ENSURING SPARE PART MATERIAL AVAILABILITY BY IMPROVING PROCUREMENT DATA QUALITY WITH AUTOMATED REPORTING

Lappeenranta–Lahti University of Technology LUT

Master's degree programme in Industrial Engineering and Management

2023

Arvi Pahkamäki

Examiner: Docent Jouni Koivuniemi

ABSTRACT

Lappeenranta–Lahti University of Technology LUT

LUT School of Engineering Science

Industrial Engineering and Management

Arvi Pahkamäki

Ensuring spare part material availability by improving procurement data quality with automated reporting

Master's thesis

2023

65 pages, 9 figures, 1 table and 1 appendix

Examiner: Docent Jouni Koivuniemi

Keywords: After-sales, spare part, Power BI, data quality, data availability, automated reporting, material availability

With the Industry 4.0 technologies taking over industries, the ways of conducting procurement and ensuring material availability is changing. Vast amounts of data are being produced and used daily, and organizations are becoming more reliant on the data to perform purchasing activities. Importance of keeping up the quality of data has increased, as the poor-quality data can incur problems for the organization's operation, which can have long lasting impacts on the revenue and customer satisfaction. Value of the data is directly linked to its quality, and by increasing the quality, the value also increases. One of the main aspects of data quality is data availability, meaning how easily the data is accessible at any given time.

The case company has used material reporting to increase the spare part material data availability. This report was manually created to a spreadsheet, and it includes otherwise quite difficult to access data from the company's systems. Goal of this study was to create a new RPA-powered report with visualizations, to enhance the usability of the report. The effect of this new report on the data quality and material availability was studied as a case study and data was collected by interviews with the company's employees.

Results of this study indicate that the report has increased the data availability and it can be utilized for procurement data validation. As the data availability increases, employees have better access to reliable data which helps them to better focus action to materials that are suffering from low availability. By doing these actions, the overall spare-part material availability can be ensured.

TIIVISTELMÄ

Lappeenrannan–Lahden teknillinen yliopisto LUT

LUT Teknis-luonnontieteellinen

Tuotantotalous

Arvi Pahkamäki

Varaosamateriaalien saatavuuden ja hankintatietojen laadun varmistaminen automaattisen raportoinnin avulla

Tuotantotalouden diplomityö

2023

65 sivua, 9 kuvaa, 1 taulukko ja 1 liite

Tarkastaja: Dosentti Jouni Koivuniemi

Avainsanat: jälkimarkkinointi, varaosat, Power BI, datan laatu, datan saatavuus, automatisoitu raportointi, materiaalien saatavuus

Industry 4.0 mahdollistamien teknologioiden käytön lisääntyessä, yritysten materiaalien hankinta ja niiden saatavuuden varmistaminen muuttuvat. Yrityksissä tuotetaan ja käytetään suuria määriä dataa päivittäin ja myös materiaalien hankinta on entistä riippuvaisempi datasta. Datan laadun ylläpitämisen tärkeys on korostunut, koska huonolaatuinen data voi aiheuttaa ongelmia yrityksen toiminnalle, jolla voi olla pitkäaikaisia vaikutuksia liikevaihtoon ja asiakastyytyväisyyteen. Datan arvo on suoraan yhteydessä sen laatuun, joten parantamalla datan laatua myös sen arvo kasvaa. Yksi datan laadun tärkeimmistä näkökulmista on datan saavutettavuus.

Työn Case yritys on parantanut varaosamateriaalitietojen saavutettavuutta materiaaliraportoinnilla. Tämä raportti on luotu manuaalisesti laskentataulukkoon, ja se sisältää tietoja yrityksen järjestelmistä, jotka olisivat muuten työlästä löytää. Tämän työn tavoitteena oli luoda uusi RPA:ta hyödyntävä visualinen raportti parantamaan materiaalitietojen käytettävyyttä. Tämän uuden raportin vaikutusta datan laatuun ja materiaalien saatavuuteen tutkittiin tapaustutkimuksena, jossa empiirinen data kerättiin haastattelemalla yrityksen työntekijöitä.

Tämän tutkimuksen tulokset osoittavat, että raportti on lisännyt materiaalidatan saatavuutta ja että sitä voidaan hyödyntää hankintatietojen validoinnissa. Datan saatavuuden lisääntyessä työntekijöillä on parempi pääsy luotettavaan tietoon, mikä auttaa heitä keskittämään korjaavia toimenpiteitä materiaaleihin, joiden saatavuus on heikko. Näillä toimilla voidaan varmistaa ja parantaa varaosien saatavuutta.

ACKNOWLEDGEMENTS

This master's thesis concludes my studies at LUT-University. My time at the university has had its ups and downs, mostly due to the recent pandemic, but somehow it all has directed me to the path I am now following.

