conducted research has been focused on the upper-stream part of supply chains, e.g., manufacturing, suppliers, components, and raw materials. Although supply chain improvement in general, and in the automotive industry aren't understudied fields of research, there remains plenty of room for additional research. As a matter of fact, there is little to no research conducted specifically on automotive downstream supply chain improvement in the Finnish market.

The objectives of this study are to discuss the existing literature of supply chain improvement within and outside of the automotive sector, contribute to the existing research on downstream supply chain improvement in the automotive sector providing insight specifically related to the Finnish market. Additionally other objectives are to highlight the case company areas of improvement concerning their downstream supply chain and to further build the authors expertise on SCI.

1.3 Authors motivations

During the authors Supply Management master`s studies and prior bachelor studies, Supply Chain Improvement has always been a topic of interest due to its problem-solving nature and potential impact towards business processes and bottom line. Especially when considering that the variety of tools implemented in SCI can be utilised also in other business functions, learning them in theory and utilising them in practice is rather appealing due the possible impact that can be made with them.

Once the golden opportunity to research SCI in an actual automotive supply chain arose, standing up to the task wasn't a difficult decision to make. As mentioned in the previous sub-chapter the authors motivation to this research stems from the chance to discuss and contribute to existing literature on automotive SCI and researching an enticing case company's downstream supply chain whilst having the possibility to put theory into practice.

1.4 Research problem and questions

This research is executed as a single company case study to company X, later referred in this paper as “the case company”. The case company is the Finnish importer of a global manufacturer that produces cars under several brand names. The business of manufacturing and selling cars is a highly capital-intensive business as the produced goods (cars) per unit are very valuable usually in the range of several tens of thousands of euros and in some cases even up to the hundreds of thousands. Thus, a vast amount of capital is tied into stock, which can be categorised as produced vehicles on their logistical journey to customers, and cars in free stock where a customer can obtain his/her new vehicle with shorter lead times. As the logistical journey from factory to consumer takes multiple weeks depending on the distance/route between the customer and factory, a lot of capital is tied for longer periods of time into this stock, even when there is an existing customer contract for a built to order vehicle, since money exchanges hands roughly at the time of delivery.

Therefore, lead time substantially affects the cash-to-cash (C2C) cycle in this field of business, which is already from the start (research & development (R&D), raw materials, components, manufacturing) a complex and capital intense process. Thus, improvements on lead time improves the C2C cycle and capital is freed quicker for R&D, production, etc. Shorter lead times aren’t only preferable to the manufacturer as also customers are more satisfied with faster deliveries (i.e., shorter waiting times) and authorised dealers are able to monetise the sale at a faster pace, and more reliably evaluate the value of a possible trade-in car that the customer may provide. Now, getting to the exact research problem. The problem of this research lies in whether significant areas/activities for improvement can be identified in the case company’s passenger car (PC) downstream supply chain for future considerations (improvement actions).

To tackle the research problem, the research question (RQ) below was formulated by the author.

RQ: *What aspects could be improved in the downstream supply chain of an automotive company to shorten lead times?*

To answer the RQ in a holistic fashion. the sub-questions (SQ) below were formulated during the research.

SQ1: *What areas generate the most non-value-added time in the downstream supply chain?*

SQ2: *What influences dealer lead times?*

SQ3: *What factors should the case company focus on to support dealers to achieve shorter lead times?*

1.5 Design and limitations

For this thesis a single case study approach is applied, which as a type of research comes with its typical limitations. The reasonings for choosing a single vs multiple case study are the following: firstly, this research/thesis is conducted in collaboration with a single company and focuses on the specific set-up and characteristics of its downstream supply chain. If one would consider a multiple case study approach for a similar research, other companies may or may not have a similar set-up, but the characteristics for each company would certainly vary. Also, as this research has been conducted in collaboration with a single case company, the collection of data has been company specific. A multiple case approach would likely be less in depth in terms of company specific findings, although it could provide a more holistic higher-level picture of the topic. Another factor which limits this to be a single case study is that the conducted research goes quite far into specific details and investigates identifying areas of improvement in this particular SC. The conduction of multiple cases would also take a considerable amount of time, considering that this research is conducted by a single student as his master`s thesis.

Out of the two types of single case studies (holistic and embedded) described by (Yin, 2003, p. 39-46) this case study is the embedded type, as data is collected in two separate parts with different units of measure. The first part focuses on a more higher-level depiction of the downstream supply chain through value stream mapping (VSM) conducted via a series of smaller group sessions and one larger scale workshop. Primary units of measure being who, what and for how long. The second part focuses on a single stage of the downstream supply chain (DSC) and goes deeper to the specifics of what areas or activities could potentially be improved via a series of voice of process (VoP) interviews. VoP interview data is then quantified via quality function deployment (QFD) to illustrate the measure of what and how.

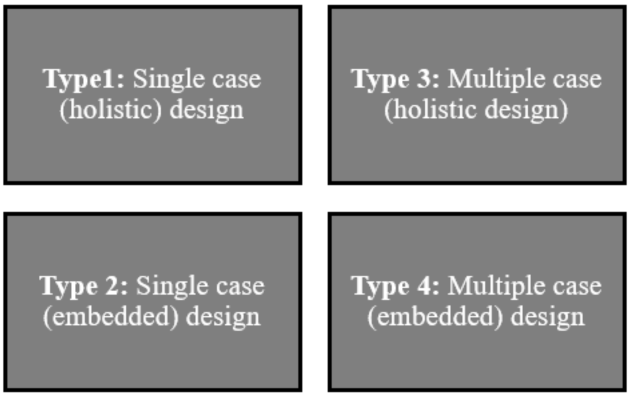

Figure 2. Types of case studies, adopted from Yin (2003, p. 40)

Figure 2 illustrates the four different case study categories; single case holistic, single case embedded, multiple case holistic and multiple case embedded. This paper falls into the category of "single case holistic" as it consists of a single case/company (network) and uses the entire scoped DSC as a unit of analysis rather than the relationships within it (Kähkönen, 2011, p. 34).

Due to the single case study approach findings of the empirical research are specific to the case company and therefore may not apply outside of this specific organisation. The empirical part is conducted on a specific field (automotive industry), which adds to the limitations of findings. Other considerable limitations are that the research is limited to the Finnish market and that the selected section of the supply chain is specifically downstream and therefore excludes upstream activities. Also, it is important to point out that in this study the downstream supply chain has been narrowed down to the section between the place of warehousing all the way to customer handover. Thus, this research does not cover activity between the factory and point of warehousing. The downstream supply chain studied is specifically for cars and doesn't consider other products (accessories, spare parts etc.) that the company produces. It is also significant to highlight that the empirical part is focused on the supply of PCs and not light commercial vehicles (LCV). The reason for the distinction is that LVC`s have the tendency to have greater variance in lead times due to their specific nature e.g., complex installations for specific company needs, and large fleet agreements.

1.6 Structure of thesis

This paper is structured in the following manner: The first chapter describes the area/focus of research and motivation behind this study. Second chapter acts as the theoretical part and provides background to the empirical part mostly focusing on SCI, Lean and Six Sigma.

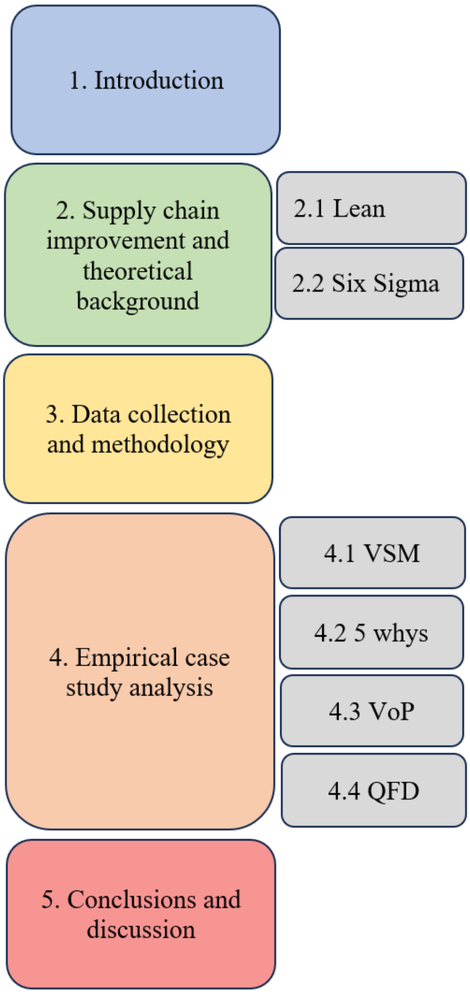

Figure 3. Structure of this thesis

Chapter three covers data collection and research methodology of this study. The fourth chapter contains the empirical part of this study utilising Lean tools; value stream mapping (VSM) and 5 whys, and Six Sigma tools voice of process (VoP) and quality function deployment (QFD). Final discussion and conclusion are provided in chapter five.

2. Supply chain improvement and theoretical background

Chapter two acts as the literature review for this paper and provides theoretical background for the empirical part. The literature review covers the following themes via mainly scientific journals, and articles: supply chain improvement, Lean, Six Sigma, supply chain improvement in the automotive industry and downstream supply chain. The aim is to present relevant literature on the before mentioned topics and to provide necessary background for further chapters in this paper. In order to limit the scope of this literature review, linking topics such as change management and statistical analysis have been deliberately excluded.

As the term supply chain improvement implies, SCI is about planning and acting to improve the status quo of a supply chain. The need/importance for SCI stems from the increased significance of supply chain management (SCM) and its ability to act as a competitive advantage in today's global economy (Ință et al. 2020, p.1). SCM is currently facing harder and harder pressure due to growing demand for higher level customer service in high competition markets, fiercer competition adding pressure to reduce costs whilst retaining profit margins and competitors attempts to improve their SC quality as has been seen for example in the automotive industry (Intă et al. 2020, p.1).

The improvements themselves can be targeted to various links/processes/activities in the SC. Radej et al. (2017, p. 388) highlight quality and its improvement as one of the most essential processes in an SC. As today's global SCs are extremely complex there are numerous of individual improvement areas, some larger and some smaller. SCI is commonly linked to improving manufacturing and supplier development however, it can also be targeted to fully internal processes. Examples of SCI could be considered anything from reducing the cost of raw materials/components, improving product quality by reducing defects, reducing the amount of waste and or space of packaging, assuring supply for critical materials, shortening lead times, etc. For an organisation to improve they first need to know where they currently stand. To be able to execute actual improvement of the supply chain, the main problems in the current situation must be identified (Intă et al. 2020, p.3). This can be achieved through several tools such as VSM, a tool discussed later in this chapter.

Burnes and New identify three different models for SCI. ***Model one*** is about collaboratively (buying company and supplier) removing waste from common processes. From a buying company perspective, the key is to replace a typical adversarial mindset more towards a collaborative one. Although this model has its perks it is also criticised for the lack of addressing possible performance issues as adequate performance may been seen as good enough as long as waste and problems are removed from common processes and interaction with the purchasing company. ***Model two*** is based on an active partnership where both parties improve each other. This model is the closest to supplier development, where generally a large purchasing company improves the performance of its suppliers (usually of smaller size than the buying company). As in model one, model two is also based on trust, however communication is more frequent. In addition to requirements to remove waste form the common interface model two also implies high-performance standards and commitment/investment to the processes tied to the buying company. Model two is the most common in for example Japanese automotive manufacturing. As it is more of a continuous process, maintaining it by the buying company during rougher economic patches may turn out challenging and requires full on commitment. ***Model three*** follows almost a Darwinian evolutionary process where the different companies partner with whomever is the fittest from a transactional, strategic and interest point of view. Therefore, it isn't a given that best practices remain in the particular supply chain, as companies partner with whom they feel the best match at the time. Bonds are built through best practices shared. This model is the most individualistic as rather than building an "family network" of suppliers it is more independent orientated focusing on the buying company's own business improvement and strategy. (Burnes and New, 1996, p. 27-28)

Table 1: A framework for supply chain improvement (Burnes & New, 1996, p. 27)

Model	Mechanism for supply chain improvement	Focus	Key requirments	Key metaphor
Model one	Partnership and cooperation to eliminate waste at interface	Relationship	Trust	Marriage
Model two	Supplier development for technology transfer from customer to supplier	Knowledge/skill	Communication	Paternalism
Model three	Best practice firms work with best practice firms: survival of the fittes	Performance	Strategic clarity	Evolution/chemical kinetics

All three models facilitate SCI, but each have different levels of expectations on purchasing:

"For model one, the key skills are developing trust, cooperative attitudes, and consistency amongst those at the interface. For model two, the emphasis shifts towards establishing mechanisms by which knowledge and skill can be transferred effectively. Model three leads to a sharper focus on the selection of evaluation of suppliers." (Burnes & New, 1996, p. 28)

2.1 Lean

Lean can be described as a philosophy for a normative production/working methodology, which roots are in Japanese automotive manufacturing (Machado & Leitner, 2010, p. 383). The fundamental concept of Lean is based on the reduction of "Muda", which is the Japanese word for waste. In Lean thinking Muda is seen as different forms of excess/undesirable activities, which reduce process/work efficiency. This means that activities of the process which do not create value to end customer should be reduced, thus leading to higher improved quality, efficiency, and productivity. The beauty of this is that unlike generally thought, improving quality doesn't have to mean doing more, and doing less doesn't always lead to decreased quality. Thus, in this sense it can be seen as a "less is more" mindset. It's important to acknowledge though that Lean isn't just a management tool for selected improvement projects, but rather a philosophy, which should be embedded in an organisations culture and adopted as a concept to work by (Machado & Leitner, 2010, p. 384). In order to evaluate what is waste, Lean thinking divides process activities into three different categories:

- *Value adding activity* – activities that generate value to the product/service delivered to the end customer and that the customer perceives as valuable
- *Nonvalue adding activity* – activities, which in the current process don't add value to the product/service delivered to the end customer
- Necessary nonvalue adding activity – activities, that are essential to the current process however do not add value to the customer. (Hines & Taylor, 2000, p. 10)

When Lean is applied in the correct fashion, resource optimisation and evaluation of activities and flows according to the categorisation above delivers overall process improvements leading to improved efficiency and quality. Lean philosophy identifies seven different categories of waste as it may be perceived from table 2, which according to Hines & Rich (1997) lists the Seven forms waste in Toyota Production System (TPS). The systemic identification and removal of these wastes from process/es is the main goal in lean thinking.

Table 2: Seven forms of Muda (waste) in TPS according to Hines & Rich (1997, p. 47 - 48).

MUDA (WASTE)	**DESCRIPTION**
1. Overproduction	Excess production or producing products/materials too early will lead to excess inventory (extra costs) and have a negative effect on process flow. Overproduction may also lead to unnecessarily long storage and lead times.
2. Waiting	Waiting stems from the inefficient use of time. Substantial periods of inactivity for machine, people production etc. ramps up costs and inflates process lead times.
3. Transport	Transportation of goods/materials/information is a necessity, however excess transport should be avoided when necessary. Unnecessary transport should be avoided as it leads to excess waiting and wasteful use of resources. Minimisation of excess movement will thus make the process more efficient.

4. Inappropriate processing	Unnecessarily complicated processes when simpler solutions are available leads to excess work. Inappropriate tools deteriorate quality and efficiency. Poor layouts generate additional process steps and poor flow of materials and information.
5. Unnecessary inventory	Unnecessary inventory creates additional storage costs and increases the use of space. It also increases lead times and can negatively affect customer service and communication.
6. Unnecessary motion	Unnecessary motion (bending, stretching, squatting etc.) lead to poor work ergonomics and thus putting a strain on employees, which may lead to injuries and inconsistent product quality. Thus, reducing such movement will make a better workplace and promote quality.
7. Defects	Defects (poor product quality, mistakes in documents, poor service delivery) generate excess costs and thus have a negative impact on profit. However, defects also highlight a need for improvements and make great cases for implementing Kaizens.

Generally Lean is considered to have five widely accepted key principles. These five principles are listed below according to Hines & Taylor (2000) and Machado & Leitner (2010):

(1) Specify value to customer: from a customer perspective, everything a company does for its customer is either valuable or nonvaluable. Value adding activities are ones that can be seen to positively impact customer needs. In the contrary nonvalue adding activities are activities that require resources and time without adding value in the product or service delivered to the customer.

(2) Identify the whole value stream: This principle requires the use of value stream mapping to specify the flow of the process and differentiation of value adding activities from nonvalue adding activities in order to challenge all "wasteful" process steps.

(3) Making functional flows: The product/ service should be made to flow in a manner that reduces waiting, delays and minimise lead time within the process by applying just in time (JIT) delivery from one step to another.

(4) <u>Make only what is "pulled":</u> the basic concept of pull in Lean is the use of resources to create products based on actual customer demand and not projected orders (forecasts).

(5) <u>Strive for perfection:</u> The Japanese word "Kaizen" is a methodology of applying continuous improvement into an organisations culture. It aims to promote continuous improvement of processes and elimination of waste in a systemic manner.

The flexibility and adaptivity of Lean philosophy make it a widely applicable methodology for smaller and large organisations, within companies and between companies for example in SCs. However as mentioned earlier it should be adopted throughout the work culture in order to achieve long-term benefits from continuous improvement. This wide applicability is also supported by the extensive variety of Lean tools, as Machado & Leitner (2010, p. 384) state that there are over 100 different Lean tools designed for different tasks/focus areas. Lean tools can be viewed as a series of methods that provide direction and guidance in applying Lean. Some essential tools are discussed later in this chapter.

Lean pioneer: Toyota

Toyota is widely recognised as the creator of the Lean concept and it has created a lean learning culture for employees at all levels (operational, middle management & top management), focusing on continuous improvement in all their operations (Sissons & Elshennawy, 2014, p. 263). Toyota is also known for working with their key suppliers to make sure their processes and thus Toyota`s entire supply chains are lean, acknowledging that their suppliers are an important part of the extended value stream (Sissons & Elshennawy, 2014, p. 265). The practical model behind the famous Toyota Production System is based on three main pillars "jidoka" (automation), "kaizen" (continuous improvement) and "just-in-time (JIT)" (Chiarini et al. 2018, p. 427).

The way Toyota has been able to successfully implement Lean is by deploying lean improvements in all areas of their business from top to the back end of their business (Sissons & Elshennawy, 2014, p. 265). Engagement of all employees from all parts and levels of the organisation, as part of the lean concept, in a consistent manner is part of their continuous improvement – "kaizen". Toyota does not guarantee lifetime employment, however when a person "frees up" due to a successful kaizen, the person is given an opportunity to work somewhere else (Sissons & Elshennawy, 2014, p. 266). This not only is a gesture of caring for employees and appreciating their contributions towards the success of the company, but it also alleviates some of the concerns that employees generally might have towards the aim for constant pursue of efficiency gains by reducing “unnecessary work”.

Training is a necessary part of implementing Lean and Toyota is committed to train their staff into leaders on Lean. When “problems” occur, lean sensei’s guide and coach past the problems enabling the less experienced staff to complete the initiative (Sissons & Elshennawy, 2014, p. 267). Standardisation of work is an important process part of lean implementation and Toyota has made this one of their key lean components (Sissons & Elshennawy, 2014, p. 268). The purpose of standardisation is eliminating waste, creating best practices, and achieving productivity gains. Another process contributing factor to Toyota`s success is their policy deployment and target setting system called “hoshin kanri”, which takes broad corporate-wide strategies and translates them down to “meaningful objectives at the working level of the organization (Sissons & Elshennawy, 2014, p. 268).

After the most crucial driver behind Lean the customer, kaizen is another key driver of Lean in the sense of creating a culture focused on continuous improvement (Sissons & Elshennawy, 2014, p. 269). Kaizen is so important at Toyota that they even have a certain percentage of factory floor workers working full time in kaizen events instead of performing their normal production job duties (Sissons & Elshennawy, 2014, p. 269). The Lean methodology has been embedded into Toyota’s culture, also “trickling down” to its supplier network. By transferring their knowledge to suppliers, Toyota has greatly improved supplier performance which in return has generated tremendous competitive advantages for Toyota (Dyer & Hatch, 2004, p. 63).

2.2 Six Sigma

Six Sigma is defined as a logical and systematic approach for achieving continuous process improvements. Sigma quality level indicates the regularity of defects. The higher the sigma level is the better, as a high sigma quality level indicates a low defect rate (Pepper & Spedding, 2009, p. 142). Wang et al. (2010, p. 1219) state that the name Six Sigma stems from the standard deviation process normal deviation:

"Originally, Six-Sigma was so named because the process mean will produce 3.4 defects per million opportunities (DPMO) and is shifted 1.5 standard deviations from the target mean that has six standard deviations on each side of the specified limit."

As a management tool Six Sigma is known for being a customer driven methodology focusing on statistical decision making with priority on cost reduction (Näslund, 2008, p. 271). Six Sigma essentially aims to eliminate defects in products/services and processes (Knowles et al. 2005, p. 56). Organisations can improve their operations and alleviate problems by reducing variation in their processes (Corbett, 2011, p. 121).

Implementation of Six Sigma cannot be regarded as a short-term "quick fix". As like in all forms of major change, some amounts of initial disruptions should be expected. Six Sigma projects should be in-line with organisational strategy. It is intended to be executed as a series with the focus to improve bottom-line results (Knowles et al. 2005, p. 58). Six Sigma teams transform strategic objectives into operational goals with the purpose of improving defect rate of a product/service to a specific target level. Projects should be led by trained project leaders (master black belts) also known as "champions" and operational roles called black belts and green belts based on the amount of training and level of past project experience (Wang et al. 2010, p. 1220).

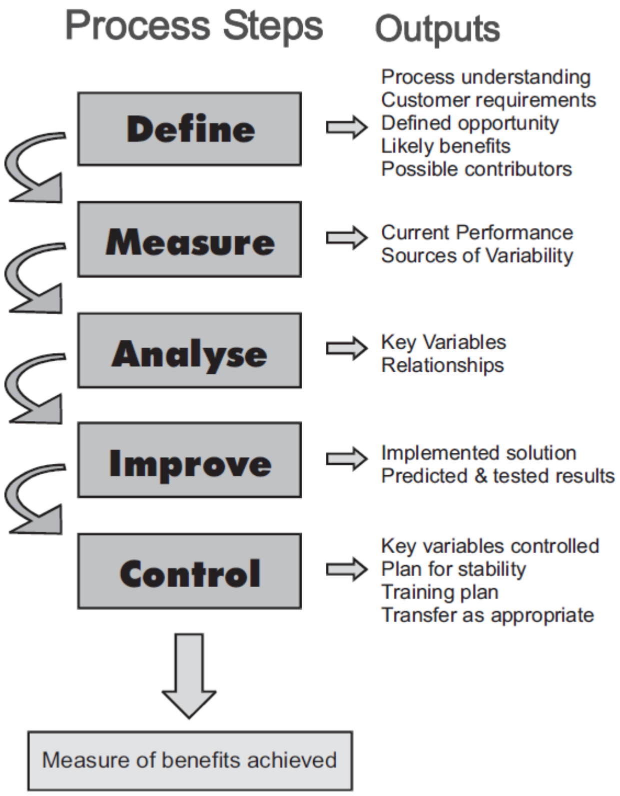

Figure 4. The Six Sigma DMAIC process (Knowles et al. 2005, p. 387)

Six Sigma is driven by the DMAIC process (see figure 4), and it consists of five steps: Define, Measure, Analyse, Improve, and Control. Although different authors have presented different variations of it depending on the type of Six Sigma project the basic idea remains. Yang et al. (2007) discuss multiple variations of DMAIC including DMAEV (Define, Measure, Analyse, Enable and Verify) and DABTL (Define, Architect, Build, Test and Launch), later of which is for System development Six Sigma projects. *Define* stage targets to define improvement opportunities in the process and their potential positive impacts. Improvement opportunities with high potential impacts and quick wins are prioritised. *Measure* phase aims to identify performance measures such as cost and productivity and measure process capability. *Analyse* phase focuses to detect main reasons/sources for process inefficiencies and defects. *Improve* phase identifies and implements solutions for process improvement. Finally, the *Control* stage is used to verify that the implemented improvements meet the identified standards and proposed control measures. Each of the DMAIC tools utilise specific Six Sigma tools some of which are discussed in sub-section 2.3.2 (see figure 6).

Six Sigma pioneer: Motorola

The Six Sigma methodology was created by Motorola, a company built upon this experience, and it has continued to focus its efforts on developing the Six Sigma methodology (Matthews, 2006, p. 35). Motorola has utilised Six Sigma throughout their business, and they have implemented the practice into several of their operations in addition to manufacturing. The company has also worked with their suppliers and customers for over two decades to deliver the benefits of Six Sigma throughout their Supply Chain (Matthews, 2006, p. 35). As a result, Motorola has been able to improve their manufacturing and their service sector as well as their finances (Matthews, 2006, p. 35). According to Ingle & Roe (2002, p. 65) many internal and external viewers believe that Six Sigma has ensured the long-term survival of Motorola. By utilising Six Sigma Motorola has been able to avoid costly oversight and save the company's resources (Matthews, 2006, p. 36). It has also allowed the company to offer unique quality products to its customers. As a result of implementing the Six Sigma methodology, Motorola have documented in the past over $17 billion in savings for their organisation (Matthews, 2006, p. 35).

Motorola introduced the term Six Sigma "black belt" to describe employees who are trained and experienced in applying statistical techniques to business processes and procedures so that they can make positive contributions to the core. The black belt program helped Motorola to facilitate comparisons between diverse products and services, which is seen as a competitive advantage throughout the organisation. At Motorola, the black belt trained staff members are viewed as subject matter experts and skilled data analysists who play the important roles of team leaders, mentors, trainers, and facilitators. (Ingle & Roe, 2002, p. 64-65)

There are three standard levels for belts: green belt, black belt, and master black belt. Green belt employees at Motorola are trained and experienced in using Six Sigma tools and techniques. As discussed above, black belted personnel are specialist in the use of Six Sigma problem solving and prevention tools and techniques. Master black belted personnel have practiced the "art" of Six Sigma as a black belt for at least five years and are full-time practitioners of Six Sigma tools and act as mentors to black belt candidates. (Ingle & Roe, 2002, p. 65)

2.3 Lean & Six Sigma tools

This section focuses on presenting some of the commonly used Lean and Six Sigma tools. To add clarity these tools are reviewed in two separate sections: 1) Lean tools 2) Six Sigma tools. However, it is good to keep in mind that some of these tools can be applied for both Lean and Six Sigma initiatives. To name a couple examples such tools are quality function deployment (QFD) and SIPOC). To limit the number of tools reviewed in this paper multiple Lean and Six Sigma tools (such as pareto chart, root cause analysis (fishbone) and critical to quality tree) have been deliberately excluded from a more detailed review.

2.3.1 Lean tools

Value stream map (VSM): is perhaps viewed as the most commonly implemented Lean tool and it's seen as the primary "go to" analysis in Lean endeavours (Machado & Leitner, 2010, p. 385). Even though the tool originates from operational manufacturing development, it can also be applied for more knowledge intense activities and operations (knowledge-based work). VSM acts as a process chart for product/service/customer flows, which also indicates key information such as non-value adding activities, bottlenecks, lead times etc. The "beauty" in VSM lies within in its ability to not only acts as a representation of the current situation, but it may also be used to map the "ideal situation" to strive for. VSM also enables management and staff to visualise the process as a whole and thus grasp a better understanding of "connecting the dots" and reaching a better understanding of how activities are linked to each other, and their effects towards each other and the overall process. (Machado & Leitner, 2010, p. 385-386)

As depicted in figure 5, VSM can provide a rather holistic view of the current and if required the future (desired) states of the process. In the simplified example below it is clearly illustrated that by eliminating non-value adding phases, the overall process lead-time of this insurance claim process could be reduced from 28 days down to 8h 20min.

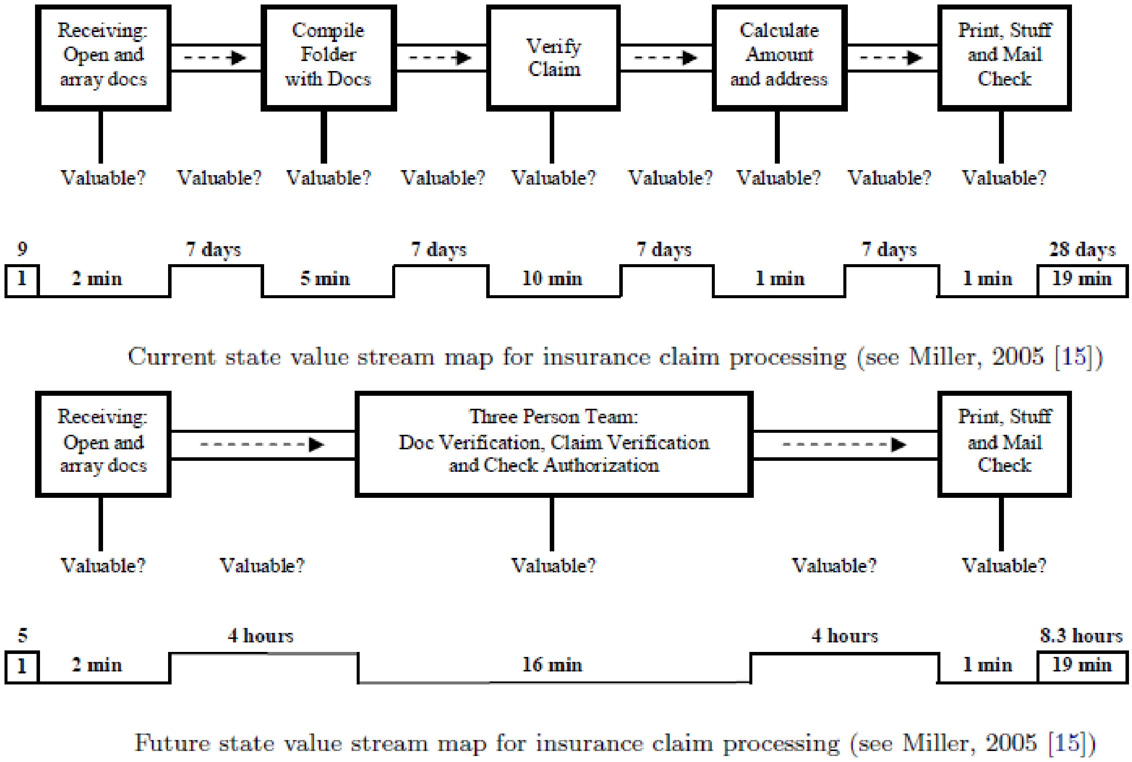

Figure 5. Current state VSM and future state VSM for insurance claim processing by Miller, 2005 (Machado & Leitner, 2010, p. 387)

Hines & Rich (1997, p. 51 – 58) showcase that value stream mapping contains a wide variety of different mapping tools targeted to tackle the “seven wastes” identified in TPS. Below listed are the seven mapping tools presented by the two authors. Brackets indicate the waste/structure that they are useful for.

- *Process activity mapping* (waiting, transport, inappropriate processing, unnecessary inventory, unnecessary motion)
- *Supply chain response matrix* (overproduction, waiting, unnecessary inventory)
- *Production variety funnel* (inappropriate processing, unnecessary inventory, overall structure)
- *Quality filter mapping* (defects)
- *Demand amplification mapping* (over production, waiting, unnecessary inventory, overall structure)

- *Decision point analysis* (over production, waiting, unnecessary inventory, overall structure)
- *Physical structure a) volume b) value* (overall structure). (Hines & Rich, 1997, p. 50)

5S: is a tool/method for workspace organising, which consists of five Japanese words that translate to sort, straighten, scrub, standardise and sustain. 5S aims to enhance/ensure smooth workflows by organising the workplace is well organised and maintained in optimum order.

Sort: means that the necessity of tools and equipment are evaluated, and unnecessary items are removed so that they don't slow things down or get in the way. As examples, one would not want unnecessary objects lying around in a busy warehouse or hospital operating room. In order to remove all excess, only items that are seen as necessary are retained. However, one must not get too carried away so that necessary items end up being removed. (Machado & Leitner, 2010, p. 387)

Straighten: means that tools/equipment are placed so that they are in a logical order and can be accessed with little effort. This means that items that are in constant use should be able to access with little if no effort whilst rarely used items may be slightly less convenient to reach. This also contains clear guidance/labelling for where to find something. As an example, a large warehouse or hospital can be difficult to navigate. See-through cabinets and open shelves ease the task of finding what's needed. This "S" is also seen to link to several lean concepts such is "Jidoka" and "JIT". Jidoka meaning that defects are handled at first sight and JIT referring to the widely known "just-in-time" delivery, which reduces excess inventory, and ensures sufficient flows whilst minimising costs. (Machado & Leitner, 2010, p. 387)

Scrub: As one may guess this "S" guides to have a clean work environment. Sufficient cleanliness and lighting not only make work more comfortable, but it also increases efficiency and quality whilst also promoting safety. (Machado & Leitner, 2010, p. 388)

Standardise: focuses on turning the earlier steps into best practices in order to formalise the quality and efficiency gains from the first three steps. Communication and knowledge share play a key role in the efficient rollout of standardised processes throughout the company and reaching everyone whom they concern. (Machado & Leitner, 2010, p. 388)

Sustain: requires the most perseverance out of the "5S" steps as it is the only one that cannot be completed in a relatively brief period. Once best practices and/or improvements have been identified, it can be surprisingly challenging to maintain them in the long run. One may think that completing the four preceding steps is enough, however what really makes the difference and makes the 5S "count" is the enforcing the disciplined practice in the long run. Slipping away from it may lead to process deficiencies and varying quality as sustaining the desired level work should also be lived by management as it is something that needs to be embedded in the work culture in order to thrive with the 5S principles. (Machado & Leitner, 2010, p. 388)

PDCA/PDSA: The PDCA (plan, do, check, act) / PDSA (plan, do, study, act) cycle is a continuous improvement promoting tool for creating and sustaining future best practices. This four-step tool can be applied for example in larger scale processes such as project implementation and/or during smaller process improvements such as a workstation Kaizen.

- *Plan:* contains the planning of the process / change / improvement that is to be implemented. As an example, one may have identified an opportunity for a Kaizen and plans how it can be implemented.
- *Do:* phase is the implementation of the plan from phase one.
- *Check / Study:* In this stage, the plan that has been generated and executed in the two previous stages is reviewed. Did the desired improvements materialise? Is there still room for further improvement? are the type of questions that should be answered in this stage as this stage is also a type of a "sanity check" that the improvement is an improvement and that it is feasible to implement. Depending on the obtained results one may revisit stage one and two or proceed to the fourth and final step.
- *Act:* in this last stage the enhanced process is implemented on a wide scale and introduced as the new best practice for the improved task. In case sometime later a new improvement idea or opportunity arises, the PDCA/PDSA process is revisited. (Machado & Leitner, 2010, p. 390)

5 Whys: is essentially a root cause analysis tool, which can be utilised to gain a thorough understanding of the roots/causes to a particular problem. By identifying the root cause, the actual task of fixing the problem becomes far easier and precise. The basic concept of this tool is rather simple yet effective, the question why is applied towards a problem until the key reason for it (root cause) arises. This process has multiple levels of reasons to the problem, slightly resembling the way roots for a tree (the problem) are formed. The number five does not indicate that this is the exact and always correct number of "whys" to ask. Sometimes it may be sometimes it will not be. What is essential though is that not too few or many "whys" are asked, as the tool needs to be applied "beneath the surface", however one shouldn't go too far "down" to end up asking why for consequences that are less meaningful and beyond the root cause. (Machado & Leitner, 2010, p. 390)

2.3.2 Six Sigma tools

As stated in the beginning of this section both Six Sigma and Lean provide a wide variety of useful tools to improve efficiency and quality and reducing non valuable activities (waste). Even though the intention of this section isn't to cover all these tools it's still good to comprehend the extensiveness of tools that these management philosophies provide. Figure 6 is used to illustrate different Six Sigma tools and how they correlate with the DMAIC variables.

	D	M	A	I	C		D	M	A	I	C
Affinity diagram	♦		♦			Pareto chart		♦	♦	♦	
Brainstorming	♦		♦	♦		Planning tools (Gantt charts)				♦	
Business case	♦					Prioritisation matrix		♦		♦	
Cause-and-effect diagram			♦			Process capability		♦		♦	
Charter	♦					Process Sigma		♦		♦	
Consensus				♦		Quality control process chart					♦
Control charts		♦	♦	♦	♦	Regression			♦		
CTQ (critical-to-quality) tree	♦					Rolled throughout yield	♦				
Data collection formats		♦	♦	♦	♦	Sampling		♦	♦	♦	♦
Data collection plans		♦	♦	♦	♦	Scatter plots			♦		
DOE (design of experiments)			♦	♦		SIPOC diagram	♦				
Flow diagrams	♦	♦	♦	♦	♦	Stakeholder analysis	♦			♦	
Histogram/frequency plots		♦	♦	♦	♦	Standardisation					♦
FMEA		♦		♦		Stratification		♦	♦	♦	♦
Gage repeatability & reproduceability		♦				Stratified frequency plots			♦		
Hypothesis test			♦			Time series plots (run charts)		♦			
Kano model		♦				VOC (voice of the customer)	♦				

Figure 6. Six Sigma tools and their relationship with DMAIC (Knowles et al. 2005, p. 57).

SIPOC: diagram (Supplier, Input, Process, Output & Customer) is used to identify relevant elements in SCI projects before they are rolled out. The key in executing a SIPOC is to include the correct people who have a thorough understanding of the process. Thus, it may be more beneficial to include operative level employees rather than executives and/or managers. The *supplier* is an internal or external participant who supplies one or several inputs to complete a process. *Inputs* can take the forms of materials, services, documents etc. which are necessary for the process to be completed. *Process* is a multiple step chain of progress and usually has around 6-8 steps. Process is the chain of steps that mould the inputs into outputs. *Outputs* take similar forms as inputs (materials, services, documents etc.) and they are what "come out" as the finished products/services of processes. *Customers* can be external and/or internal. They are identified as the recipient of the output/s. Designing a SIPOC is of use in scenarios where for example its isn't entirely clear what are the customers' requirements and who receive the outputs, who provide the inputs and what are the exact process steps to transform outputs into inputs. SIPOC diagrams can be used to generate process maps that provide value in the form of a high-level status of the "big picture", which displays potential areas of improvement. SIPOC adds value in its flexible, intuitive, and visual way of showcasing relationships and dependencies between different stakeholders. (Brown, 2018, p. 205-209)

Failure Mode and Effects Analysis (FMEA): is a tool for identifying potential and existing failures / defects, prioritising these failures, and taking action to reduce or perhaps even eliminate them (Kubiak, 2014, p. 42). FMEA helps to identify failures in a quantitative fashion and prioritise them according to certainty (likelihood to happen), severity (impact) and the effort (difficulty) it takes to address them. It is a commonly used tool in Six Sigma projects as not only does it work as a reactive tool, but most importantly it can be applied as a preventive action. According to Kubiak (2014, p. 42-43) Six Sigma FMEAs can generally be divided into two different categories: 1. Design FMEAs, which are used to identify risk that apply to specific hardware design and 2. Process FMEAs focusing on process related risk analysis. FMEAs are commonly created in a spreadsheet format quantifying scores based on severity, frequency of occurrence and detection probability for various scenarios and their consequences. Risk priority number (RPN) is calculated by multiplying scores for severity, occurrence, and detection. The higher the RPN score is the greater of a threat it is to process quality. Therefore, this tool indicates what failures or risk should be dealt first, to obtain the most significant improvements. This previously mentioned logic of prioritisation shares some features with the “80:20” rule of the pareto analysis.