First, I want to dedicate this thesis to my grandparent, especially to the ones who are not here to see the graduation of their grandson. I want to thank my family for showing support and believing in me for the entirety of my life. I want to thank my girlfriend for her support during these last six months.

I want to thank my friends, the ones who have been with me from the start and the ones whom I had the pleasure to meet in Lappeenranta. Thank you for making my time in the university rememberable for years to come.

I want to express my gratitude to Docent Jouni Koivuniemi from LUT-University, for being the examiner of this thesis, and for providing valuable feedback to improve it in the final phases of the project.

Finally, I want to thank the case company for providing me with the topic for this thesis and for the freedom to do this my way. Thank you to all the colleagues who showed interest in this topic and to those who participated in this work. Thank you to my supervisor and the examiner of this thesis in the company.

Arvi Pahkamäki

Tampere, 12.6.2023

ABBREVIATIONS

BSR	Buyer-Supplier Relationship
DAX	Data Analysis Expressions
ERP	Enterprise Resource Planning
GR	Goods Receipt
KPI	Key Performance Indicators
MDM	Master Data Management
OEM	Original Equipment Manufacturer
PDT	Planned Delivery Time
RPA	Robotic Process Automation
SCM	Supply Chain Management
SQL	Structured Query Language

Table of contents

Appendices

Figures

Tables

1 Introduction

1.1 Background

Digitalization has been the driving force for changes in recent decades. Industry 4.0 has revolutionized the way of doing business with the introduction of data analytical possibilities to the day-to-day work (Jahani et al. 2021). The vast amount of data being produced and collected has a great potential to help organizations to optimize their performance. To achieve this, the visualization of data is a key aspect in turning the vast amounts of numerical and text-form data into usable information (Kubernatova et al 2018). Within the ever-changing and fast-paced world of technology industries, keeping the organization up with the trends is necessary to achieve competitive advantages over competitors.

In today's world with endless amounts of data, the definitions for data, information, and knowledge are sometimes defined differently regarding the area of research (Miksch et al. 2020). Ackoff (1989) presented a data-information-knowledge-wisdom (DIKW) hierarchy model for understanding the relationships between these three terms. This model distinguishes these terms by the type of question those could answer. Data is the collection of symbols and numbers. Information is data that is processed to a more useful format, answering to questions like "what", "where", and "when". Knowledge is answering to "how" questions with information gained from data. (Ackoff 1989)

Going forwards, this thesis uses above mentioned definition when discussing about data and information. Turning this data into knowledge and business intelligence requires the willingness to do so from organizations. The benefits gained from introducing report automation and improved quality of material procurement data to spare part procurement processes, need to outweigh the costs and risks that the organization takes when venturing into the world of data-driven decision-making.

In this thesis, we will be looking at how data management and automatized reporting in the form of improved item data availability and data reliability can help in spare part availability in after-sales business. This thesis is done as a single case study, where the

case company's key spare part report is transformed into visualized and automated Power Bi report, and its impacts on material availability and effects on the procurement team are studied. The main goal of this thesis is to improve the material availability in the after-sales department of the case company by enhancing the availability and the quality of the spare part material data, which will help in directing the corrective actions to the right materials.

There was a limited number of previous studies about material reporting combined with automated reporting. Most of the studies found were focused on the healthcare sector, which results have no correlation to the manufacturing technology industry or after-sales business. Material availability and ways to improve and ensure it has been studied before in various ways, but the data management approach seems to be quite uncharted research territory. This study combines the view from the after-sale business to the possibilities of report automation in a way that the spare part material availability can be ensured by incorporating modern practices into the spare part purchasing unit's daily work.

1.2 Aims and limitations of the thesis

The main focus of this thesis is the so-called TPD-report that is used in the case company. This report is a listing and analysis of the actively sold and used spare part materials which have been in use for a few years. The name "TPD" comes from the availability class codes that are assigned to all the spare part materials in the company ERP's material master. Availability classes are "T" for the stocked items, "P" for the items that are used in after-sales production, and "D" for the items that are sold with delivery time. This availability class is the main data field that guides the material in spare part sales and in procurement, in terms of the delivery times, how much stock is kept on hand, and what kind of visibility the customers have on the material in the company's online spare part ordering platform.

The aim of this thesis is to create an automated material data report and study the impact of automated procurement data reporting on spare part availability. This study looks at the data correctness and data availability, and in addition, what kind of effects the automated material reporting has on the team's work, that is creating and using the report. The goal is to end up with an automated TPD-report that is in the condition to be used daily in the organization, but this does not limit any future improvements and iterations of the report. This implies that the report in its present state is deemed fit for its intended purpose by the

case company, yet it remains open to further modifications or enhancements that may be deemed necessary or desirable at a later time. In other words, submitting the report does not signify the end of the development process, and it is subject to further refinements or updates in the future, as well as this report may be used as a base for other similar reports.

The main research question in this thesis is "*What possible impacts does automated material reporting have on ensuring spare part material availability?"* By making the material data more coherent and more easily accessible, does this have any effects on the perceived spare part material availability in the company and to its customers. The availability of materials in the after-sales service industry is a critical factor as it directly affects the level of satisfaction of customers (Kurata 2014).

The main research question is supported by two sub-questions, the first one being: *"How does automated material reporting improve the accessibility to the material data and efficiency in the use of the report?"* First, in order to answer this question, the automated report must be built, and after that, the impacts of the report can be studied. This question focuses on the probable positive impacts that are derived from using automated reporting in terms of the availability of the information and its effects on the organization using it to its advantage.

The second sub-question is: *"How does automated material reporting decrease data errors and improve the reliability of the material data?"* This sub-question is about data correctness and aims to find out if the number of errors in material data can be reduced by using the automated material reporting tool to seek out possible defects more proactively in the data. In this thesis when we are talking about data, it specifically means the material data that is used for spare part procurement, inventory management, and sales.

This thesis and case are limited to after-sales spare part materials and automated reporting regarding material procurement data. Since this study only focuses on one company and its specific business unit, it has some limitations regarding the reproducibility of results on in other business cases. This implies that the findings and conclusions of this study are only relevant to this particular case. Also, the sample size of the empirical part of this study is quite limited as it focuses on procurement professionals in the case company's spare part procurement team. On the other hand, if more people had been interviewed for this case,

the results of the research could have been different due to the possibility of obtaining data from more varied perspectives.

1.3 Research methodology

This study was conducted as a single case study where the target of the study is a case company's after-sales business unit and more specifically its spare part procurement and inventory management team. According to Yin (2009), a case study focuses on real-life phenomena and contemporary events, and for a case study, research questions are in the form of "how" and "why". Other characteristics of a caste study are that the study is limited to one individual unit, as an example a group of people or a team, of study and this unit could be studied in multiple ways, for example quantitively or qualitatively, or methods could be combined (Flyvbjerg 2011).

The case study method is widely used in academic studies, but its significance in contributing to wider academic research has been questioned. Case study as a study methodology has been criticized for its lack of potential to generalize the study results to a wider audience, and that the studies are missing external validity. (Cartwright 2022) This means that the results and conclusions of a case may not be comparable to other situations. It has been also stated that case studies have a tendency to validate preconceived concepts and case studies may be biased on the researcher's preferences and personal opinions (Cartwright 2022; Flyvbjerg 2011).

This research is centered around a particular business unit within a company, specifically their after-sales spare part procurement and inventory management operations. Since this study exclusively investigates a single target, it is classified as a single case study. The primary objective of this research is to gain an in-depth understanding of the real-life occurrences and contemporary events taking place within this unit of study. As such, a case study is a suitable research strategy for this study.

Semi-structured interviews were chosen for the data collection method, as the semi-structured interview is flexible and versatile. For the interviews, a rough structure is formed to guide the participants to talk about the topic area in discussion to collect needed information from participants. (Kallio et al. 2016) One of the advantages of a semi-

structured interview is that as an interview method, it is a two-way discussion and it enables more communication during the interview, where follow-up questions subjects can be established on the participant's responses. Said that each question in the interview should be connected to the topic of research. (Galletta 2012)

Primary data for this study was collected through 7 semi-structured interviews, which were conducted online using the company's preferred communication platform. The interviewees were chosen from the business unit by their work positions and responsibilities in order to collect versatile data from different point-of-views around this topic and to provide a comprehensive understanding of the impacts and possibilities that the automation of the material reporting has on the unit. The interview questions were firstly constructed in English, but the interviews were held in Finnis to keep the smoothly flowing conversation.

The purpose of the theoretical part of this study is split into two perspectives: resource efficiency and automated reporting perspective and supply chain and availability monitoring perspective. Resource efficiency and automated reporting perspective is focusing on improving the accessibility and efficiency of the material information and the supply chain and availability monitoring perspective is helping to focus the necessary actions for materials where the yield is low, at the same time.

These above-mentioned perspectives are supported by the literature review, where the aim is to gather further knowledge about the topics from previously published literature. Literature review in this thesis was done as a narrative literature review (Salminen 2011), where the goal was to get an overview about these topics from the existing literature. According to Salminen (2011), narrative literature review does not approach literature with strict systematic review process, and the objective is to gain insights into the topics that are being studied.

Sources for this literature review were searched from academic library databases, like LUT Primo, and from open databases, like Google Scholar. Keywords that were used included search terms like: material availability, spare part procurement, data quality management, impacts of RPA, and benefits of data visualizations. Secondary data for this thesis was collected from publications, the company's ERP system, and the company's public websites.