Design of Experiment (DOE): is one of the most efficient yet complicated methods to improve quality in Six Sigma endeavours. DOE aims to find cause and effect relationships between different factors and their parameters (Allen, 2006, p. 241-242). Optimum parameters can then be established to improve the output that the factors generate. DOE can be thought to consist of three key elements 1) factors 2) levels 3) response.

- *Factors:* are the input parameters, which depending on the experiment may or may not be adjustable/controlled. In DOE, factors that have the greatest impact on the process output (product/service) should be selected as the ones to focus on.
- *Levels:* refers to how much the different process factors are adjusted during the experiment. These levels define the amount of runs that are necessary to carry out the experiment.
- *Response:* indicates the experiments effect on the DOE output, which is created via the adjustment of variables. Factorial design can be used to simultaneously analyse the effect and response of multiple variables at the time.

Quality Function Deployment (QFD): is a tool for adapting customer requirements into a process, product or service (Yang et al. 2007, p. 90). This is achieved by turning customer want/needs into a specified plan, which aims to meet these requirements. A QFD sets a X axis to indicate the areas of value for the customers/process and a Y axis how these areas of value are covered by the business. The matrix is then multiplied to define importance of the “What’s” (x- axis) in the process and critical to quality (CTQ) priorities of the “How’s” (y-axis). QFD is a tool, which helps to identify what are the most critical factors to customers/the process and what elements contribute to these factors. To sum up the quality function deployment is a tool for quantifying customer/process requirements and critical to quality process steps. Applying it helps companies to improve work and produce better outcomes. QFD is a tool to help organisations achieve optimum satisfaction of customers (internal and/or external) and/or stakeholders (Radej et al. 2017, p. 394).

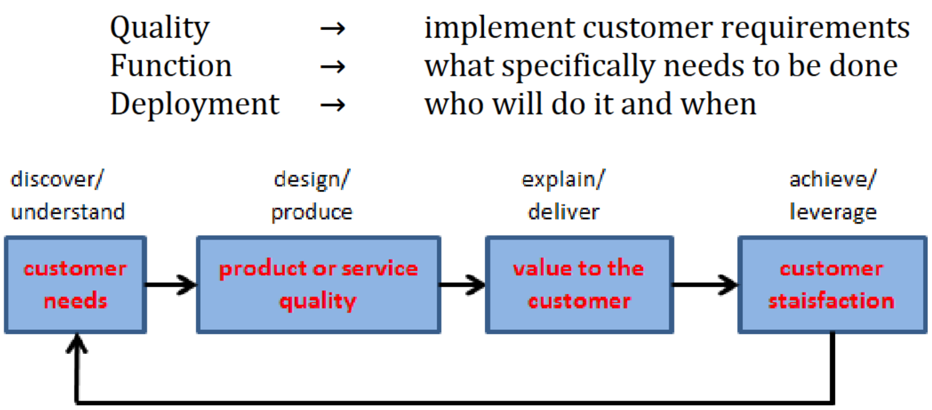

Figure 7. Process display of the QFD method (Radej et al. 2017, p. 395)

Voice of Process (VoP): Customer feedback is considered by many a highly valuable if not critical element for a successful business. Afterall if not for the customer there would be no business and therefore understanding customer opinions and requirements is paramount. The voice of customer can be understood through VoC (voice of customer), which can be conducted in the form of questionnaires, interviews, feedback forms e.g. (Aguwa et al. 2017, p.137-139). The same can also be done for a process, where the voice of process (VoP) is heard from the process participants. VoP is a tool for adapting customer/process requirements into a process, product, or service.

QFD is commonly implemented together with VoP as they both aim to ensure value to the customer. QFD can be utilised to prioritise requirements that have been found from VoC and/or VoP (voice of customer/process). The tool brings deeper insight and understanding to the underlying issues and customer needs. (Mazur, 2015, p. 24-25)

2.3.3 Summary on Lean & Six Sigma

As discussed in this chapter Lean and Six Sigma are both comprehensive and versatile methodologies for process improvement. Even though both originate from production/manufacturing they can successfully be applied into various activities as for example in SCI. Despite of some similarities Lean and Six Sigma do differ. Out of the two Lean is a less project-based methodology and rather advocates overall continuous improvement being embedded into corporate culture from the “ground floor” to the “C-suite”. Six Sigma is on the other hand more processes orientated with dedicated Six Sigma specialist who carry the improvement projects. Lean tends to have both qualitative and quantitative aspects, while Six Sigma leans more on quantified information.

Adopting Lean and/or Six Sigma into company culture requires long-term commitment and investing resources towards it, however by doing so a company/organisation can significantly improve its operations leading to greater efficiency, improved profitability, better customer service and improve the competitiveness of the company. As a great example Toyota has turned learning through lean thinking into a sustainable competitive advantage that competition hasn’t been able to fully mimic despite of several attempts, making it arguably one of the most powerful players in the highly competitive and consolidated global automotive industry.

2.4 Automotive supply chain improvement

The automotive industry has received its fair share of academic/research focus when it comes to SCI. To name a couple of reasons for this, one rather obvious reason is that many SCI practices originate from the industry, second is the complexity and vastness of automotive SC`s which require careful yet determined orchestration to perform and third being the significance and importance of the industry to the societies we live in globally.

When the author of this paper searched Scopus for articles and conference papers with the search term *"Supply Chain" AND "Improv*" AND "Automo*"* he got the following results:

- 1, 161 document results. It can be determined that the subject area is widely studied.
- Time range of publications 1988 – present. The number of publications per year has had quite a linear growing trajectory peaking so far in 2021 with 99 publications. The subject area became popular approximately 2005 when the number of publications broke 30 per year.

- Most significant subject areas being engineering (27.1%), business (19.5%) computer science (14.8%) and decision sciences (11.3%).

When he added the phrase “Downstream” to the search term ("Supply Chain" AND "Improv*" AND "Automo*" AND "Downstream" the number of results dropped to 26 publications limiting the time range of publications to 2004 – present.

Duarte & Machado (2016, p. 82-83) discovered in their multi-case study research on the assessment of lean and green implementation in automotive supply chains, that companies operating in the automotive industry have high a high rate of lean implementation according to their assessment (scoring) framework, which was applied in their research. The following part of this section will introduce some of the prior academic research on automotive industry SCI with Lean and Six Sigma tools.

El Kihel et al. (2019, p. 1) state that there is a lack of downstream SCI in the automotive industry:

“The automotive industry in general is characterized by a diversity of products and equipment manufacturers who are dedicated to a production mainly for export to several destinations. This sector still lacks downstream logistics competitiveness with a low quality/price ratio of transport. For these companies to remain competitive in a competitive world, improving downstream chain processes is essential.”

Supporting the scarcity of automotive downstream SC improvement, both Cirita & Glaser Segura (2012, p. 299) and Narayanamurthy & Gurumurthy (2015, p. 189) state the field of downstream SC improvement to be understudied in general. To contribute to the topic of automotive downstream SC improvement El Kihel et al. utilised value stream mapping to identify waste and/ or non-value adding activities in an automotive equipment manufacturing company specialised in automotive electrical wiring. Their research provided both a current state and a future case VSM illustrated in figure 8 (El Kihel et al. 2019, p. 1-6). As a result of their proposed future state scenario, the cycle time could be reduced by almost 20%, which would decrease delivery time form 10 days down to seven via steps such as utilisation of 5s, task specialisation, reorganising of SC processes and reducing unnecessary and/or empty road transportation (El Kihel et al. 2019, p. 6).

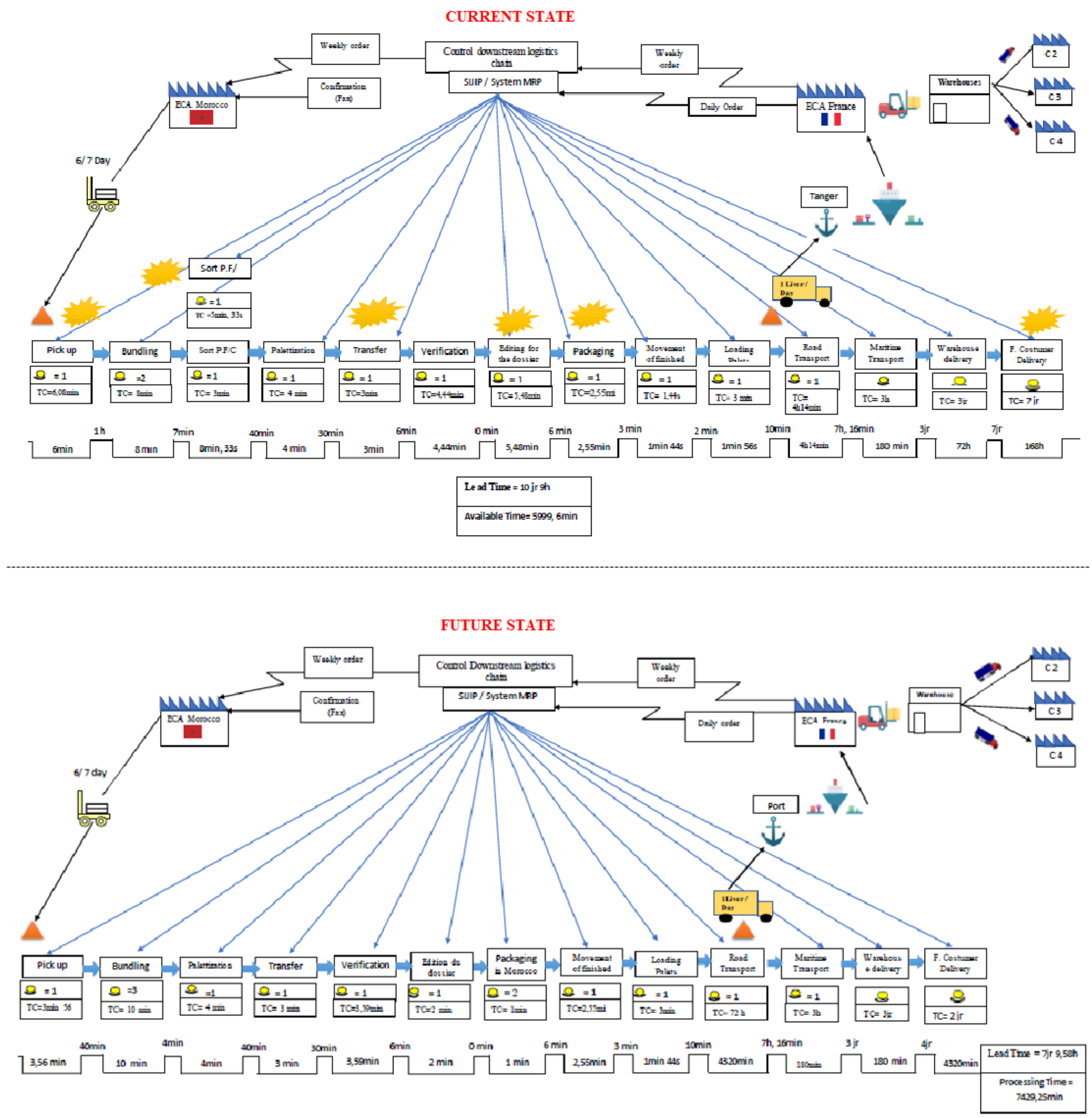

Figure 8. Current and future state VSM by Kihel et al. (2019, p. 5).

Saraswat et al. (2015, p. 27-35) also conducted a similar type of VSM process improvement via current state and future mapping in the SC of an automotive bearing manufacturer from an inventory and process lead time perspective reducing process lead time from 7.3 days to 3.8 days. Vinodh et al. (2012, p. 380-399) present a similar VSM and Lean based SCI case in an Indian automotive components manufacturer.

Inţă et al. (2020, p. 1-8) present an automotive SCI case of a Romanian automotive supplier, with a Six Sigma approach. The supplier manufacturers electrical wiring to various automotive companies including OEM`s such as Audi, BMW, Hyundai, Kia, Volvo and

Volkswagen. As an outcome of the improvement ideas, they proposed delays in supply were reduced by 15%. This improvement was achieved via the utilisation of DMAIC, root cause analysis (hybrid of 5whys and fishbone) and pareto analysis. Pareto analysis being a primarily Six Sigma tool based on the concept that approximately 80% of delays/defects e.g., are generated by 20% of activities/processes e.g. Therefore, according to the principal, most issues can be alleviated by focusing on the strictly scoped key issues. The concept of Pareto Analysis is also referred as the 80:20 rule.

2.5 Downstream supply chain

A supply chain (SC) can be defined as a chain of linkages which ties together multiple companies/operators that act and contribute to the various stages in the process of providing a product to the market from the very beginning of raw material sourcing to the very end in which the product is delivered to the customer for use/consumption.

Mentzer et al. (2001, p. 3) provide multiple similar definitions for SC from prior literature, one of them being the following:

"…a supply chain is the network of organizations that are involved, through upstream and downstream linkages, in the different processes and activities that produce value in the form of products and services delivered to the ultimate consumer (Christopher 1992). In other words, a supply chain consists of multiple firms, both upstream (i.e., supply) and downstream (i.e., distribution), and the ultimate consumer."

Supply Chain Management (SCM) in existing academic literature can be seen to have three different classifications that are: 1. a management philosophy, 2. the implementation of a management philosophy and 3. a set of management processes (Metzer et al. 2001, p. 5-11). After a comprehensive dive into SCM literature Mentzer et al. sum up SCM as follows:

"…the systemic, strategic coordination of the traditional business functions and the tactics across these business functions within a particular company and across businesses within the supply chain, for the purposes of improving the long-term performance of the individual companies and the supply chain as a whole."

A core part of SCM is to integrate planning, forecasting and executions of activities within the supply chain to create value to the customer. Today it can also be seen evolve from the prior mentioned towards seamless end to end data management enabled by the availability of extensive real time visibility. (Min et al. 2019, p. 49-50)

A SC can be thought to be like a stream flowing with water, but instead of water the stream flows with products and services. Whether or not one SC participant does or doesn't recognise the strategic and systemic importance of managing the flow, the flow remains as is. It is only once the philosophy of active joint management and/or improvement amongst multiple entities in the SC is agreed and acted upon can SCM be seen to take place. (Mentzer et al. 2001, p. 14-15)

The SC can be defined to be divided into three sections: upstream, midstream, and downstream (Lima et al. 2016, p. 79). Upstream SC consisting of the "upstream activities" sourcing and manufacturing raw material, components, parts all the way to the first-tier suppliers. Upstream operators being commonly the multiple tiers of suppliers from the furthest tier to the first tier. Midstream consisting of manufacturing the end product. Downstream SC containing the distribution, warehousing, retailing and consumption of the product/service. Downstream operators being commonly logistics service providers, wholesalers, warehouses, retailers, and the customer. An illustration of the of downstream and upstream SC by Raja Santhi & Muthuswamy (2022, p. 4) is displayed in figure 9.

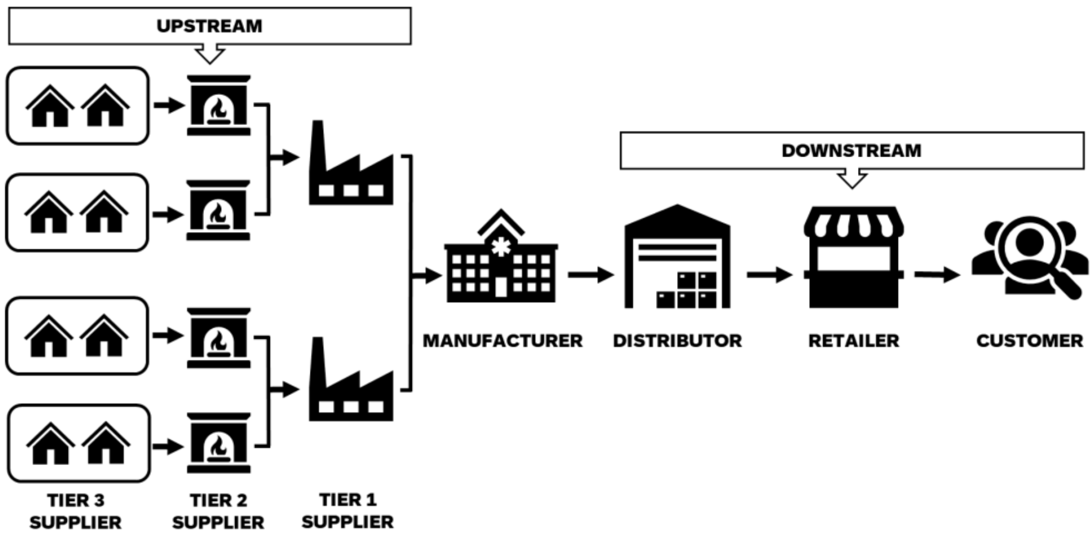

Figure 9. Upstream and downstream SC (Raja Santhi & Muthuswamy, 2022, p. 4).

SC risks/challenges can be divided into two different categories: high-frequency low-impact and low-frequency high-impact. Throughout a supply chain, fluctuations in lead-times, demand fulfilment and delivery can be seen as high probability low impact, whilst major global and regional disruptions such as pandemics, wars, natural disasters etc. are categorised as low frequency, but high impact. (Raja Santhi & Muthuswamy, 2022, p. 3-5)

Research of Shih et al. (2011, p. 78-70) highlights the importance of knowledge sharing in downstream supply chains (DSC) and their research indicates that a company that is looking to improve its SC performance should focus on knowledge sharing and the quality of it, instead of focusing solely on saving costs. The case study results of McLaughlin et al. (2003, p. 76-79) concluded that IT integrations that connect systems of different SC stages can be used to improve downstream SC performance. Groson & Donohue`s (2005, p. 258-259) research conducted via virtual game simulation with human participants, indicates that the sharing of downstream SC information (specifically inventory) has a more significant impact in mitigating the forester effect (small fluctuation of demand in the downstream SC causing large fluctuation in the upstream SC) than the sharing of upstream information, highlighting the importance of information sharing and quality in SC performance.