1.4 Structure of the thesis

This thesis is structured as follows. Firstly, the study begins with a literature review, where the existing literature on material management, spare part availability, report automation, and data visualization is reviewed. The literature review starts with an examination of item master data management, which is a critical aspect of effective material management. Then the importance of spare part availability in ensuring efficient operations is explored, and the role of automated reporting and data visualization in supporting effective decision-making is examined.

After the literature review chapter, the next chapter outlines the methodology used in the research and provides an overview of the case company. A brief overview of the case study itself is provided, including the specific challenges faced by the company and the solutions that were implemented to address these challenges. Finally, the process of creating an automated report for the case company is described in detail.

The next chapter presents the empirical findings of the research, which are based on the data collected from the case study. The impact of automated material reporting is studied, reflecting the case on the findings from the literature review.

In the final chapter, the empirical findings are reflected upon, and their relationship to the theoretical framework is discussed. The research questions posed at the outset of the study are answered, and the limitations of the research are discussed. Finally, suggestions for future research are provided, and conclusions are drawn based on the study's findings.

To sum up, this thesis is structured in a way that allows for a comprehensive study of material data management, spare part availability, and automated reporting. The literature review, methodology, and empirical findings are presented logically, with clear subsections that make it easy to follow the argument. The discussion and conclusions chapter provides a thoughtful reflection on the findings and their implications, while also highlighting areas for future research and evolvement of this report in the case.

2 Literature review

In this part of the thesis, we will be taking a look at previous literature and studies about the main theories regarding this study. Topics that are being researched are material data management and quality, availability of spare parts in the after-sales business, and report automation and data visualization. These theories are needed to further understand the effects that TPD-report has on the spare part material availability which reflects to the results of this case study.

2.1 Data management

In this section, data management is looked at from two dimensions. First is the overview of what is master data, where it used, and what is the effects of poor-quality master data. Then the ways of improving the quality of master data is studied, and what is the benefits for companies to take the time and resources to ensure effective data quality management. Insight to these parts of data management is needed to create comprehensive understanding on why data quality management is important for organizations. The negative effects that may incur from poor-quality data have deeper effects that many organizations thought them to have.

2.1.1 Master data

In organizations, the vast amount of data is being created, stored, and used for the business to operate efficiently. According to Vayghan et al. (2007), the data commonly handled by enterprises can be categorized into three groups: master data, transactional data, and historical data. In this chapter, we will be taking a look at master data and why it is important for after-sales organizations, why the quality of the data is important, and how data quality can be improved within the organization.

Master data can be defined with two main principles: firstly, it includes data that is critical to the organization's operations, and secondly, this information is shared across different departments and teams within the organization. (Väre 2019) One way to characterize

master data is that it is created once, but used multiple times and it does not frequently change. Master data refers to the fundamental attributes of business entities such as customers, products, employees, and suppliers. (Haug et al. 2011)

In the manufacturing industry, master data can also be also referred to as material master. Key components of material master are bills of materials, which include information like materials detailed descriptions, stock balances, and upcoming stock transactions. These all are essential assets that allow for access to a valuable insight into the company's manufacturing activities. (Radke et al. 2020) As this study is conducted for an after-sales organization and specifically for its spare part procurement team, the most important part of the master data is the procurement data. This includes vendor information, stock balances, and other data that controls the materials purchasing activities. Procurement data together with the material master provides all the needed information that is need in purchasing planning.

Transactional data refers to the significant occurrences in a company, such as orders, invoices, payments, deliveries, and storage records. Master data forms the basis of these transactions, so if the master data contains incorrect data, it can result in multiplying errors on the transactional data. This can result in costs for the organizations, which may be difficult to calculate as the effects of poor-quality data are often indirect. (Haug et al. 2011)

In order to understand the importance of good master data quality, it is needed to understand the effects and impacts that can occur from poor-quality data. According to Mahanti (2018), poor data quality can have negative effects on business, such as reduced customer satisfaction, higher operating expenses, revenue loss, flawed decision-making processes, time wastage, poor performance, and diminishing employee job satisfaction. Different types of costs incurred by poor-quality data are presented in Figure 1.