2.7 Summary of literature

As discussed in chapter two Lean and Six Sigma are both comprehensive and versatile methodologies for process improvement. Even though these methodologies originate from manufacturing/production they can be applied into various type of processes such as other activities in supply chains beside manufacturing. It is useful to remember that these methodologies can also be applied to processes of other business units and not solely SC related processes. Despite of some similarities Lean and Six Sigma do differ. Lean being a less project-based metrology and rather advocates overall continuous improvement that is embedded into company culture from the "ground floor" up to the "C-suite". However, both methods can be applied in project-based improvement endeavours. Lean is the primary process improvement methodology associated with the automotive industry due to originating from it. Therefore, it is also logical that it has been primarily applied in prior Automotive SCI related academic research. Six Sigma on the other hand is more process orientated with Six Sigma specialist leading the improvement projects. Lean tends to have both qualitative and quantitative aspects, whilst Six Sigma focuses on quantified information. Adopting Lean and/or Six Sigma into company culture requires long-term commitment and resources, however by doing so an organisation can significantly improve its processes leading to greater efficiency, improved profitability, better customer service and improves its overall operations and competitiveness. Motorola and especially Toyota being two great examples of how process improvement thinking has turned into sustainable competitive advantages that competitors haven't been able to fully mimic despite of many attempts. Lean and Six Sigma have been significant contributors in these companies becoming powerful players in highly competitive and consolidated global industries. Concerning downstream supply chains, information sharing in the DSC and the quality of shared information impacts overall SC performance. As mentioned by prior studies, research on DSC specific SCI is scarce. And even though some does exist more is welcomed. Thus, this thesis will contribute to the area of research through the presented Finnish automotive industry case.

3. Data collection and methodology

Chapter three discusses data collection and research methodology for this thesis. For this case study the author planned and implemented a seven-step research process illustrated in figure 10, which is inspired by the five-step research process model of Stuart et al. (2002, p. 420). Development of his plan was also inspired by the writings of Yin (2003, p. 5-54), highlighting the significance of a well-planned research in terms of conducting a good case study. The research began with identification of the research problem both with and without the case company. Once the research problem and research question and sub-questions had been formulated the author proceeded to conduct the literature review. After the initial literature review the section was enhanced at later stages of the writing process. Collection of empirical data and the empirical analysis were both completed at two separate stages. Steps 3A and 4A consisting of VSM and 5 whys and once they had been completed steps 3B and 4B (VoP and QFD) were initiated. Lastly the results were discussed and concluded. Some of the research plan steps had overlap with each other due to the nature of progress of this research.

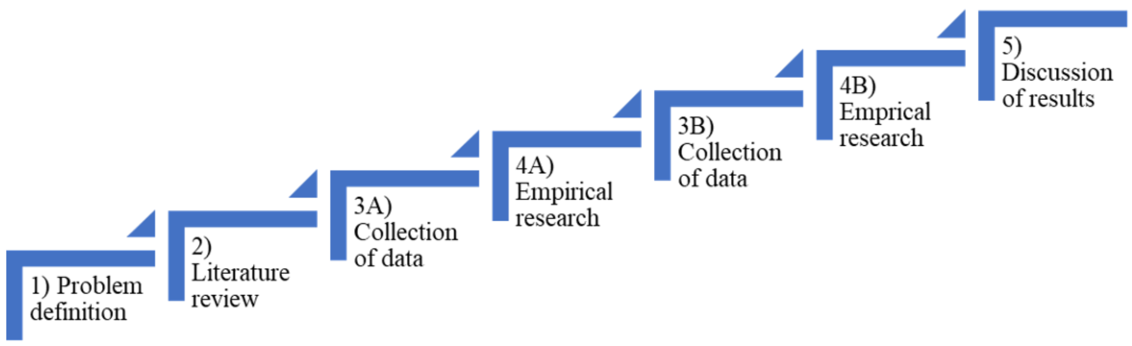

Figure 10. Steps of research modified from Stuart et al. (2002, p. 420)

As discussed in chapter one, this master's thesis is a holistic single case study that is primarily qualitative of nature, however a portion of it has quantitative elements. The empirical research is divided into two parts, first of which is fully qualitative and the second part both qualitative and quantitative. The upcoming sections of this chapter present the data collection and analysis methods used for the two sections of empirical research:

- Value stream mapping (VSM) and 5 whys
- Voice of process (VoP) and quality function deployment (QFD)

Empirical research begun with a kick-off meeting with key staff members of the case company. The meeting took place in February 2023 and included the following persons: General Manager (Sales channels and network operations), Senior Manager (Network Performance), Senior Manager (Distribution, product & accessories), Distribution Manager, three Area Sales Managers and the researcher.

3.1 VSM and 5 whys data collection

Following the empirical research kick-off meeting the author began to collect information for value stream mapping via a series of separate smaller meetings. Eventually the data collected for VSM was utilised also for 5 whys analysis to find focus points for more in depth research. A total of five pre-mapping meetings were arranged to cover in detail all the phases included in the VSM. The meetings were collaborative of nature in which, the author requested to provide key information on these different phases. The key information being primarily activities and how long the activities take time. In the very first meeting it was also defined based on order management system (OMS) data how long the average lead time is for this specified part of the downstream supply chain.

Table 3: Stages of VSM data gathering

Event	VSM premapping (Session 1)	VSM premapping (Session 2)	VSM premapping (Session 3)	VSM premapping (Session 4)	VSM premapping (Session 5)	VSM Mapping (Workshop)	VSM (Order system specifications)
Date	6.3.2023	6.3.2023	14.3.2023	16.3.2023	3.4.2023	3.4.2023	08.05.2023
Time	30min	30min	30min	30min	30min	90min	45min
Type	Face to Face	Teams	Teams	Teams	Face to Face	Face to Face	Face to face
Methodology	Group work (Whiteboard + post-it notes)	Group work (Excel speadsheet)	Group work (Excel speadsheet)	Group work (Excel speadsheet)	Group work (Whiteboard + post-it notes)	Group work (Whiteboard + post-it notes, excel and recording)	Group work (Excel speadsheet)
Participant 1	Manager (Distribution)	Area Sales Manager	Manager (Distribution)	Manager (Distribution)	Manager (Distribution)	Area Sales Manager	Manager (Distribution)
Participant 2	Senior Manager (Distribution, Product & Accesories)	Area Sales Manager	Researcher	Researcher	Researcher	Area Sales Manager	Senior Specialist (Order System)
Participant 3	Researcher	Researcher	N/A	N/A	N/A	Area Sales Manager	Researcher
Participant 4	N/A	N/A	N/A	N/A	N/A	General Manager (Sales & Network Operations)	N/A
Participant 5	N/A	N/A	N/A	N/A	N/A	Manager (Distribution)	N/A
Participant 6	N/A	N/A	N/A	N/A	N/A	Senior Manager (Network Performance & Operations)	N/A
Participant 7	N/A	N/A	N/A	N/A	N/A	Senior Manager (Distribution, Product & Accesories)	N/A
Participant 8	N/A	N/A	N/A	N/A	N/A	Researcher	N/A

Table 3 describes the separate stages of data collection for VSM. All the meetings and workshop were carried out in Finnish.

3.1.1 VSM workshop

A VSM workshop was conducted and facilitated by the author on the 3rd of April 2023 being the main phase for VSM data collection and validation. The workshop was conducted as a face-to-face meeting with key subject matter experts who were also part of the empirical research kick-of meeting. Discussion in the workshop was audio recorded, and a verbatim transcription was formed by the author.

Agenda for the workshop was the following:

- Overview of draft value stream map on the case company`s downstream supply chain
- Step by step discussion of the VSM and the different phases and actions in the case company’s downstream supply chain
- Validation of draft VSM – accuracy and validity
- Open discussion and recommendations for amendments and add-inns.

As sufficient time had been spent on the pre-mapping there were rather few alterations required for the VSM draft. The step-by-step discussion proved out to be rather fruitful as not only did it provide deeper discussion on the process and its activities, but it also provided information on what areas could be beneficial to further investigate in the second part of the empirical research. For further consideration the focus group workshop suggested that the VSM would benefit of including the delivery status that the OMS provides for each of the five phases. As a result of this the researcher arranged an additional meeting with Senior System Specialist and Distribution Manager who were the appropriate experts on the order management system used by the company and its authorised dealers.

3.1.2 System flow meeting and field visits

Due to the recommendation of adding requested order management system data to the VSM, the researcher arranged an additional meeting with Senior System Specialist and Distribution Manager who were the appropriate experts on the ordering system used both by the case company and its authorised dealers. This meeting focused on adding the following information into the VSM; how much time the order management system estimates each phase to take time and what information does the OMS provide for each phase when the vehicles proceed in the supply chain. This meeting also contained high level discussion on how information flows from one operator to another.

In addition to the pre-mapping meetings, workshop and system flow meeting, the author also conducted two field visits to obtain further insight and understanding of the mapped downstream supply chain of the case company. Both field visits took place in June 2023. The first visit was to logistics HUB 1 and the second to an authorised dealer.

3.2 VoP and QFD data collection

A total of six authorised dealers were invited to take part in the VoP interviews via a formal invitation sent on the 19th of May 2023. The acceptance rate ended up being 100% as all six agreed to participate and took part. The selection process considered several factors. First of the factors being the geographical location, where the dealers were selected so that they cover most of the different Finnish geographical regions. Second factor being the size of the dealership and therefore the group contained large, medium, and small dealers. The third factor was that the sample should represent different retailers meaning that all six dealers represented different dealer groups. Some of the dealers were part of larger dealer groups whilst others were part of smaller groups. The sample size of six dealers was determined (by the author and case company) to provide an insightful and sufficiently reliable dataset while simultaneously limiting enough the data collection process considering that the data was collected by the author for this project/thesis.

Table 4 presents a list of the sample group and job titles of the interviewees representing the authorised dealers. A total of 11 people were interviewed so that 5/6 interviews had two respondents and 1/6 one respondent.

Table 4: VoP interview sample group

Authorised dealer	Size	Interviewees
Authorised dealer A)	Large	Aftersales Director Sales Director
Authorised dealer B)	Medium	CEO N/A
Authorised dealer C)	Small	CEO Aftersales Manager
Authorised dealer D)	Medium	Aftersales Director Sales Director
Authorised dealer E)	Large	Sales Director Workshop Manager
Authorised dealer F)	Large	Sales Manager Service Manager

The interviews were conducted between the 7th of June – 21st of June 2023 in the Finnish language. Audio recordings were taken from all interviews which were transcribed verbatim. Direct citations have been translated to the authors best capability. The interviews were booked as individual 60min slots for each dealer and ended up taking between 50 – 65 min. The interviews were conducted as semi-structured interviews so that the author had formulated 10 predefined questions and further questions were asked by the author based on the answers provided in the interviews. In the beginning of each interview the author briefly showcased a summarised version of the VSM constructed for the case company. Table 5 illustrates the 10 predefined questions which worked as the framework for the interviews. These predefined questions were provided to the interviewees on the 4th of June so that they had the opportunity to view and give some thought to them beforehand.

Table 5: Predefined VoP interview questions

#	Predefined interview questions
1	What factors affect dealer lead times?
2	What makes this process time consuming?
3	What can cause the process to go off track?
4	What aspects of this process/tasks are wasteful?
5	What causes a vehicle that is ready for handover to wait for a substantial time, before actual handover to the customer?
6	Do you take into account the order system ETA in your delaerships planning/processes? (If not, why not?)
7	How close to the order system ETA do you book/plan preparation and accessory installation times for arriving vehicles?
8	What kind of actions does it require from dealers to speed up vehicle lead time? (For example; at the end of certain sales target thresholds when the pace is temporaily improved.)
9	What are the most critical factors affecting dealer lead times?
10	How could dealers be supported/helped to achieve faster customer deliveries?

Eventually the analysed interview data was utilised by the author to form a quality function deployment (QFD) matrix.

3.2.1 Voice of process interviews

As the transcribed VoP interview data was quite vast, adding up to 132 pages (22+23+ 28+19+17+23), it soon became clear that such a large amount of data requires an appropriate form of coding in order capture the essence of the qualitative data and discover underlying patterns and themes (Lee & Lings, 2008, p. 243-246).

The author decided to utilise a form or grounded theory thematic analysis for the VoP interview data. This means that coding was started with no predetermined themes, but rather with a “blank canvas” approach. Themes were constructed when going through the data set and when useful, individual codes were assigned. The goal of thematic analysis being to identify and describing patterns via text in the data (Ozuem et al. 2021, p. 144-146).

The authors steps in the analysis were to first code the data and then manually colour highlighting identified themes and individual codes. Afterwards all six data sets were analysed one at a time. After the analysis the data and its findings were utilised by the author to form the QFD matrix.

4. Empirical case study analysis

Chapter four presents the analysis and findings of the empirical research conducted for this master's thesis. As described in the prior chapters of this paper, the empirical research is conducted in two separate phases. The goal of the first part (VSM & 5 whys) is to map out the case company's downstream supply chain in scope and identify relevant areas for more detailed analysis. The second part (VoP & QFD) aims to identify points for future improvement/considerations and prioritise them via quantification. The first section presents the value stream map, the second section enlightens the rationale behind chosen area for further investigation via 5 whys, the third section presents the voice of a selected group of authorised dealers and lastly section four quantifies the voice of the process (dealers) through quality function deployment.

4.1 Value stream mapping

In the beginning of the VSM mapping process it was established that the DSC in scope has five different stages/operators. First of them being HUB1, which is the initial logistics HUB for several markets, it also acts as the point of warehousing any excess stock for these markets. HUB1 is located outside of Finland in country X. The second stage is the vessel that transports the vehicles via sea from HUB1 to Finland. The Vessel carries the vehicles to HUB2 located on the coast of Finland. HUB2 is the third stage and point of importation, where eventually the cars are picked up for road transport. The fourth stage is the road freight, which is carried via trucks. Finally, the fifth stage are the authorised dealers across Finland who have sold the car to the customer and handover it to him/her. HUB1 is part of the same corporation as the case company. The vessel/s, HUB 2 and the road freight company work as contractors and have frequent interaction with the case company and are of strategic importance. The authorised dealers being individual retailers (companies) who are in a key role as they serve the customers and represent the case company (car brands) to the customers and form the national dealer network. Figure 11 present the current state VSM of the case company's downstream supply chain in scope.

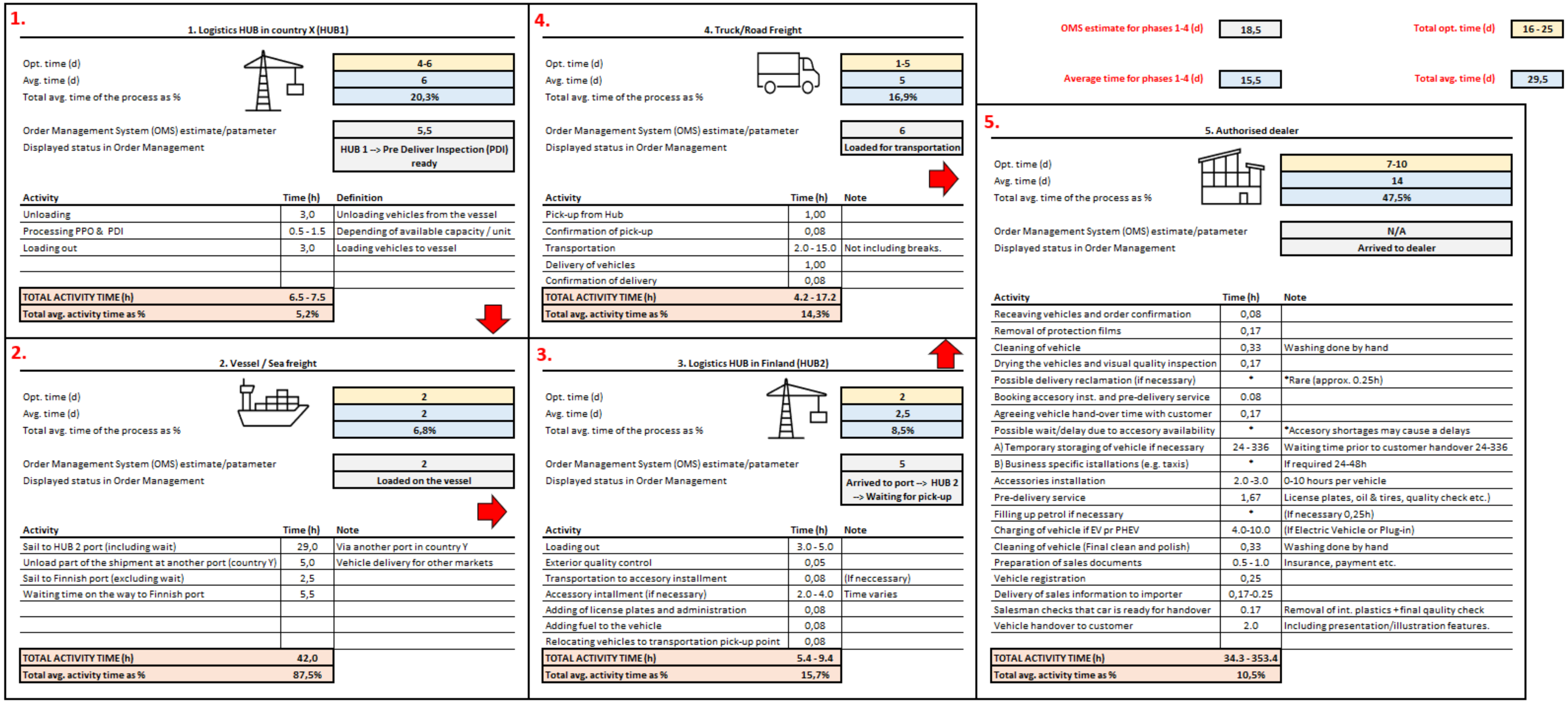

Figure 11. VSM of the downstream SC in scope

Based on the gathered data (mostly historic data from the previous year) the total average lead time for passenger cars to go through the downstream SC in scope is 29.5 days. Days are calculated as total days and aren't limited to workdays, as the amount of them per week can vary among the five different stages. It is significant to highlight that this process lead time represents cars that have an existing customer order and doesn't take into account warehousing time for potential free stock vehicles. In optimum conditions it is currently possible for a passenger car to make its way from HUB1 to the customer between 16-25 days, meaning that there is a minimum 4.5-day gap between the optimal average lead time and current average lead time. The order management system estimates the fixed lead time for passenger cars to move from HUB 1 to the retailer to be 18.5 days. The average total time for cars to go through the first four stages is 15.5 days meaning that the order management system provides a slightly pessimistic estimate that is three (3) days longer than the real average.

The total average time a passenger car spends in HUB1 is six (6) days, which is 20.3% of the overall process lead time. Shipments arrive commonly twice a week (Mondays and Wednesdays) as these two shipments carry vehicles produced in different factories. The vehicles depart HUB1 once a week on Mondays. Incoming vehicles are processed so that they can be loaded on the next departing vessel in 4-7 days from arrival. The order management system displays the vehicles status as “HUB1” when the vehicle has arrived in HUB1 and is waiting for the pre-delivery inspection (PDI). When HUB1 has completed the PDI and the vehicle is waiting for departing shipment the order management system displays the status as “PDI ready”. The estimate/parameter that the OMS calculates for a passenger car to pass through HUB1 when providing an estimated time of arrival (ETA) to dealership is five and a half (5.5) days. Three core activities take place in HUB1. Two of them are the unloading of incoming vessels and loading outgoing vessels, which are handled by stevedores. The third activity, which is completed in between unloading and loading is the pre-delivery inspection (PDI) and installation of possible postproduction options (PPOs) that may have been ordered by the customer. Total average activity time in HUB1 varies between 6.5 – 7.5 hours, which correlates to approximately 5.2% of the average time a passenger car spends in HUB 1.