Hidden costs	E.g. long lead times, data being registered multiple times, employee dissatisfaction, etc.	E.g. focus on wrong customer segments, poor overall production planning, poor price policies, etc.
Direct costs	E.g. manufacturing errors, wrong deliveries, payment errors, etc.	E.g. few sales, low efficiency, problems in keeping delivery times, etc.
	Effects of poor-quality data on operational tasks	**Effects of poor-quality data on strategic decisions**

Figure 1. Four types of costs incurred by poor quality data. (Haug et al. 2011)

Figure 1 displays the four types of costs that may occur to an organization, regarding the type of data, operational or strategic data, and the type of cost, direct or hidden costs. These direct cost dimensions that incur from poor-quality data in operational tasks are easily recognized, as the effects of this are seen more visible in the organization's day-to-day activities, like in logistics and invoicing. Another dimension of poor data quality in operational tasks is hidden costs. These costs incur as well in the day-to-day operations, but the effects of the poor-quality data are not seen as effectively. In a manufacturing company, this dimension can be found in Material Requirements Planning (MRP) systems, when incorrect data is inputted into the system, and it causes the MRP system not to operate with the optimal parameters. (Haug et al. 2011)

Viewing costs derived from poor data quality from a strategic data perspective can uncover inefficient operations that have a significant impact on the company's strategic direction. For instance, using poor-quality data to make decisions can result in lost sales. Improper management of inventory locations due to poorly organized data can also lead to costs. In cases where costs from faulty data are not visible to management, the wrong allocation of costs can lead to incorrect decision-making regarding pricing policies for materials. This could occur when product profitability is wrongly calculated due to improper tracking and

allocation of costs caused by poor-quality of data. More strategic hidden costs for the organization could occur from focusing on the wrong customer segments based on flawed data, which will lead to long-term revenue loss. (Haug et al. 2011)

2.1.2 Data quality

Data quality is critical for organizations to successfully operate with ever-growing amounts of data and information. The management of data quality is a significant concern that many organizations face. This concern is expected to become even more critical due to the rising volume and variety of data, enhanced analysis capabilities, and the integration of business processes. Despite the benefit that businesses gain from the data, many do not see data as a key business resource. (Gordon 2022)

The quality of master data plays a crucial role in the quality of decision-making as well as the overall efficiency of business processes such as purchasing, production, sales, and logistics (Knapp & Hasibether 2011). Österle & Otto (2015) describes data quality as a multi-dimensional concept, that cannot be described with a single characteristic. Miller (2017) links the data quality to the value of the data, meaning higher data quality is equal to a higher value that can be get from the data. Overall data quality can be described with various dimensions of data quality which typically include dimensions like (Mahanti 2015; Österle & Otto 2015; Williams & Tang 2020, Miller 2017):

- Correctness: is the data correct regarding its real-world counterparts' properties?
- Consistency: does the different versions of the same data in other information system agree with each other?
- Completeness: are all the data attributes and values completed in the records?
- Actuality: is data in line with the current status of the real object at any point in time and will that data be modified if the status of the object is changed?
- Availability: is data easily accessible to the users at a desired point in time?

As presented earlier, insufficient data quality can lead to many costs for the organization using set data in their day-to-day operations and strategic decision-making. Silvola et al. (2011) present in their study a four-step process of different activity levels that can be used to evaluate the level of data quality in the respective organization. These data quality activity levels are presented in Figure 2.

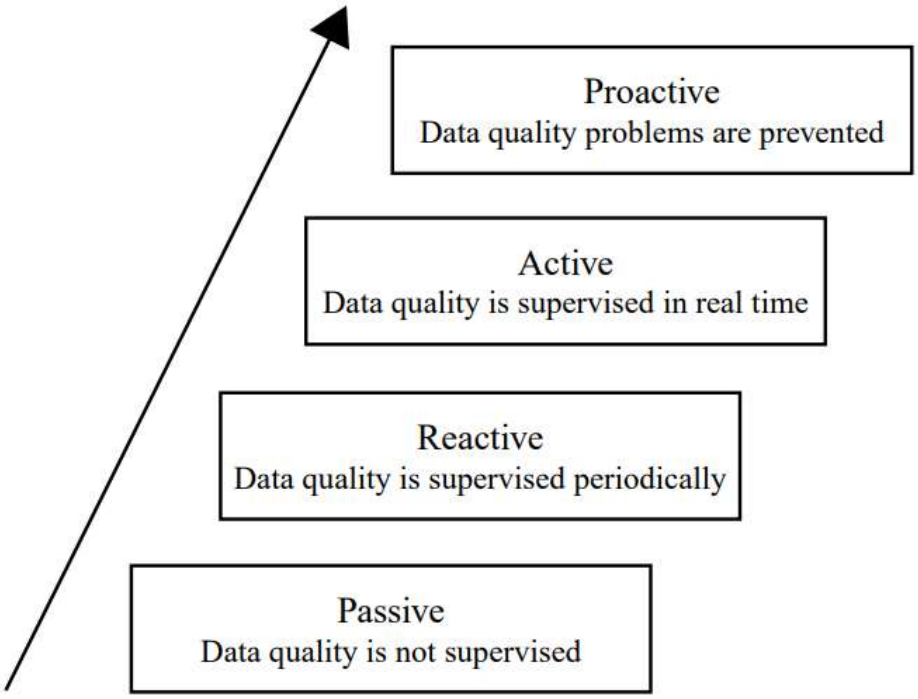

Figure 2. The data quality activity levels (Silvola et al. 2011)

The first and the poorest level of activity in this process is Passive, where data quality is not supervised at all. This means that the mishaps in data quality will result in problems when that data is being used, and those data errors are corrected once they appear. The next level is Reactive, where data quality is supervised periodically, like once every month. This will have some positive effect on the overall quality of the data as the data quality goes up after periodical supervision, but it begins to decline after it (Österle & Otto 2015).