The sea freight from HUB1 to HUB2 takes on average two (2) days, which is also the optimal time for this part of the process taking into consideration the shipment route. The two days spent at sea represents 6.8% of the total average lead time. The order management system calculates this phase to take two days when providing an ETA to dealership. The status displayed in the OMS is “loaded on vessel” throughout this whole stage. Four core activities can be seen to take place at this stage. In the beginning of the sea journey the vessel sails to a port in country Y and unloads vehicles for several other markets prior to continuing to HUB2. Once a part of the shipment has been unloaded the vessel continues to Finland and ports in HUB2. Total average activity time for this stage is 42 hours which correlates to approximately 87,5%, however it is relevant to point out that a varying time is spent waiting before arrival permission is granted at the two ports.

The total average time a passenger car spends in HUB2 is two and a half (2.5) days, which is 8.5% of the overall process lead time. Shipments arrive once a week on Wednesdays, however it is relevant to note that HUB2 acts as a contractor also for several competitors, making it likely that there are multiple shipments a week. A variety of activities are completed at HUB2. First one being the unloading, which is handled by stevedores, followed by an exterior quality inspection, adding license plates to the vehicle, several post-production accessory installation related steps if necessary, fuelling of the vehicle if agreed with dealer and transportation of the vehicle to the pick-up area. The order management system displays the vehicles status as “Arrived to port” when the vehicle has been unloaded. “HUB2” is displayed as the status once the vehicle is taken in. Once the PDI, accessory instalment/s (if any), have been completed and the vehicle has been driven to the pick-up area, the status in the OMS is updated to “waiting for pick-up”. The estimate/parameter that the order management system calculates for a passenger car to pass through HUB2 when providing an estimated time of arrival (ETA) to dealership is two (2) days. It is of importance to point out that some vehicles pass through HUB2 in very short time whilst others spend more time as they for example wait for accessory instalment.

The truck/road freight from HUB2 pick-up area to the authorised dealers located across Finland is considered to take five (5) days, which is the agreed service level for the transport service. Five days represents approximately 16.9% of the overall process lead time. In reality this stage takes time anywhere from one to five days depending on the location of the dealer (the further away the dealer is the longer it generally takes). The freight begins with pick-up from HUB2, which is followed by the confirmation of the pick-up. After this the freight company is free to short-term store vehicles and optimise their transportation as they desire, as long as required performance metrics are fulfilled. The actual road transportation takes anywhere from two to 15 hours (excluding the breaks of the drivers) based on the location of the authorised dealer that the car is delivered to. After the road freight, the vehicle/s are delivered/unloaded, and a confirmation of delivery is provided. The order management system calculates this phase to take six (6) days when providing an ETA to authorised dealer. The status displayed in the order management system is “loaded for transportation” throughout this whole stage.

The total average time a passenger car spends at a dealer prior to being delivered to the customer is 14 days, which represents approximately 47,5% of the total process lead time. In optimal circumstances the time required for this process is between seven (7) to 10 days. Once a vehicle has been delivered to the dealer, the status displayed in the order management time is “arrived at dealer”. The OMS doesn’t calculate a time for this stage since there is no longer an ETA to the dealer as the car has already arrived. Once the vehicle/s have been dropped to the dealer and the delivery has been confirmed the extensive preparations for the customer handover begins. Protection films are removed, and the cars are washed by hand, dried, and inspected that they are in factory condition. Once a time for the pre-delivery service has been confirmed, an appointment for the vehicle handover is agreed with the customer. In some cases, the vehicles are stored temporarily due to various reasons. Once the PDI and possible accessory installations have been completed a series of tasks are completed within approximately 24 hours prior to the handover. These tasks being charging of the vehicle (if it is an electric or plug-in vehicle) and possible fuelling of the vehicle if not already completed at HUB2. The car is once again washed by hand and then polished. After administrative tasks such as completion of payment and insurance paperwork are completed, the vehicle is registered. Once all the before mentioned steps are completed, information of the sale is delivered to the case company. Prior to the handover appointment the salesman makes sure that everything in the vehicle is up to standard. Finally, the actual customer handover takes place including guidance to the vehicles features (dials, multimedia, mobile application, safety features etc.). The before mentioned activities take time approximately between 34.4 and even anywhere up to 353.4 hours if the possible intermediate storage and business specific installations are taken into account.

Information system set-up and flow of information within the downstream supply chain is broadly as follows:

- HUB1 has its own IT-system that is fully integrated with the order management system. Communication (booking of shipments etc.) with the vessel/s is handled directly by HUB1. They also send HUB2 and the road freight company detailed shipment information of each vessel approximately when the cargo has been confirmed (close to departure in order to optimise the capacity) and the vessel is setting sail.

- HUB 2 has partial access to the order management system and is able to see relevant reports etc. and in addition to this they have their own system that isn't integrated to the OMS or system of HUB1. HUB 2 provides the road freight company information of vehicles ready for pick-up. The lack of system integration causing sometime issues was pointed out in the workshop as the Senior Manager of Network performance stated:

  "If the vehicle goes through the downstream supply chain without any issues, the actual lead time is less than the ETA due to estimate not being based on the vehicles real-time movement but rather on the sum of slightly pessimistic projected lead times of each stage. However, HUB2 being a type of a "blind spot" in the Order Management System as the IT system of HUB2 and the OMS aren't integrated. Once HUB2 has confirmed that the vehicle has been received, no further status update is received until the vehicle is ready for pick-up".

- The road transportation company has its own system that is partially integrated (receives information) from the system of HUB1. The road transportation company sends the dealers delivery information (delivered by date) close to the departure of the truck (in order to optimise capacity and routes). Information isn't commonly shared much earlier as adjustments are common, and it could therefore create confusion and increase the number of unnecessary communication/corrections.

- Retailers have user rights to the order management system on top of which they have their own dealer management systems (DMS). The retailers send the case company information that a sale is made once the car has been registered and is to be handed over to the customer.

It is significant to point out that the order management system doesn't provide up to date estimates for how long a certain phase is actually taking time, as the ETA to the dealership is provided based on fixed estimated assumptions on how many days each phase takes time. However, the location and status of the vehicle is provided based on somewhat close to real-time information. The lack of up-to date ETA estimates can be problematic as stated by one of the Area Sales Managers:

"The amount of time it takes for a retailer to process the vehicle and hand it over to the customer, is considerably affected by how far ahead the retailer has been able to determine and schedule the date and time for the pre-delivery service and accessory installation. This is problematic because the final ETA provided by the order management system is given at the point when the vehicle leaves HUB1 and the next time ETA information is provided to the dealer is when the road freight company sends the dealer a list of incoming deliveries and even then, the exact day of delivery isn't necessarily 100% accurate. This means that dealers need to schedule the workshop time enough ahead that the vehicle has for sure arrived by then, and this consequently lengthens the lead time."

If the vehicle for one reason or another (for example the license plates haven't arrived, type approval is partially pending, the accessory installation is delayed due to pending part delivery or the resources are tight, etc.) doesn't move forwards in the downstream supply chain as designed, the order management system lacks the ability to react to this and showcases an outdated ETA. This leaves the case company (and dealers in particular) to wonder why the car hasn't arrived as estimated. The next time an update on progress is provided by the order management system is when the car proceeds in the SC and a new vehicle status is provided. This generates waste (unnecessary work) as described by one of the Area Sales Managers:

"The bad thing about this is that additional work is then created as dealers contact distribution, area sales managers, HUB2 and the road freight company asking what is causing the delay and when will the car arrive."

4.2 5 whys

The VSM was analysed and discussed in the workshop to comprehend the overall process and how the five stages individually and together play a part in the process. The 5 whys analysis illustrated in figure 12 depicts the decision-making process on what the author decided to conduct more in-depth research on. It is important to emphasise that instead of using the 5 whys tool the conventional way to find a root cause, the author used it to ask the following questions for each of the five stages in order to narrow down further research.

- A) What impacts the lead time of this stage most?
- B) Could an improvement significantly shorten the overall DSC lead time?
- C) Would it be possible and/or sensible to improve?

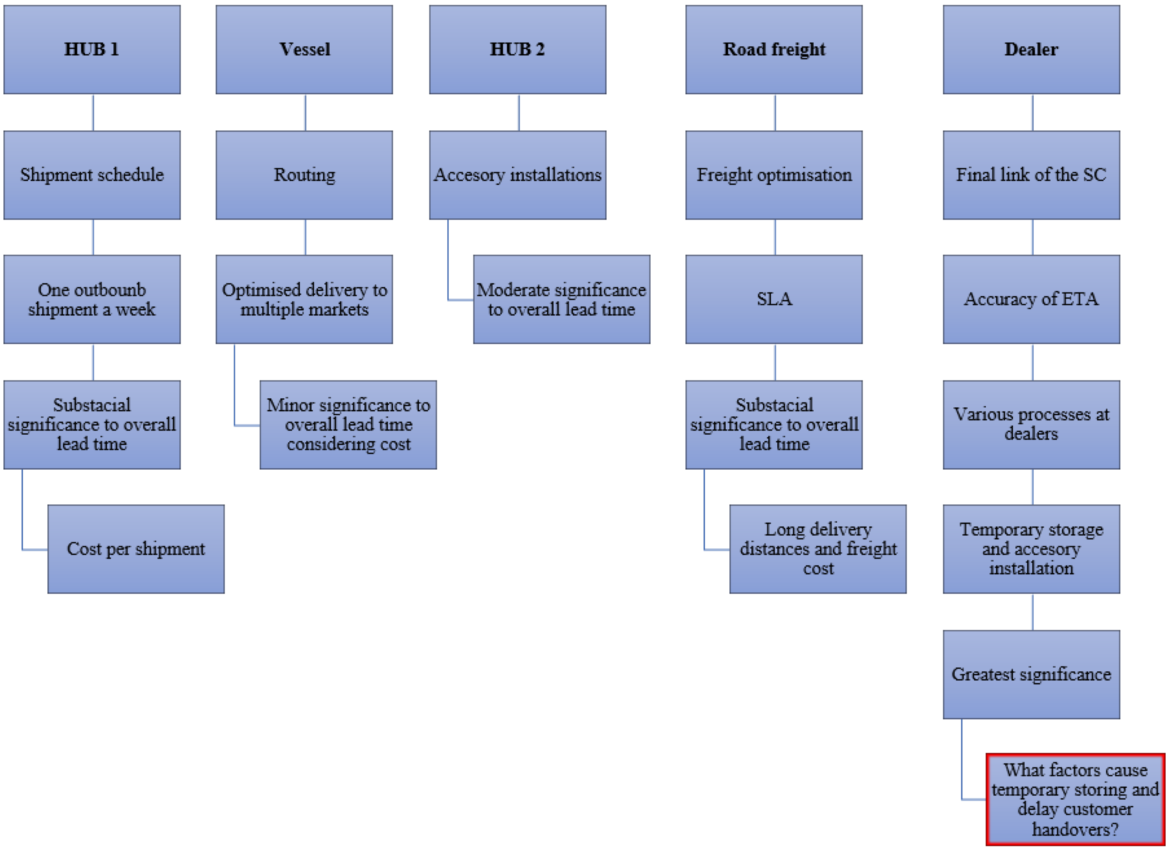

Figure 12. Focusing the research - 5 whys analysis

The lead time of HUB1 is primarily determined by the shipment schedule. As there is only one outbound shipment a week, the fastest possible lead time is limited to four to five days. Prior to the war in Ukraine shipments departed twice a week, but after the war broke, cars were no longer shipped to Russia and therefore the weekly volume dropped. As the weekly volume dropped it was no longer financially sensible to continue with two outgoing weekly shipments.

Lead time for the Vessel is mostly affected by the shipment route. The selected route has been chosen based on optimising delivery for multiple markets. Considering the overall DSC lead time, minor improvement could be generated by adjusting the route, however this would likely increase costs and decrease the performance of the wider logistical process.

The primary factor in HUB2 lead time is the installation of accessories. Considering the overall DSC lead time, the possible efficiency gains would be moderate. Regarding this research project the significance wasn't determined to be significant enough to pick HUB2 to be the focus of a more in-depth study. However, taking into consideration its impact on the next two process stages to follow (road freight and authorised dealer) there could be a benefit in further researching what impacts this process stage and its lead-time in the future.

Lead time for the road freight is primarily determined by route planning and importantly optimisation of freight. The boundaries for the prior mentioned is defined by the agreed service level. Improving/shortening the average delivery time would have the potential to significantly shorten the overall DSC process lead time, however taking into consideration the long freight distances covering the whole country, it would be likely to considerably increase the freight cost.

Dealer lead-time is considerably impacted by (the dealer/s) being at the end of the DSC and accuracy of received delivery information. As stated by the Senior Manager of Network performance:

"Dealers are at the end of the SC, meaning that all prior delays and deviations to the normal process accumulate at their end. Prior to COVID when everything in the SC ran like a charm and ETA`s were reliable, our dealers could trust and plan accordingly. Due to the global circumstances, the past few years have weakened our dealers trust towards the information provided by the OMS and since the provided information has no longer been accurate enough, they have had to adjust their planning and processes."

As showcased in the VSM there is a wide variety of steps and tasks completed at the dealers some being larger than others. Performance differences amongst the dealer network do exist based on monthly reports. At some dealers the cars make their way to customers faster on a consistent basis than at others. Also, the processes and arrangements at dealers vary as discussed by Senior manager of Network Performance, Senior Manager of Distribution, Products and Accessories, and the Area Sales Managers:

"Then it also varies amongst the dealers whether the accessory installers are dedicated personnel only for that task. In large dealers there tends to be dedicated accessory installers, but at smaller dealers the service mechanics also install the accessories. If a dealer has dedicated personnel for accessory installations, it is easier to adjust the schedules if there are other incoming new and or second-hand vehicles in-line for accessory instalment. On the other hand, if the accessory installations are handled by service mechanics, then their schedules also have service and repair times booked for customers, which of course cannot be postponed. So, if the vehicle didn't arrive on time for the pre-booked predelivery service and accessory installation time, then the car will simply have to wait for the next available time."

Based on the VSM temporary storing of vehicles significantly impacts both the dealer and overall process lead-time. If the amount of occurrences and their length could be reduced, it could lead to significant improvement. As the VSM indicates this final stage takes up 47.5% of the overall process lead-time, making it the most significant. Hence the author concluded to further research the dealer end and try to find out what causes temporary storing of vehicles and delays handing the vehicles to customers. In addition, the author thought to investigate how the case company could support dealers to achieve shorter lead times.

4.3 Voice of process

In the pursuit to understand; what affects dealers lead times, why cars are temporarily stored, what delays customer handovers and could the case company improve the dealer lead-time and consequently the overall process lead time, the author conducted a series of Voice of Process interviews with a group of authorised dealers as described in section 3.2. Via coding the data and thematic analysis, the author identified a total of 12 themes discussed by the interviewees. These themes are listed in table 6.

Table 6. VoP analysis themes

VoP Analysis Themes			
1	Information	7	Seasonality
2	Accesories	8	3rd party installations
3	Planning	9	Connectivity
4	Internal resourcers	10	New powertrains
5	Supply flow	11	Incentives
6	Customer	12	Manufacturer restrictions

The following part discusses these themes and their importance based on what the interviewees described. The themes are listed in order of their prevalence in the authors interviews. Based on the interviews, the first five to seven themes can be considered the most significant regarding dealer lead times, whilst the remaining can be considered less impactful yet worthy of discussion.

Information

This theme covered mainly estimated time of arrival (ETA) information of vehicle deliveries provided to the dealers. As discussed in VSM analysis dealers receive delivery information from two sources: the order management system (OMS) and the road freight company.

All six interviewed authorised dealers raised up issues concerning the reliability and validity of ETA information received. It was seen as a major issue that based on their experiences the OMS very often present ETA information which is false. The interviewees described that although not perfect before, the quality of OMS ETA information used to be a lot better prior to the global supply chain issues generated by COVID and the war in Ukraine. One of the authorised dealers also said that the quality of information provided by the road freight company weakened considerably approximately around eight years ago. Each of the dealers emphasised the issue with OMS information being unreliable and it being one of the primary causes for issues and delays.

Authorised dealer A: *"Three-four years ago we considered the information to be rather accurate but these days the information tends to be extremely unreliable. And that's a real shame because we no longer can act based on the OMS information. In a way the OMS ETA information has experienced a "crying for wolf" phenomena in the sense that nobody any-longer believes the information as it so often false. Therefore, we hope that the information could be made reliable again."*

Authorised dealer B: *"I have been very critical towards this process for eight years and am getting quite tired of bringing it up. We used to get a reasonably accurate information from the road freight company that the car will arrive on a specific date more than a week in advance. And this information started a wide preparation process at all our relevant business units to so that the car would be processed through a smooth and efficient process. Back then we were able to reach around 3–4-day lead times quite effortlessly as it allowed us to run a clear process which everyone knew how to follow. Today this info is no longer available and as I see it has been deemed no longer necessary to us dealers."*

Authorised dealer E: *"In optimal conditions the downstream supply chain runs with the timetable indicated in the VSM, but it significantly impacts us if the car for some reason is stalled in any of the prior stages. Because what happens then is that as the vehicle is delayed the OMS ends up showcasing us a false ETA. That causes our schedules both internal and with the customer to become disorganised and then we need to re-plan everything."*

Authorised dealer E: *"Accuracy of the OMS information is key in addition with the reliability of the logistical process all the way to us. The OMS ETA doesn't need to be wrong by more than a day or two that our operations are impacted, which adds a considerable number of days to the lead time."*

All interviewees presented examples on how the inaccuracy of both OMS information and to some extent also the road freight company information makes it impossible to make exact plans/schedules before the cars physically arrive to the dealer for vehicle processing and arrangement of vehicle handover times (date and time) with customers. One of the dealers mentioned that a small positive improvement was made during a recent OMS upgrade. However, the overall tone regarding this theme was critical and the author sensed that all the interviewees were frustrated when describing matters related to this theme. It was also mentioned by almost all dealers that even a slight improvement in terms of providing a delivered by date would be enough to reduce the lead time.

Authorised dealer B): *But every single day that we dealers could receive earlier accurate information of the actual delivery date of the car would count and be a great help to us. In the larger picture almost, all other information is irrelevant other than the actual latest (delivered by) date of delivery. The delivery list provided by the road freight company includes an estimate of arrival and delivered by date, however we aren't interested in the estimate, because it is just an estimate and not reliable. But the delivered by date is critical information because once we know that we know when we will be able to process the vehicle and deliver it to the customer.*

Authorised dealer C: *"I would like to add that the road freight company delivers the cars very well so no problem in that, but the gap in road freight information provided is just too wide because we don't really know where the car is and when it will actually arrive to us. We just know that the car has been picked-up and loaded for transportation. And we get this somewhat vague information on a report provided to us once a day… And actually prior to the upgraded OMS system it was quite difficult to know which customer order is even being delivered to us. But have to say that the* *upgraded OMS system has improved that part a lot and figuring out which customer order is arriving is no longer an issue."*

Authorised dealer F: *"Well here is a common concrete example from the past few weeks. I checked from the OMS report of cars to be delivered, that a batch of our cars were in HUB2 and at that time the OMS stated that the cars will be delivered to us on the 3rd of June. Well, these cars were in reality delivered to us in in three different shipments on the 8th, 12th and 13th of June. And as I see the least that us authorised dealers should be able to expect is that once the car has arrived to HUB1 the delivery schedule should be reliable."*

Authorised dealer E: *"Especially during COVID when we have experienced a lot of delays in vehicle deliveries, there have been cases where the cars have stopped for considerable time to HUB2 and or HUB1, probably to wait for something. Sometimes we might not receive a reason on why they don't proceed onwards and then the delivery of these cars are considerably delayed from the OMS ETA, based on which we have informed a rough estimate of vehicle delivery to the customer. Now during the summer and the beginning of the summer holiday season we might have been in the initial understanding that the customers new car can be delivered before they head on holiday. But then the car arrives late, and the customer goes on holiday and will say that he/she can't make it now and will be able to pick-up the vehicle in three weeks once back from holiday. We do get quite a few of such cases and there isn't much we can do about them."*

The authorised dealers raised that if the quality and timing of information would be improved, and if reliable delivered by dates could be provided it would help them. Most of the interviewees raised the reliability and accuracy of ETA information to be the most critical area for improvement.

Authorised dealer A: *"Reliable and accurate ETAs would help remarkably, that's for sure. If we would have a reliable ETA we could plan and lock preparations and the actual customer handover well in advance if we could be certain of when the car and accessories arrive. This would benefit us a lot, but for now we need to wait until all is certain."*

Authorised dealer B: *"Concerning dealer lead times the timing and quality of received data is critical. We as a dealer wish that we would receive exact ETA data enough in advance. We don't need it excessively in advance, but plus one week would be extremely cool because it would tremendously help the work at our end."*

Authorised dealer D: *"We would need more reliable delivery information so that the cars would actually arrive to us when indicated. It would make our planning so much easier. And especially when considering our smaller satellite locations who need to squeeze in accessory installations in the middle of their busy service calendars full of service customer bookings."*

Authorised dealer E: *"In my opinion the most essential thing is that we could rely on the information in the OMS and that the car would arrive to us on an exact provided date. As discussed today, in such circumstances we could make precise plans and agree the customer handover well in advance. Because the OMS information is the foundation for our planning."*

Authorised dealer E: *"The more reliable the supply chain and ETA information provided to us, all the way from the factory to our dealership, the better we can plan and prepare… If the information isn't reliable then we can't make necessary preparations and plan the vehicle handover schedule with the customer. This then creates us issues and often we are forced to delay these preparations until we have better insight on when the vehicle will arrive."*

Accessories

Along with ETA information, the availability of accessories was another “hot topic” during the interviews. All six interviewed dealers brough this topic up as a key influencer on dealer lead times due to it being a cause for intermediate storing and delayed customer handovers, as the ordered accessories simply can’t be installed if they aren’t available. The interviewees described that the current situation with accessory availability is extremely tough due to supply shortages and lack of predictability concerning them. Shortages were mentioned to affect many essential and popular accessories form a wide range: alloy wheels, winter tires, tow bars and tow bar wirings, mudflaps, trunk liners, rubber floor mats etc.

Authorised dealer E: *“Accessory logistics and supply issues have been increasingly highlighted during COVID and are a genuine challenge.”*

Authorised dealer F: *“At the current moment there is a constant shortage of accessories. Pretty much all accessories. At some point there was a time where there was a shortage on alloy wheels, but now it seems that there are supply issues with everything: tow bars, rubber floor mats, mudflaps, trunk liners, so pretty much everything and no information on when the availability will improve.”*

Authorised dealer A: “*Accessory scarcity and the backorders caused by them is something that lengthens lead times and delays customer handovers. Unfortunately, it is common that we would otherwise have the car ready, but we are still waiting for the delivery of one accessory and then we need to move the car to intermediate storage and finish the installation once the missing accessory is delivered to us. Then one of our staff members goes and fetches the car again to finalise the installation and this basically creates unnecessary work.”*

Authorised dealer B: *“And if there is some sort of issue in the supply of a component or tow bar then it will delay the customer handover and that’s why some of the cars have over 14-day lead times. But yeah, accessory shortages are a key reason for why cars are temporarily stored in our yard if we know that a missing post-production accessory would create an unpleasant discussion with the customer or some sort of compensation demands because the vehicle isn’t yet as the customer has it ordered.”*

The interviewees presented many examples on why accessory shortages cause vehicles to be intermediately stored for both short and long times. Some customers were described to be more willing to pick-up their new car despite of some post-production accessories being delivered later, whilst some customers require these accessories for their regular vehicle use and therefore won’t take the new car until accessories are installed. Supply issues were also described to inflict financial challenges as delayed customer deliveries can end up impacting the value of trade-in-cars.

Authorised dealer C: *“And then we of course face these accessory supply issues. With many customers we can come to agreement that the car doesn’t for example have a tow bar yet, but we will install it once we receive it, however there are also some customers who don’t want to receive* *their new car until all accessories are installed. Tow bar is a good example of an accessory, which is so essential to a customer that they can prefer to drive their old vehicle rather than taking their new car without one."*

Authorised dealer E: *"Especially this time of the year during summer it plays an increasing role if we are otherwise able to hand over the car to the customer, and ask the customer that would it be ok if we deliver the car now and install the tow bar in autumn once it has arrived from back-order and the customer decides that he/she will continue with their existing car until the tow bar is installed to their new vehicle. This means that the trade-in-cars mileage increases while we have committed to a certain exchange value for it beforehand and this changes the financial structure of the whole deal to the worse, such cases can be quite common. Then sometimes we may reach an agreement with the customer that he/she takes their new vehicle if we lend one of our suitable demo vehicles so that they can move their boat or whatever the customer's particular short-term towing need is."*

Authorised dealer A: *"Accessory availability plays a considerable role, if we don't receive a tow bar and the customer requires a tow bar on a weekly basis then we simply aren't able to deliver the car until the tow bar arrives, so such cases impact lead times significantly."*

The interviewees described that they have tried to adapt to the situation by carrying excess accessory stock by ordering accessories in larger volumes and further in advance. This alleviates to some extent their issues but introduces other challenges such as limited warehousing space and inefficiently tying up considerable amounts of cash into a large accessory stock. It was brought up that smaller dealers may be able to be more successful in holding sufficient stock in advance than larger dealers as their monthly vehicle volume can be a lot higher and therefore considerably limiting how long the buffer is sufficient for. Storing large quantities of accessories wasn't seen to be an efficient solution nor anything that the dealers would want to stick to long-term.

Authorised dealer C: "*Accessory supply used to be far better and now we just don't know when we will receive ordered accessories and that's quite a problem. We have now prepared so that we have placed accessory orders for the upcoming one to two-month vehicle deliveries, and we have a lot of capital tied into the stock and they take an awfully lot of space, so the situation has really changed to the worse from what it used to be."*

Authorised dealer A: *"We have limited space and simply can't take accessories and tire sets for dozens of cars well in advance. There isn't enough space to store for a whole months' worth of stock. We are a large retailer, and our sales team sells a lot of cars and therefore we also receive a lot of cars. Perhaps at some smaller volume dealers it is possible if let's say they would deliver around 10-15 new cars a month, but on a very good month we may deliver up to 100 new cars and therefore can't just order everything in advance because there is no space, so we need to time our accessory orders to the right moment."*

Authorised dealer E: *"Especially in terms of tires we have had to do very large financial decisions in terms of the stock we hold due to tire shortages caused by the war in Ukraine. So, we have tied a serious amount of capital into tire stock alone. This is because we simply cannot have a situation with our high volumes where we would deliver large amounts of customers cars without such a necessity as winter tires. Considering the circumstances, I would say that we have managed quite well."*

Authorised dealer D: *"It would be most optimal if accessories would always arrive slightly before the car, and it is also what we have experienced to be the best procedure. This is because we have limited warehousing space and try to operate somewhat on a just-in-time basis in the sense that we just can't hold accessories for our whole order bank on our premises."*

At one of the authorised dealer's smaller accessory supply issues could sometimes be resolved for specific customers by utilising this dealer groups accessory stock from one of their satellite locations.

Authorised dealer B: *"Yes indeed, if we have an accessory such as a tow bar in stock at one of our multiple locations without a sales reservation then it will be transported to the location where we have place for it in the rear of a car. I would say that we transfer items between our different sales locations on a daily basis. If we happen to have an item that suffers from a supply shortage in our company's stock, then no one is allowed to "sit on it" if there is a customer demand for it. Whether or not the customer need is for new car sales or some other type, it will always be shipped to our requiring location if it can't otherwise be obtained through the regular ordering route for that particular customer need."*

Several of the authorised dealers mentioned that although being a part of the regular process, certain accessory installations take-up considerable time. As an example, dealers mentioned that fuel powered heater installations are complex and take a long time to install. And although some cars are delivered with very few if no post-production accessories, then on the other hand some customers may have chosen an extensive variety of them which may lengthen the lead times of such vehicles.

One of the dealers said that they handle a moderate yet substantial amount of specialty installations work for rough use LCVs such as mines. Although these cars aren't passenger cars and thus don't directly affect the lead times of passenger cars, the dealer described that the amount of work, they generate can tie up half of their accessory installation resources four couple of days and thus indirectly affecting the amount of resources allocated for other arriving vehicles and their lead times. It was also brough up by one of the dealers that they try to do all possible accessory installations at the dealership instead of ordering them from the two logistics HUBs because this way the delivery of cars is less likely to be delayed further up the downstream supply chain.

Two of the dealers also questioned the entire ordering process wondering why the process can't be automated so that the information of specific accessories for each vehicle goes forward when the car is ordered and then the accessory order would be automatically placed when the car arrives to HUB1. Such automation could provide information earlier upstream of the SC and therefore improve the availability of accessories and time their arrival in line with the vehicle logistics.

Planning

This theme had some overlap with many of the other themes, as planning naturally has a lot to do with other key areas such as information and vehicle and accessory supply. Regarding the utilisation of OMS ETA data most of the dealers (5/6) described using it in their planning process and one dealer told it to be insufficient for their aftersales needs.

Authorised dealer A: *"Yes, it goes so that when we at sales find out the first OMS ETA when we order the vehicle, we provide this best estimate to aftersales. And if we know that some accessories will take long to arrive then they are order in advance to meet the ETA of the vehicle, so yes, we do use OMS data in our planning… In the past we used it even more when we found it reliable but unfortunately know the current situation is what it is."*

Authorised dealer B: *"We don't utilise OMS information in our aftersales planning as it simply too inaccurate. It provides some sort of direction but in terms of this process, in its current form it doesn't have relevance to us. We base our planning solely on the information provided by the road freight company."*

Authorised dealer C: *"Our planning process is fully dependent on the OMS ETA information provided to us and we adjust our plans and actions according to it… If we would start preparations only once the vehicle has arrived, we would be too much behind. We face so many variables that if we wouldn't plan to our best capability the odds for delays would increase considerably. It is all about anticipation, especially in terms of having accessories on time. Organising all of this requires a large group of staff and space so that we can be as ready as possible when the cars arrive. But if cars arrive early then the accessories might not have arrived yet. So, the OMS information really needs to be accurate for plans to work."*

Authorised dealer D: *"Well as discussed in aftersales we follow the progress of cars in the OMS and once they start to approach HUB2 and are on their way to us, we order the accessories to the vehicles if not done already. In sales each salesman follows the progress of their own vehicles and then our management also keeps administration and finance updated by providing OMS reports on incoming vehicles so that they can prepare accordingly."*

Authorised dealer E: *"We treat the OMS somewhat as our "holy bible" in the sense that we follow the status of cars daily and if we notice changes then we update the info internally as soon as possible. Based on the OMS ETA we make our plans and visualise them on our aftersales information board, and our sales staff discusses with customers of initial handover schedules etc."*

Authorised dealer F: *"We always take into account the OMS ETA in our planning. It is a considerable part of it due to the reasons discussed today. As mentioned earlier it's what we base the allocation of necessary aftersales resources such as accessory installations on…"*

Many of the retailers described that they use OMS information on longer horizon/initial planning, but then the more concrete planning takes place when the vehicle is close to arrive and is mostly based on the information provided by the road freight company or once the vehicle has actually arrived at the dealer. OMS data was particularly pointed out to be used to identify possible supply peaks which require exceptional arrangements for resources. The dealers described different ways and systems they use OMS information as a part of their planning process. One of them has their own cloud-based planning system, while some have manual visualization boards and most rely on different excel and or DMS based planning solutions. It was also noted that for the planning to work, the OMS information should be as accurate as possible. At the current time, dealers described planning to be a struggle, due to inaccurate information. It was interesting to hear that the dealers run quite different types of processes due to the way they have arranged their staff resources to process new vehicles. This is discussed further in theme “Internal resources.” Some of the dealers also told that they systematically track their own process to identify reasons for delays.

Authorised dealer A: *“The information in OMS data and therefore also our own report varies a lot on a weekly basis, but it gives our sales and aftersales departments insight on if we need to prepare for abnormally large deliveries. But to be honest our accessory ordering and aftersales planning has moved towards using the road freight company’s information as it is just better. Because it provides factual information on the car’s status, and when they inform let’s say that a car has been picked-up by them, the car will arrive within a few days, and it gives us some time to prepare. That’s actually what our accessory team has moved to follow.”*

Authorised dealer A: *“And our Finance Director has created a visual excel report which showcases the estimated number of incoming vehicles according to OMS data. That report is shared to us once a week and we find it is very useful. This is because based on it we know that for example if I recall correctly, we should have next week Friday 27 new vehicles arriving to our premises based on the report.”*

Authorised dealer A: *“Well from an aftersales perspective it is rather unpleasant that the process has become this type of constant act of “putting out fires” because in the current situation it is extremely difficult to create reliable planning around it. And in the past, we didn’t have to deal with similar issues other than during peak times such as the tire change seasons. So, we have experience on how to deliver cars at a decent pace during challenging peak seasons but back then they were the exception, and the rest of the year went rather smoothly without all the hassle we deal with today.”*

Authorised dealer F: *“Our planning process goes so that when a salesman makes a sale let’s say for example in October and the OMS showcases an ETA for May, then the order contract is used to create an electronic work order through our DMS to our aftersales department via a “push of a button” and basically this is always done right away once a sale has been made. So, our aftersales department is aware of accessories and the initial schedule which they can use for planning and if necessary, accessories can be ordered well in advance. On top of this our aftersales foreman follows the OMS information daily and is thus aware of incoming vehicles and it’s a major part of his job. So, he follows which cars are arriving and make required plans for them.”*

Authorised dealer F: *“We have one staff member who`s sole job is to organise our workshop schedules and book resources for each vehicle… He books resources approximately one month in advance and often I hear about the challenges he faces… For example, some while ago we were supposed to receive a significant shipment of vehicles, but then they just didn’t arrive. Then we had staff resources reserved for the work and had to try and find them some other work so that their time* *doesn't go completely to waste. As you may understand it is extremely challenging to allocate resources sufficiently in such conditions and then we also need to make sure that our service queues don't grow too long."*

Authorised dealer C: *"So the problem is that if cars arrive for example late Thursday evening, then the next day is already day two in terms of lead-time, and then we have a several days que in our workshop and with the information provided to us we simply can't pre-book service time in advance and because of this it might be already Wednesday or Thursday before we are able to start actually working on the car."*

Authorised dealer E: *"We have a visualisation board where we have scheduled the approximate number of incoming vehicles per month, so that we have an understanding on how much work will be needed to be done, based on which we can then plan the amount of hourly work and staff resources required for it."*

Authorised dealer B: *"We follow internally our process from the point of when the car has arrived to us all the way to the customer handover via a form that is added into each vehicle when they arrive and then filled by our staff members. We can then see afterwards where the vehicles wait and for what reason and we always check the form in abnormally slow cases for example to know why the car didn't move in our process for two days. Usually, we can identify a clear and valid reason why a delay has occurred."*

The dealers felt very strongly that not pre-booking exact time slots does cause a slight delay but is still a requirement to run an efficient and profitable workshop considering the level of information they currently receive on vehicle deliveries. In aftersales time is concretely seen as money and therefore a key attribute that they don't want to waste.

Authorise dealer B*: "The OMS information would ideally be the most useful for aftersales. But our workshop runs on the accuracy of six-minute cycles and the OMS information is just not accurate enough. For example, if in aftersales one of our staff member wonders around for 15minutes it will be forever a lost 15 minutes. On the other hand, if a salesman wonders around for seven hours but during the last 30minutes of the workday he/she completes the deal of his/her life it is more than enough. But in aftersales you can never make back the lost time and therefore you can't make back the lost revenue and productivity… When considering the information that we receive for our planning and its accuracy, when we can be sure that a vehicle will arrive by a precise date it means that we have had to delay our own process so that we start planning around one week later than optimal because we need have reliable knowledge on when the car will arrive in order run our end efficiently."*

Authorised dealer B: *"When we know for certain that a car arrives by a given date, we can book required aftersales resources and have a staff member ready for the job. As mentioned earlier our workshop runs on the accuracy of six-minute cycles and as stated earlier we don't really benefit from estimations as we can't rely, and act based on them. For us it is far better that the car arrives for example two days earlier than indicated by the road freight company because although it will wait on our property to be processed our own preparations are ongoing and we will be able to start processing it right after the two days."*

Authorised dealer C: *"We don't book specific time slots based on OMS information because it isn't accurate enough for it, as said workshop time is money, but we anticipate and plan very close to the OMS information and as mentioned regularly follow the information it provides. To answer the question, we plan very close but leave some margin for error so let's say plus two to three days and we also utilise information provided by the freight company… We don't plan exact time slots for* *each vehicle, but we rather reserve enough time and staff resources to process the number of vehicles we anticipate arriving on that week. We book specific times only once the vehicles actually arrive because as said earlier, we need to be very careful on what we do with the workshops time. History has taught us that if we book times prior to the arrival of the cars then they simply don't arrive on time and then we lose that time for good."*

Authorised dealer C: *"As we see, it is better to make sure that the car has arrived and have it wait for a day and handle a pre-booked customer's vehicle service instead as this way we are able to make sure that we use workshop time efficiently…If the system would want to be changed so that we would pre-book times from our workshop based on estimates it simply wouldn't work with the information we currently receive. Because we don't even know the road freight company's schedules on a day's accuracy let alone on an hour's basis."*

Authorised dealer D: "*We don't book times as such but run the process on a "first in- first out" principal meaning that cars are processed mostly in the order they arrive in. We have two dedicated accessory installers who work only on installations because it is easier to run it this way. If we would try to pre-book times from our regular service calendar, we would run into immense problems because cars rarely would arrive on time for their specific pre-booked calendar slot. One of our satellite locations has tried it out and criticised that when they check the OMS ETA and book a time from their workshop calendar based on it the cars don't arrive accordingly."*

Authorised dealer D: *"Aftersales being a business of selling time presents its own challenges as we can't sell time that has already passed. Therefore, we prefer that once the vehicles have arrived our dedicated accessory installers work on them. We have considerable service queues and fitting in accessory installations in the middle of our busy workshop calendar would be too challenging. And the reason for our first-in-first-out process is that if a cars delivery has been considerably delayed then we can prioritise it so that it can be delivered shortly to the customer. But we do of course order the accessories in advance. Our accessory foreman follows incoming vehicles from the OMS on a regular basis and orders required accessories for each vehicle."*

Supply Flow

Dealers mentioned that ever since the start of COVID when delivery times became abnormally long the fluctuation in supply flow has increased drastically. This has made it challenging for them to allocate and maintain optimal resource levels. According to the dealers not only is it hard from the perspective of planning, but it also creates bottle necks and creates issues in terms of where they can physically find room for the abnormally large vehicle deliveries. The fluctuation was said to create "waste" and lengthen dealer lead times due to the bottle necks and additional "hassle" generated by them. All six of the dealers highlighted supply flow to be a key reason why lead times can grow in length in addition to the quality and timing of ETA information, accessory shortages and availability and allocation of resources.