Step up from the Reactive level is Active, where data quality is supervised in real-time, and errors in the data are corrected as soon as they are found. Although the Active level is great at reducing data errors, it does not prevent them and works as the “cure” for poor data

quality. The most admirable level is Proactive, where the goal is to prevent data quality problems before they arise and cause problems in the organization. Mahanti (2015) presents the “1-10-100 rule”, which demonstrates the benefits gained from proactive data quality management. This rule states that if cost for data verification upon data entry costs $1, data record modification and cleansing costs $10, and the potential cost of lost revenue or productivity costs $100 that can arise due to the poor quality of data (Mahanti 2015).

To summarize, master data is the basis for all data-related business activities within an organization. Any data quality problems in this data can lead to costs for the organization using it in their day-to-day activities and strategical planning in the form of loss of revenue or incurred cost from unnecessary work. Data quality can be monitored and improved with data quality management, where the most effective way is to proactively seek out and prevent data errors.

2.2 Spare part purchasing and availability

The main purpose of a supply chain is to answer to the needs of the customers, meaning the availability of resources and the overall functionality of the supply chain must be guaranteed (Heckmann et al. 2015). As a part of a supply chain, purchasing is a critical activity in any manufacturing organization, but its importance is more significant when dealing with the after-sale market and spare parts. According to Kurata (2014), the unavailability of materials does have an impact on customer satisfaction, which can lead to a loss of revenue for the organization. Extending on this, disruptions in purchasing activities can often have negative influences on other operations within an organization (Luukkainen 2019).

With the introduction of Industry 4.0 methodologies to purchasing, such as AI-enhanced material planning and advanced procurement platforms, the term Procurement 4.0 has emerged. This evolvement of digitalization in purchasing has been found to be beneficial as the procurement processes get more effective and profitable, and it becomes focused on strategic decisions and activities. Purchasing teams in organizations will have an extended role of gathering, examining, and managing internal and external data, which will assist in supporting decision-making processes. (Bienhaus & Haddud 2018)

A key aspect of a properly working procurement process is the co-operation between the supplier and the customer. Most of the day-to-day communications between these two have shifted to digital platforms and channels. Communication and information sharing through digital platforms and ERPs using channels like Electric Data Interchange (EDI) or web-based advanced communication systems, has increased the efficiency and agility, and decreased the total costs in the supply chain (Frank et al. 2019).

This improved transparency and collaboration between parties in the Buyer-Supplier Relationship (BSR) has also led to stronger relationships and increased trust as well as to a more efficient flow of information and improved accuracy in forecasting (Ghadge et al. 2020, Ussik 2021). Linking this topic to the issue of material availability, through efficient information flow any potential problems that may result from unavailability of materials can be detected and communicated during the initial stages and corrective actions can be taken to avoid or mitigate it (Ussik 2021).

For a company that is Original Equipment Manufacturer (OEM) is usually beneficial or even required to keep spare parts available through the products lifecycle (Dombrowski et al 2007). This means that the OEM needs to be able to provide the customer with spare parts for the agreed time frame or for the length of contractual agreements with customers. Some agreements include clauses for the promised service level of spare part availability, which may include agreements for repair time commitments. (Dekker et al. 2013) In these types of cases the need for ensuring spare part material availability is emphasized.

The effectiveness of the spare part supply chain and the spare part offering can be measured by using appropriate Key Performance Indicators (KPIs) (Paakki et al. 2013). The material availability from stock together with on-time delivery was defined by Chae (2009) as the main KPIs which can be used to measure the supply chain's performance. Materials from stock availability is especially relevant to spare parts that are being stocked, and these types of materials are usually either critical for the equipment's operation or they are a high-volume material. On-time delivery can be used for both the materials vendor, to measure their performance, or to the outbound deliveries, to measure how on-time spare parts can be sent out to customers based on the requested delivery date.

The goal of measuring the spare part supply chain performance is to seek out any possible disturbances in its operation. What you measure is what you will see. This meaning that if

the supply chain is measured by the on-time delivery of the outbound deliveries, the reasons affecting the deliveries being late from the required delivery date are noticed on time, and possible corrective actions can be done to address the issue.