Authorised dealer A: *"High fluctuations in the supply flow of cars considerable impacts our lead times. It would be far easier to run the process if cars would arrive as a steady stream, let's say for example 10 cars a week. But now there are weeks that almost no cars arrive and then suddenly 500 cars arrive to HUB2, which are then distributed across the country and then we might suddenly* *receive 30 vehicles within a week, and it is impossible to balance our resources in such fluctuating supply."*

Authorised dealer B: *"For us when a flood of 15 cars arrives in one morning to our premise it is a very poor starting point to turn them into a functioning and efficient concept."*

Authorised dealer C: *"We might have two weeks that we "kick rocks" and then one beautiful Monday morning a truck full of vehicles are delivered to us all at once. For the process to run smoothly we would really need a steadier logistical stream and I can only imagine what it can be in the capital city region when 40 or more vehicles arrive at once considering that the premise and number of staff have their limitations."*

Authorised dealer D: *"Cars aren't delivered at a steady frequency to us. For example, this spring there was a period that we had no deliveries and our accessory installers had very little work to do and then suddenly, we received a huge number of vehicles that we were instructed by the importer to quickly deliver to the customers… So, the fluctuating supply flow impacts us a lot, both the availability of vehicles and then that they are delivered in massive bulks. This means that at some points there is almost nothing to do and then suddenly, an enormous rush. Always when large fluctuations occur, it also generates hassle and waste… Probably nothing can be done about it, but it does impact lead times."*

Authorised dealer E: "*If we go all the way to the beginning, steady production flow is key so that there wouldn't be production months were we don't receive almost any vehicles and then others from which we receive very large quantities. Because this creates bottle necks at our end, and as we are a large dealer and sell high volumes it means that we receive massive shipments when the supply flow fluctuates. This probably isn't something that can be much affected, but it is currently an issue and hopefully the situation will improve... We really hope that steadiness could be brought back to the supply flow. For example, yesterday we had several truck shipments and then days when no cars arrive. And we really need to get creative in figuring where to fit all the cars."*

Authorised dealer F: *"Regarding the topic of unnecessary work, something astonishing has happened in the sense that although vehicles didn't arrive as a perfectly steady flow in the past, today they arrive in exceptionally large shipments. We might receive 30 cars and then for three weeks almost none come through although the OMS shows that our cars are relatively close somewhere between HUB1 and our dealership… Fluctuations in supply flow are very challenging in terms of where we find space for the large bulk deliveries let alone the trouble it causes to our aftersales department and car wash supplier as balancing resources is very difficult… And probably the road freight company has its own role in this. Because as the overall market for new cars has decreased, they have probably had to adjust their resources as I would imagine that they don't have the luxury of being able to keep excess trucks and drivers around."*

Internal resources

As many of the previous themes revealed, dealers consider their internal resources mostly meaning staff, time, and workstations, to be highly important as they are what enables work to be completed. Planning the right resources for the right time was described to be extremely challenging due to lack of accurate ETA information. The interviewees told that their service capacity is not only restricted by the availability of staff but also by the number of workstations (lifts) they have. Meaning that there isn't space for more workstations, and they are often already “maxed out”. The interviewees described implementing different ways to organise staff resource allocations for processing arriving new vehicles. Some dealers tended to rely on the same resources that run their regular services or express services whilst others had dedicated accessory installers who mainly work only on the incoming new vehicles. Half of the dealers mentioned having external suppliers on their premises or in their neighbourhood for washing the cars. During peak weeks and months for new cars deliveries many described allocating further resources from their service mechanics. Although this works as a supportive action dealers mentioned that some of the installations such as fuel powered heaters require a high level of expertise and experience, so they are usually done only by their full-time accessory installers.

Authorised dealer A: *“We don’t run incoming new vehicles through our regular service, but we have our express service process them, which to my understanding is quite exceptional on a national level… We have allocated overcapacity in the sense that we have 4-5 permanent express service mechanics who take care of express customer demand and process our incoming new vehicles as well.”*

Authorised dealer C: *“Our mechanics handle all services, repairs and accessory installations so we don’t have dedicated accessory installers.”*

Authorised dealer D: *“We have two dedicated accessory installers who process arriving vehicles and if we receive abnormally large quantities then we allocate more staff resources from our service mechanics”.*

Authorised dealer E: *“We have three dedicated accessory installers and at the busiest times we have allocated up to three service mechanics to process incoming vehicles… And we face the problem that we don’t have any surplus lifts in our workshop. That’s why we have been very happy to be part of the importers pilot project that enables a more efficient use of our lifts. We have a high number of internal services due to our sales staff doing a great job selling a lot of vehicles.”*

Authorised dealer F: *“We have currently two dedicated accessory installers and then we have an additional four other persons who are allocated for processing new cars when necessary.”*

Many of the dealers also pointed out that staff absences such as sick-leaves and sometimes the holiday seasons can cause temporary resource shortages and therefore impact lead times.

Authorised dealer B: *“In our own operations it is very important that our staff stays healthy so that we are able to allocate staff to each workstation in our workshop.”*

Authorised dealer A: *“During COVID and influenza peaks we have had so many of our staff sick at the same time, that I can’t recall such wide scale absences in the past. So sick leave can present a challenge occasionally.”*

Authorised dealer C: *“Sick-leave and staff holidays can make it difficult to match work with the required skill set”.*

Dealers described that when the pace of delivering vehicles to customers needs to be tightened then it can be done temporarily by agreeing overtime with mechanics and booking the calendars of sales staff full of customer handovers. It was mentioned though, that overtime is only a short-term solution and in no sense a desired situation. Also, temporarily filling up the sales staff's calendars only with vehicle handovers was seen to be negative from the sense that if all sales staff is busy delivering cars, then there is no one responding to new sales leads and serving customers who walk in their showrooms.

Customers

All the dealers mentioned that sometimes lead times can run long due to customer related reasons and preferences. Although the dealers said that most customers are eager to come and pick-up their new vehicle as quickly as possible, some customers can be hard to reach and then some might be too busy (travelling for work or holiday) to come and pick-up their car on a given date or week. This was also described by the dealers to be the reason for why an otherwise delivery ready vehicle can be intermediately stored especially during the holiday seasons. Some of the dealers also described that usually they and their customers are very flexible, but a suitable time can't always be found right away, and that can delay the vehicle hand-over. The end of the calendar year was also mentioned to be a reason for delays as some customers prefer to have their car registered on the next calendar year, and it was also brought up that some customers prefer to wait a short time to get their new car on the "right set of tires" if the vehicle handover is very close to a tire change season. Other noted customer preferences were such that some customers can be very determined that the car is delivered by "their own" salesman especially if in question is a long-term customer who has formed a personal relationship with the salesman. The reason why this was mentioned is because it can add few days to the lead-time if the salesman is unavailable for a short period of time (holiday, sick leave etc).

Authorised dealer B: *"Sometimes when we contact customers and request if it would be ok for one of our other available salesmen to handover the vehicle, our customers sometimes say that it's not an option. This type of customer preferences can sometimes cause the cars to wait even if they are otherwise ready."*

Authorised dealer C: *"The customers' availability to come and pick up the vehicle once it is ready. Because if let's say the delivery of the car to us takes place one or two weeks late or ahead of schedule it can sometimes mean that the customer is just during that time on an all-inclusive holiday abroad and simply isn't around to pick-up their new car at that timeframe… Sometimes such cases may be* *down to us misinterpreting the arrival of the car but commonly it is because the OMS ETA is wrong, and the car is delivered to considerably late or early."*

Authorised dealer C: *"Our experience is that if the salesman who has sold the car isn't available and we have another member of our sales staff handover the car, then it can always be seen as a lower customer satisfaction rating."*

Authorised dealer D: *"As a base principal all our customers are excited about the arrival of their new car and are happy to come and get it as soon as possible… But we have experienced cases where a car arrives even up to one and a half months in advance and when we receive this information the customer has already booked their holiday. For example, last fall we had such cases during the national school holiday week when we had multiple cars waiting for their new owners to return from holiday. So, such cases can lengthen our lead times and cause an otherwise ready vehicle to wait."*

Authorised dealer E: *"If we think about our private customers, usually we can arrange a vehicle handover time quite quickly, for example if we know that we have their car ready on Tuesday we will agree the handover for Wednesday. However, if the customer is simply very busy or out of town then it becomes tricky. I go through lists of cars that approach a 10-day lead-time and try to speed up the delivery. Well for example last time one customer told that as the vehicle delivery was late by such a long time, they unfortunately were already at their cottage on the countryside and would be able to pick-up the new car after a few weeks when they come back home. And usually, they state that they would have been happy to take their new car two to three weeks ago when it was originally supposed to arrive. In terms of our private customers there is always a genuine reason for why they can't come and pick-up their new car right away. Usually, they are out of town for work or holiday. Never do they delay it because they aren't bothered to come and get it."*

Corporate customers were described to be sometimes a challenge in terms of timing the vehicle delivery. Especially customers with ongoing lease deals (who are mostly business customers), the end of their current lease deals impact when the car can be delivered as the customer isn't able to take in their new car until the current lease deal has run out. Interviewees described that the delays in vehicle deliveries and inaccuracy of OMS ETA play a significant part in this, as the new vehicle orders are timed so that customer will be able to move from the old company car to the new one seamlessly, however when a delivery is delayed the customers lease contract needs to be extended meaning that the car may have to wait for that once it eventually arrives. Also, larger customer deliveries were told to present their own challenges as customers usually want all the cars to be delivered at once and this has its own issues because large orders don't always arrive at the same time and may create bottle necks.

Authorised dealer B*: "And then sometimes we have large fleet customer deals for example delivering 50 cars to one customer and to some of our sales locations it takes a fair bit of time to have them prepared and delivered to the customer all at once."*

Authorised dealer E: *"Well a corporate customer may state that the time doesn't suit them because they don't have their vehicle reception open then and in the case of fleet cars some companies take in new cars only in the beginning of the week. For example, car rental companies who we sell large* *batches of cars to, we must deliver the cars either on Monday or Tuesday afternoon or otherwise the handover will have to wait one-week forwards."*

Authorised dealer F: *"Then if we think of corporate sales the customer plays a really large role in when the vehicle can be delivered. If a corporate customer tells that a specific time isn't possible then there isn't really much we can do about it, because there are leasing contracts that need to expire at the same time and a wide range of other things that influence why it isn't possible to deliver the cars within certain days or even weeks, which can't be foreseen when making the order …Well as mentioned prior, leasing contracts are a great example as when the vehicle is sold and ordered, the customers extended their current lease contract in-line with the OMS ETA provided to us at that time, but then when the car doesn't arrive as originally estimated, then the customer has to extend the lease deal again and then we have to wait for that new extension to run-out before we can deliver the vehicle."*

Authorised dealer F: *"Usually if a company has ordered eight vehicles all at once then they also want to receive them all at once and this isn't necessarily optimal considering that the cars can arrive to us on different days or even weeks. Especially if we have trade-in cars coming in from that deal, because the customer doesn't want to have two sets of insurances valid simultaneously for both sets of cars… Then we also provide more tailored services for some corporate customers, for example with one large customer we have agreed to provide vehicles to all their company car users who are located all around the country. Reaching these company car users and arranging times from their busy calendars for a vehicle swap including the summer/winter tire in the boot and arranging someone to deliver the new car and bring back the trade-inn car is a complex equation to solve, which can take time."*

Seasonality

Seasonality was described by several dealers to play a role in the amount of work that their workshops face, for example summer and winter tyre change seasons generate a considerable amount of work. However, this is somewhat balanced by other times of the year when there is more flexibility as the customer demand is slightly lower and there are more vacant spaces in their workshop calendars. The amount of work workshops have and therefore their room for flexibility is directly linked to whether the ongoing season is busy or not. This can also impact lead times in the sense that if large volumes arrive during the tire seasons, then it can delay lead times as resources are already in full use. Certain national holiday seasons were also mentioned to delay lead times when staff are away from work for several days. Also, concerning availability of resources many mentioned that during the summer they have less resources as their staff are taking turns to go on holiday.

Authorised dealer A: "*We have a large amount of tire hotel customers, and it takes around one month to have all our customers tires changed and we are really busy in aftersales during those times… Then of course if cars arrived right on the verge of national holidays for example right before Easter, then it will be four days before people are back at work."*

Authorised dealer C: *"Usually we need to deliver abnormally large number of cars in March, and it honestly is almost the only time of the year that such a peak is manageable. Because during that time* *we don't have a tire change season and it isn't the holiday season either, so we have the required staff on site."*

3rd party installations

Some of the dealers raised that many large corporate customers have dedicated 3rd party companies who handle some of their customised installation tasks. Although this apparently mainly concerns only LCVs, they indirectly impact also lead times for passenger cars because they affect planning and especially impact the sufficiency of planned resources. In terms of passenger cars, taxi handovers were seen to have long lead times because of the service queues that the taxi meter installation providers have.

Authorised dealer A: *"Well just today we will be delivering a new taxi and usually with taxis the 3rd party taxi meter installers aren't always able to find a vacant time for the work, even in up to two or three weeks… So especially this type of third-party installer queues can lengthen lead times."*

Authorised dealer E: *"Lease companies and large corporate customers tendered certain installation work and they have agreements to handle all installations at one dedicated supplier. In such cases we lose some control of the schedule… Every time a car leaves our premise for third party installation work then we don't have full control on when the cars arrive and when it will be ready for handover."*

Authorised dealer F: *"Particularly with LCVs there are 3rd party installations that impact our lead-times and of course on the passenger car side with taxis we are also impacted by the schedule of 3rd party installations."*

Connectivity

Quite surprisingly all the six dealers brought up connectivity, mostly meaning the mobile service application provided to customers. Although the impact of this theme on lead times is mainly constrained to vehicle handovers, the dealers appeared to be frustrated about the additional work (waste) it causes them. The mobile app was described complicating the vehicle handover process due to the complex set-up process and mandatory linking to the vehicles multimedia system. Also, the ETA information provided in the mobile app to customers was described as a cause of unnecessary work via customer misunderstandings caused by it. This theme seemed to impact the dealers more in terms of their overall moral than the actual lead times.

Authorised dealer F: *"And at this point I could mention about the unnecessary work that is generated by the mobile application. We have customers who call us when they see in the app that their car is* *stalled in HUB1 or HUB2 and hasn't moved in two weeks, so we receive this type of unnecessary calls due to that and often we haven't been informed about the reason for the delay."*

Authorised dealer E: *"Customers are very eager to pick-up their new car and often they follow the process from the mobile app and sometimes may even show up the same day that the car arrives requesting whether or not they could already take their new car home when its waiting to go for the pre-delivery service and accessory installation."*

Authorised dealer D: *"The mobile application doesn't work ideally, because right away when the app shows that the car has arrived, we have some customers coming asking for it before it has been processed and sometimes, they are unhappy to hear that they can't just take their new car on the spot… The app sometimes creates misunderstandings which aren't beneficial either to the customers or us".*

Authorised dealer C: "*Well, if we go to the actual vehicle handover there is one thing that generates quite a bit of "headache" probably throughout the dealer network, but most likely in a short timeframe nothing can be done about it. Now when the newest vehicle multimedia devices require to link the customers mobile app account to the device it creates us issues. For example, just a while ago we delivered a car to an elderly gentleman who doesn't have an e-mail address or bank user credentials. Well, the new multimedia device doesn't work without a mobile app account which requires an e-mail address. And when the handover process starts from such a situation it takes a considerable amount of time to get everything set-up… Then just recently for one customer we connected the vehicle to the customers user accounts according to the process and had to run the whole process all over again due to bug in app. So, we end up spending our valuable time fixing the shortages of this imperfect process… And even our younger customers and employees who are "digital natives" can struggle to set everything up in the correct manner."*

Authorised dealer B: *"At one point we had situations where customers came first thing in the morning to ask for their new car."*

Authorised dealer A: *"And today when customers can see the progress of their car delivery from their mobile app, they naturally can't know that their cars arrive in large deliveries and that it can be one of 50 vehicles on our premise waiting for its turn to be processed. So, many customers come right away to ask about their new vehicle… Customers are naturally excited and if I would be in their position, I would be very excited too if I received frequent updates that now the car is in HUB1, then HUB2 and now at the dealer. I understand why some of them are tempted to come and physically see their car."*

New powertrains

One of the dealers brought up that the increasing number of electric and plug-in vehicles has some impact on lead-times. As the manufacturer instructs that pre-customer delivery charges must be done via slower alternative current charging the amount of time required for charging especially with electric vehicles takes several hours. Adding this activity to the dealer's process without impacting lead times was said to have its own challenges.

Authorised dealer E: *"I want to raise this because all authorised dealers in Finland are increasingly facing growing numbers of EV and Plug-in vehicles and we need to make sure that the batteries are 100% full when the cars are delivered to customers."*

Authorised dealer E: *"Charging battery powered vehicles provides customer value and it is a relatively new additional step that we have tried to include in a way that it wouldn't impact lead times. Growing volumes have brought their challenges, and we haven't quite "cracked the code" in a way that it wouldn't add time to our preparation process… We have our own processes and do our best to figure out how we could optimise the time when cars aren't moved around so that they would be charged always when possible."*

Incentives

Some of the dealers raised up that different types of incentives can add focus towards lead times. Performance targets and potential bonuses provide an additional incentive. However, during the interviewees, it became obvious that dealers themselves want to deliver the cars to customer swiftly because it's beneficial to their business. Some of the dealers mentioned that the interest of manufacturer, importer, dealers are very much in-line in the sense that all benefit from the cars finding their ways to customers as shortly as possible.

Authorised dealer A: *"I think that "carrot and stick" play their own role in dealer lead times in the sense that if there is some concrete "carrot" available, it motivates us to deliver cars at the required target speed and vice versa if there is a "stick" then we dealers try to avoid receiving it".*

Authorised dealer B: *"I don't think that it is in anyone's interest to have cash (cars) lying around on our premises for any longer than necessary, it isn't in our interest and to my understanding it isn't in the importers or manufacturers interest either."*

Authorised dealer E: *"Performance bonuses and target settings do have their own impact and make sure that conflicts of interest don't arise. But the importers support has its role in enabling us to achieve shorter lead times in general."*

Authorised dealer F: *"And as closing remark I would like to say that I can guarantee that not a single vehicle is intermittently stored for the fun of it. We run a business here and we receive our share only once the car is delivered to our customer. Whether or not we speak about payments from the customer or importer we aim to receive them as soon as possible."*

Manufacturer restrictions

In one of the interviews, the point was raised that certain manufacturer restrictions can lengthen dealer lead times. The dealer described that occasionally, the manufacturer instructs certain quality control steps to be performed at dealers prior to delivering the vehicle to the customer. Such instructions and steps are part of quality control and a way to ensure that the customer receives a better product. These upgrades can contain for example software updates or specified part replacements. Based on the discussion such cases are very rare and therefore don't impact day to day business, but when they occur, they can lengthen dealer lead times.

Authorised dealer A: *"From an aftersales perspective, something that delays our work is ongoing pre-delivery campaigns. Because if we are not permitted to deliver a vehicle before the instructed additional actions have been implemented, it will naturally delay the handover and in the worst case it will take even weeks that we firstly receive the detailed instructions and then completed the task on all required vehicles."*

4.4 Quality function deployment

To quantify the essence of the VoP interviewees, the author used the acquired information to create a quality function deployment (QFD) matrix illustrated in figure 13. As dealer lead times are important to the dealers themselves and represent the most time-consuming process phase in the entire downstream SC in scope, it is beneficial to quantify and provide visualisation on what factors impact these lead times and how they could potentially be sought to be improved. In addition, the QFD also aims to highlight what should be focused on to improve lead times via critical to quality prioritisation.