2.3 Automated reporting and data visualization

In this chapter we will be taking a look into automated reporting and data visualization. These two topics are closely related to each other, and they are needed to disclose the importance of using these features in reporting. Microsoft's Power BI platform has the capability to create reports that utilize visualizations in data presentation and have automation working in the background to keep the report up to date.

2.3.1 Report automatization

Robotic Process Automation (RPA) has gained a lot of interest from businesses in recent years for its possibilities to reliability automate repetitive routine tasks with a high level of operational efficiency (Ng et al. 2021). RPA can be utilized in various business activities and processes to eliminate the need for a human to do the same task repeatedly. As a term, RPA has been defined in different ways, but the most commonly occurring definition is, according to Marciniak & Stanisławski (2021), a software solution that describes robotic process automation as a computer program, with the effect of, automation of work that is so far being performed by a human.

When discussing about RPA, the idea of physical robots performing tasks comes to mind. But as disclosed earlier, this robot is working in the background from a computer to complete processes that human workers used to do. The RPA software follows predetermined guidelines in order to execute the established process to get the desired outcomes. In businesses, RPA is commonly used to transfer data from multiple sources to other systems, like from spreadsheets to ERP systems. (Madakam et al. 2019) RPA software can be taught to do almost any process that humans can do with a computer, which consists of repetitive tasks and the process follows a flowchart-like model.

The nature of an RPA varies based on the use case, desired outcome, and technologies that are used to perform the tasks. The main two types of RPA are attended automation and unattended automation. As the definition suggests, these two differ from each other by the way they are executed. Attended automation is run from the user's computer when the user decides to do so to help them in process-based tasks. Unattended automation runs in the backend, usually from servers, to execute tasks in greater volume. (Mullakara & Asokan 2020) Marciniak & Stanisławski (2021) have identified different ways of approaching RPA, based on the type of task that it is performing. These can be identified as:

- *Routine tasks.* These are the process tasks that are performed with high frequency and follow a constant flow of actions. The more the same process is performed with high frequency, the more it is suitable to automate with RPA.
- *Principle-based process.* Tasks that are clearly defined with steps that forms a path for the RPA to follow. These can be tasks that are less frequent, but the process path can define with a high level of detail.
- *Structured data.* RPA can be used to unify the structure of a document by extracting the data from it. The process of receiving and reviewing invoices with different structures automatically can be used as an example.
- *Non-invasive tasks.* One way of using RPA is to teach it to mimic human actions on the user interface level. This way RPA can perform tasks, but it does not have a deeper connection to the underlying data, and it only retrieves the visible data.

In the era of Industry 4.0, where automation and connectivity are transforming industries, RPA plays a crucial role in optimizing business processes. By leveraging RPA, organizations can automate data collection from various sources, process this data, and create reports from it automatically (Madakam 2019). This eliminates the need for manual data entry, reducing human errors and ensuring access to up-to-date information. This can be seen as a form of Artificial Intelligence (AI), but in reality, RPA is in most cases a robot that follows a process, and it has been taught to handle the different scenarios that may occur during the execution. RPA processes can be enhanced with AI to increase its

resilience with error handling or other types of problem-solving (Mullakara & Asokan 2020).

The process of report creation benefits from the use of RPA. In the cases of reports that are needed to produce often or the process of creating them is complicated and time-consuming, the RPA utilization level is high. Different parts of the report creation process can be done automatically, by defining the process to the RPA software once, and then the software produces the report as described when executed. This reduces the need of doing the repetitive or complex process manually every time the report is needed.

The main incentive to implement RPA in a company's work is to gain benefits by reducing the need for manual work. Positive effects can be seen as the employees have more time to do the more meaningful tasks in their work, instead of repetitive routine tasks. This can lead to better physical and mental health as the working time is used more beneficially. For the company, this also means financial benefits, which result from increased productivity, improved quality of work, and better customer experience. These will give the company a competitive advantage in their markets. Despite the initial expenses of RPA implementation and possible risks associated with it, many companies are researching the ways to add RPA to their business. (Marciniak & Stanisławski 2021)

To summarize, report automation, powered by RPA and aligned with the principles of Industry 4.0, offers significant advantages for businesses. It streamlines the report generation process by automating data collection, report creation, and analysis. By adopting report automation, organizations can improve productivity, accuracy, and decision-making capabilities, and at the same time reduce the need for manual work, while leveraging the industry-shaping potentials of Industry 4.0 and RPA.

2.3.2 Data visualization

According to Miller (2017), the main goal of data visualization is to make a complex topic appear in a way that is much simpler. Visualization is a fundamental element of effective reporting in today's world where large amounts of data are generated and analyzed each day. Reading through a report or a spreadsheet without data visualizations can be a tedious task and the main points from those documents can be missed or lost in the sea of data.