Relationship Key:

	Strong	Medium	Weak
Weight	10-8	7-4	3-0

	X's (How's)												
Y's (What's)	Improving the reliability of OMS ETA infomation	Providing road freight delivery information earlier	OMS ETA parameter alterration (real time tracking)	Increasing central stock levels for accessories	Investigating automation possibilities for accessory ordering	Requesting less fluctuating production allocation (per month)	Further roll-out the vehicle service lift efficiency pilot	Monetary dealer incentives	Standardised process and guidelines for EV and PHEV charging prior to customer handover	Check mobile app delivery progress parameters (alter if neccessary)	Investigate adding specific guidance to the customer in the app	**Importance (1-Low. 5-High)**	**Total**
Dealer`s process downtime	8	10	9	9	4	7	7	5	3	0	1	5	315
Quality of delivery/ETA information	9	10	10	0	0	2	0	0	0	0	0	5	155
Planning conditions	9	10	9	9	7	8	7	0	3	0	0	5	310
Accessory availability	8	7	5	10	7	8	0	0	0	0	0	5	225
Supply flow fluctuation	0	0	0	4	3	10	0	0	0	0	0	4	68
Efficient utilisation of resources	9	9	9	8	6	8	10	0	3	2	2	5	330
Dealer morale	9	9	9	9	4	8	7	8	3	7	7	4	320
Customers availability	9	8	8	7	0	4	0	0	0	1	0	3	111
Growing EV and PHEV volume	0	0	0	0	0	0	0	0	9	0	0	2	18
Peak seasons (for example tire change)	8	8	8	3	5	9	10	3	1	1	1	2	114
3rd party installations	7	6	6	0	0	6	0	0	0	0	0	2	50
Mobile app	0	0	0	0	0	0	0	0	0	9	9	1	18
CTQ Priority	249	256	241	214	123	227	133	63	62	52	54	1674	
% Importance	15	15	14	13	7	14	8	4	4	3	3	100	
Priority rank	**2**	**1**	**3**	**5**	**7**	**4**	**6**	**8**	**9**	**11**	**10**		

Figure 13. Quality Function Deployment matrix

The Y-axis contains the "what`s", which are the factors that are significant to the quality of dealer process efficiency and therefore their lead times. Based on the VoP interviews and the authors analysis, a total of 12 key contributors were identified. The importance of these factors was rated by the author on a scale from one (1) – five (5). One (1) indicating low level of significance and five (5) high level of significance. The 12 "what`s" rank from high significance to lower significance as follows: downtime in the dealers process, quality of delivery/ETA information provided to the dealers, the planning conditions that dealers operate in, availability and supply of post-production accessories, fluctuations in the supply flow, efficient utilisation of the dealers resources, overall morale of dealers meaning their determination and grit to aim for shorter lead times despite faced challenges, the customers availability and ability to come and pick-up their new car within a specific timeframe, charging the growing number of electric and plug-in hybrid vehicles, peak seasons such as the twice a year occurring tire change season, specific installation work carried by 3rd party operators and the impact of connectivity and mobile application to the time spent on vehicle handovers and unnecessary work generated from the app.

In the QFD matrix, the "what's that were rated highly important (fives) are highlighted in red and include: dealer`s process downtime, quality of delivery/ETA information, planning conditions, accessory availability, and efficient utilisation of resources. Other "what's" that were rated highly important (fours) include: supply flow fluctuation and dealer morale. The reasoning for these high priority ratings was that they were described by the dealers as playing a significant role in dealer lead times and the authors viewed them also to be the base pillars of the dealers' process in the downstream supply chain and therefore also the overall process lead-time.

Customer availability was rated with a medium significance. The justification for this was that although customers can play a noticeable role in temporary storing of cars that are otherwise ready, as described by the dealers, the customers in most cases are able to come and pick-up their cars, and the exceptions that do occur can be viewed to be something that comes inherently as the nature of the business. Therefore, these abnormalities aren't such an integral part of the standard process.

Growing EV & PHEV volume, peak seasons, 3rd party installations and mobile app were rated less important for several reasons. These factors weren't mentioned by a considerable share of the authorised dealers. Peak seasons such as the twice a year tire seasons are well foreseen in advance and although they do tie up a lot of resources and limit flexibility, the impact of the actual peak season is moderate, and the actual problems are caused by other factors with limited predictability that occur during the otherwise busy moment of time. Growing battery powered vehicle volume does cause an additional step in the dealer's process; however, the volume of them can be foreseen at least to a certain extent, and therefore preparations are possible to be made. 3rd party installations can impact individual batches of cars but are rather uncommon with passenger cars as they mostly impact LCV`s. Mobile app related issues can be considered to have the lowest impact on lead times; however, it is of significance to note, that they do appear to considerable impact the dealer's morale.

The X axis consists of the "how`s" which are ways to improve the factors that play a considerable part in dealer lead times, and therefore also improve the overall process quality. The author identified a total of 11 activities that could be used to improve dealer lead times. These "how's" are: improving the reliability of OMS ETA information, providing the road freight delivery information earlier, altering OMS ETA parameters by for example real time tracking, increasing central stock levels for accessories, investigating automation possibilities for the accessory ordering process, requesting less fluctuating production allocation per month, further roll out the importers service lift efficiency pilot, provide monetary dealer incentives, standardise a process and guidelines for EV and PHEV charging prior to customer handover, check/alter the mobile app delivery progress parameters if deemed necessary and investigate adding specific guidance to the customer in the app. Relationships of the "why`s" with each "how`s" were rated on a scale of zero (0) to 10. A relationship weight between 0-3 indicates a low relationship, 4-7 a medium level of relation and 8-10 a strong relationship. The full overview of all relations between" how's" and "what`s" are presented in the QFD matrix (see figure 13.)

Critical to Quality (CTQ) values were calculated for each of the "how`s" by multiplying the relationship values of the how`s with each the importance rate of the what's. These total sums where then converted into percentages so that all the 10 "how`s" represent a total 100% of all CTQ priority importance. The results were as followed:

- Greatest CTQ priority ranks went to; providing road freight delivery information earlier and improving the reliability of OMS ETA information, as they each scored 15% importance of total priority.

- OMS ETA parameter alteration (real time tracking) was a close third with 14% priority importance.
- Requesting less fluctuating production allocation (per month) fourth with a 14% importance.
- Increasing central stock levels for accessories fifth with 13% importance.
- Further roll-out the vehicle service lift efficiency pilot sixth with 8%.
- Investigating automation possibilities for accessory ordering seventh with 7%.
- Providing monetary dealer incentives, standardising a process and guidelines for EV and PHEV charging prior to customer handover ranking eighth and ninth both with 4% importance.
- And lastly lowest importance ranks went to; checking/altering the mobile app delivery progress parameters if deemed necessary and adding specific guidance to the customer in the app, which all have a priority percentage of 3% each.

To conclude the QFD analysis results, the most efficient ways the case company could help the dealers achieve shorter lead times would be to focus further investigation on how they could contribute to the top five “how`s”:

1. Providing road freight delivery information earlier.
2. Improving the reliability of OMS ETA information.
3. Altering OMS ETA parameter or move to real time tracking.
4. Requesting a less fluctuating monthly production allocation from the factory.
5. Increasing central stock levels for accessories.

Based on the conducted analysis, these actions could improve the process quality/efficiency considerably as they represent 71% of the total CTQ priority importance. However, these aren’t all the improvement possibilities worthy of a further look, as further rolling-out the vehicle service efficiency pilot and investigating automation possibilities for accessory ordering could also provide considerable upside. The remaining four “how`s” could provide less significant improvements and therefore the analysis results indicate that they could be considered later if deemed necessary.

5. Conclusions and discussion

Chapter five acts as the final chapter of this paper and presents conclusions and discussion. The first section answers the research questions and covers the managerial implications and contribution of this paper. The second section being the last section of this paper, discusses the validity and limitations of the research and provides recommendations for future research.

5.1 Findings, managerial implications, and contribution

To answer all four research questions the author conducted two-phased empirical research for this case study. Phase one was designed to answer sub-question (SQ) 1 and provide the base for answering the main research question (RQ). Phase two answered sub-questions 2 and 3 and were designed to further support answering the main RQ. All three sub-questions play a crucial role in forming the holistic understanding required to tackle the main RQ. For this study it can be stated that all the research questions have been answered and the goals for this study have been met. When answering the research questions below it makes logical sense to start from the sub-questions and then move to the main research question.

SQ1: *What areas generate the most non-value-added time in the downstream supply chain?*

Via value stream mapping it was defined that a lot of the total non-value-added time was generated at the authorised retailers and at HUB1. On average these two stages represent a majority (67.8%) of total average lead-time for the downstream supply chain in question. The 5 whys analysis that followed the VSM, implied that a considerable portion of the non-value-added time in HUB1 was due to the shipment schedule, which isn't sensible to shorten, mainly due to cost and cargo efficiency. Authorised dealers, who are the final link in the DSC complete a long list of tasks, which naturally take their fair share of time, for example pre-delivery service and accessory installation. Processes completed at the dealers represent almost half (47.5%) of the overall DSC lead-time and includes a considerable amount of non-value-added time. Temporary storing of vehicles was discovered to be responsible for a substantial portion of the downtime.

SQ2: *What influences dealer lead times?*

A series of voice of process interviews were carried out with a total of six authorised dealers including eleven interviewees. Based on the interviews and analysis, 12 themes were identified. These themes represent factors and variables that the interviewees described to influence their lead times. Out of the twelve themes, five to seven were stated to considerably influence dealer lead times either by all or most of the six authorised dealers. The seven most significant themes relate to: information, accessories, planning, internal resources, supply flow, customer, and seasonality.

SQ3: *What factors should the case company focus on to support dealers to achieve shorter lead times?*

Based on the VoP interviews the author formed a quality function deployment matrix. The author identified the following factors to be most important to dealer process efficiency and lead times: dealer process downtime, quality of delivery/ETA information, planning conditions, accessory availability, supply flow fluctuation, efficient utilisation of resources and dealer morale. Via the QFD matrix it was concluded that dealer process efficiency and lead times could be improved by focusing on the following actions: improving the reliability of OMS ETA information, providing road freight delivery information earlier, OMS ETA parameter alteration for example to be based on real time tracking, requesting less fluctuating monthly production allocation, and increasing central stock levels for accessories.

RQ: *What aspects could be improved in the downstream supply chain of an automotive company to shorten lead times?*

The overall results suggest that as in many other complex processes there is a considerable amount of non-value-added time in the studied downstream supply chain. Non-value-added time primarily stemmed from the cars waiting lengthy periods at each of the five DSC stages. Some of the wait is caused by design, as for example optimised shipment schedules and service level agreements. The in-depth focus of this empirical case study was directed to the final stage of the DSC, being the authorised dealers. This however in no mean intends that it would be the only stage where the process could be improved, as almost all the other stages had also relatively low shares of active time, meaning the share of individual lead time that goes towards value adding or otherwise essential activities. In the first part of the empirical research, it was also stated that HUB2 could also be a stage to conduct further research on. As the DSC is a large and complex process it made sense to focus further research on the most time-consuming stage of this process. The results of this empirical case study indicate that the following factors are the most important ones that could be improved:

- ✓ Dealer process downtime
- ✓ Quality of delivery/ETA information
- ✓ Planning conditions
- ✓ Accessory availability
- ✓ Efficient utilisation of resources
- ✓ Supply flow fluctuation
- ✓ Dealer morale.

Additionally, the results provided recommendations for the case company to focus on the following improvement actions to promote DSC process efficiency and shorten automotive downstream supply chain lead times:

1) Providing road freight delivery information earlier
2) Improving the reliability of OMS ETA information
3) Altering OMS ETA parameters or move to real time tracking
4) Requesting a less fluctuating monthly production allocation from the factory
5) Increasing central stock levels for accessories.

Some of the above-mentioned improvement recommendations can be impacted by external challenges due to the ongoing global supply challenges related to COVID and the war in Ukraine. However, this doesn’t mean that they shouldn’t be attempted to be improved now. Once the global supply situation normalises, information reliability, timing of provided information, supply flow of vehicles and availability of accessories are very likely to remain as the key pillars for running the automotive downstream supply chain efficiently. It is probable that there will always be another global supply crisis behind the corner and therefore they shouldn’t be considered as barriers for improvement but rather as challenges to overcome.

The empirical case study presented is practical in nature. Both lean and six sigma tools have been utilised in this study focusing on downstream supply chain improvement. Findings present understanding of the current state downstream supply chain in scope via value stream mapping and a high-level analysis of what are the primary reasons for non-value-added time at each of the five stages, what is the most logical single stage to focus on first to improve, what factors cause friction and delay the final stage of the DSC. Additionally, the study presents which of the factors have the greatest significance and provides suggestions on what should be focused on to improve performance. Based on this study the case company can further investigate how to implement these improvement recommendations and take them into action.

During the VoP interviews, many of the dealers emphasised that dealer lead times are a genuinely important issue also to them. This is because as like the case company, dealers only generate revenue on a car once it has been delivered to the customer and therefore, they aim to deliver cars as quickly as realistically possible. Also, the faster vehicles are delivered to customers the earlier space and resources for other vehicles. This means that interests are aligned and there is genuine shared interest to improve the process. As forecasting has become a lot more difficult (unreliable) due to COVID and the Ukraine War, it appears that the base for current fixed OMS parameters seems to have suffered severely, as there is greater variance and discrepancies occur on a frequent basis. This should be addressed along with the need to provide the dealers a reliable road freight "delivered by date" as early as possible, since information is paramount for the process to be more efficient.

Prior academic research has described downstream supply chain improvement as an understudied area in automotive SCI literature (El Kihel et al. 2019; Cirita & Glaser Segura 2012; Narayanamurthy & Gurumurthy 2015). This paper contributes to this scarce area of research from the perspective of automotive DSC improvement in the Finnish market. As covered in chapter two, existing automotive SCI research have utilised VSM (El Kihel et al. 2019; Saraswat et al. 2015; Vinodh et al. 2012). The tools suitability for automotive industry related studies, is further supported by this paper. The other Lean and Six Sigma tools (5 whys, VOP and QFD) utilised in the authors research, were also demonstrated by this study to be applicable for automotive DSC improvement projects. From the author`s experience on this paper, out of the four tools 5 whys and QFD are more exposed to the researcher's own interpretations and therefore leave more room for debate. Remarks made during the empirical research on information sharing, support prior downstream supply chain related research findings that have concluded the following:

- A company that is looking to improve DSC performance should focus on the ways knowledge is being shared amongst the participants and the quality of shared information (Shih et al. 2011).
- IT and system integration can be a viable way to improve DSC performance McLaughlin et al. (2003).
- Even though information sharing is important throughout the supply chain, the significance of information on inventory (current and future) increases further down the SC (Groson & Donohue (2005).

The results of the empirical case study highlighted that information flow, timing of information and the reliability of information, considerably impacts performance/lead time. System integration isn't a necessity but based on VSM illustration and VoP interviews, it can cause friction in information flow and quality at the stages where system integration is impartial or close to non-existent. This paper doesn't cover how critical information related issues are at the other stages of the DSC in scope, but some assumptions can be made from the information gathered from the case company and its authorised dealers.

Many academic papers on SCI are either focused on Lean tools or Six Sigma tools. There are papers which discuss Lean and Six Sigma philosophies together, however academic papers such as this that cover practical implementation of Lean and Six Sigma tools simultaneously are less common. However, it is important to keep in mind that existing literature does discuss and recognise overlap among lean and six sigma tools.

To summarise the main contributions of this research, is that it thoroughly illustrates how DSC improvement is conducted at an automotive company by utilising multiple Lean and Six Sigma tools. This is something that to the author`s best knowledge hasn't been presented in a similar way in earlier automotive DSC improvement academic publications. Additionally, this research provides the case company a thorough analysis on their DSC, based on which recommendations are provided for what the case company should focus on to improve process performance and thus shorten lead times.

5.2 Validity, limitations, and future research

Validity of this research has been enforced by design thorough a well-planned data collection process including a wide group of relevant case company employees for the first part of the empirical study and with a considerable sample size of authorised dealers and their knowledgeable representatives for the second part. Only knowledgeable and experienced subject matter experts were included in the data collection process and all together it can be estimated that the experts involved had a couple of hundred years of combined experience on working in the automotive industry and at the case company and/or its authorised dealers. Further actions to ensure validity were transcribing all the gathered data, coding it, and analysing it; also, the authors understanding was supported by two field visits.

The first part of the empirical study can be considered at minimum theoretically valid due to the utilisation of historical data, consultation with subject matter experts and group verification of the VSM. Certain suppliers and stakeholders could have been more involved in the process, however in terms of forming a valid higher-level understanding of the process this wasn't necessary and would have added an additional level of complexity to an already extensive and laborious process.

To test the VSM in practice and deepen understanding of how vehicles individually proceed in the downstream supply chain, the case company could run a practical experiment. This would be supported also by the fact that dealers weren't fully able to specify the exact volume and extent of car deliveries not in being in line with OMS ETA. Some of dealers mentioned considerable irregularities especially with how long the cars can spend time in the two logistics HUBs. Testing could be done for example via an experiment where a pre-determined number of vehicles would be tracked (using trackers) after leaving the factory and enabling the monitoring of precise individual lead times and movement from HUB1 all the way to authorised dealer.

The results for the second empirical part (VoP and QFD) can be considered valid as the author collected a vast amount of data and analysed it in a systematic and thorough manner. The second phase of analysis may however be more vulnerable to cognitive biases and the authors own interpretations on the data. As mentioned, a considerable sample size of authorised dealers and their highly experienced and knowledgeable experts were interviewed. The author conducted the analysis of the data collected from six dealers and a total of 11 interviewees and the outcome represents the whole sample size. Thus, it may be that the importance on certain matters may somewhat differ from the view of a single dealer and or interviewee, but this doesn't diminish the validity of the overall results.

Like all research this study has its limitations since research without them would be endless. The research has been carried out as a single company case study and its downstream supply chain. Other limiting aspects are that the paper covers a case company operating in the Finnish market and specifically in the automotive industry. Regarding the industry in question this study was limited on passenger cars and ruled out LCVs. Although the conducted research is rather extensive, especially considering the nature of this paper (master's thesis), the author narrowed the focus for a deeper analysis on only one of the five stages, meaning that there most likely still is valuable insight to be made from the other stages, considering the overall process efficiency. The study's aim was to illustrate which areas in the DSC could be improved and provided recommendations on what improvements should be focused on. Thus, implementation of the recommendations and their results isn't included. This could be something to be done in another research.

The chosen Lean and Six Sigma tools and the way they were used, proved to work for conducting this type of research and therefore they could be seen applicable for other similar SCI endeavours. This opens opportunities for further research. One possibility would be to run the same research for a different market and see whether the results are comparable. Similar type of research where the same tools are utilised could potentially be replicated also for a company operating in another industry. Future research could be focused on what areas in downstream supply chains could/should be improved also in a cross-industry analysis. When considering from the perspective of academic studies on automotive downstream supply chain improvement, this study provides answers for this specific case company in the Finnish market. Therefore, from an academic point of view it could be interesting to see what type of results could be discovered from a higher-level multiple case study. A multiple case study wouldn't necessarily need, and most likely couldn't have the same level of detail but could instead try to investigate what areas are found challenging or important more from the overall industry perspective.

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