Humans are able to process larger amounts of information in a shorter time when the data is presented or supported with visualizations. (Miller 2017)

Data visualization has proven to be beneficial. It has given the possibility to make complex topics or data sets understandable, turning the data into information, and the information into knowledge (Miksch et al. 2020). For companies and organizations, this means that the previously raw form data, which is difficult to understand, is turned into Business Intelligence (BI) with the help of visualization, which can then be used in decision-making. Visualizations are in a key role when BI is being utilized and the introduction of more powerful tools, like the Microsoft Power BI platform, has increased its quality and popularity in companies. (Kusleika 2021)

The ways of using visualizations in reporting vary, but the main goal usually is to make the information more easily understandable by visualizing it. Different ways to visualize data, like tables, bar charts, or scatter plots, have been used to achieve these goals. Next, there are some reasons why companies may choose to include data visualization in their reporting based on existing literature on the topic:

Enhances understanding and engagement. Visualizations simplifies the complex data by presenting it in a visual format that is easier to comprehend and understand. Visual elements are also able to capture attention and engage the viewer more effectively than data in text or numerical form. This allows the viewers to quickly see the main points, patterns, and trends within the data, enabling a better understanding of the information being displayed and decision-making based on it. (Miller 2017; Chen & Edwards 2020)

Enables effective storytelling. Visualization helps transform data into a story. Presenting data in a visually appealing and logical manner, enables the report maker to tell a convincing story and convey a clear message. Visualizations have the ability to evoke emotions, highlight important points, and guide the viewer through the information that is being presented which will lead to a more beneficial reporting experience. (Chen & Edwards 2020; Kusleika 2021)

Supports data exploration. Visualization provides an interactive and exploratory experience for the viewer. By using interactive charts, graphs, or dashboards, users can investigate deeper into the data, manipulate variables, and find insights that would be otherwise hidden. This interactivity encourages a greater understanding of the data and

enables the viewer to make their own conclusions based on the data. (Miller 2017; Lee et al. 2020)

Enables data-driven decision-making. Visualization is a powerful tool for decision-making. It helps stakeholders, managers, and analysts quickly identify trends, correlations, and outliers in the data. By visualizing key metrics and performance indicators, decision-makers can gain a holistic view of the situation, identify areas for improvement, and make informed decisions based on data-driven insights. (Miller 2017)

Enhances data transparency and communication: Visualization promotes transparency and credibility in reporting. By presenting visualized data, it becomes easier to communicate complicated information in a transparent and understandable way. Also, visualizations are a common language, and it enables understanding of the data to a wider audience. Visualizations can bridge the gap between technical and non-technical individuals, enabling effective communication across teams and departments. (Lee et al. 2020; Chen & Edwards 2020)

To summarize, data visualizations play a vital role in effective reporting by making complex data accessible, engaging, and understandable. It enables effective storytelling, supports data exploration, facilitates decision-making, and enhances transparency and communication. By leveraging visualization techniques, report creators can deliver more effective and convincing reports which promote data-driven decision-making in the company.

3 Methodology, case, and case company

In this chapter we are going through the case in more detail and how this study is trying to solve it. First, we will discuss about the study method in this thesis and then taking a deeper look in to the case and the case company. Finally, in this chapter, we discuss how the case was executed for the case company and how the data collection and analysis was carried out.

3.1 Methodology

Within the realm of research, there exist several strategies that can be employed. In this context, a research strategy can be defined as a systematic plan devised by a researcher to obtain answers to their research questions. The selection of a particular research strategy is influenced by factors such as the research questions themselves, the objectives of the study, the available resources, the time constraints, and the overall purpose of the research. (Saunders et al. 2016)

Typically, research methods are categorized into two main types: qualitative and quantitative. In simple terms, quantitative methods involve the use of numerical data, while qualitative methods involve non-numerical data. Additionally, the methods of data collection and analysis differentiate these approaches. Quantitative research often employs questionnaires, while qualitative research tends to rely on interviews. However, this explanation is oversimplified and limited. It is important to note that studies can also employ a combination of both quantitative and qualitative methods. In such cases, the study is referred to as a mixed methods study. (Saunders et al. 2016)

According to Yin (2009), case study research places a strong emphasis on investigating real-life phenomena and contemporary events. It is particularly suited for research questions that seek to understand the underlying mechanisms and reasons behind certain occurrences, exploring the "how" and "why" aspects of a phenomenon in its natural context. (Yin 2009) One of the defining characteristics of a case study is its concentration on a specific unit of analysis. This unit can be an individual, a group of people, an organization, or any other identifiable entity. Additionally, case studies offer flexibility in

terms of the methods employed for data collection and analysis. During the research, there is a choice to employ various approaches, including quantitative, qualitative, or mixed methods, depending on the research question and the nature of the case being studied. (Flyvbjerg 2011) The main parts of the research process in this study are presented in Figure 3.

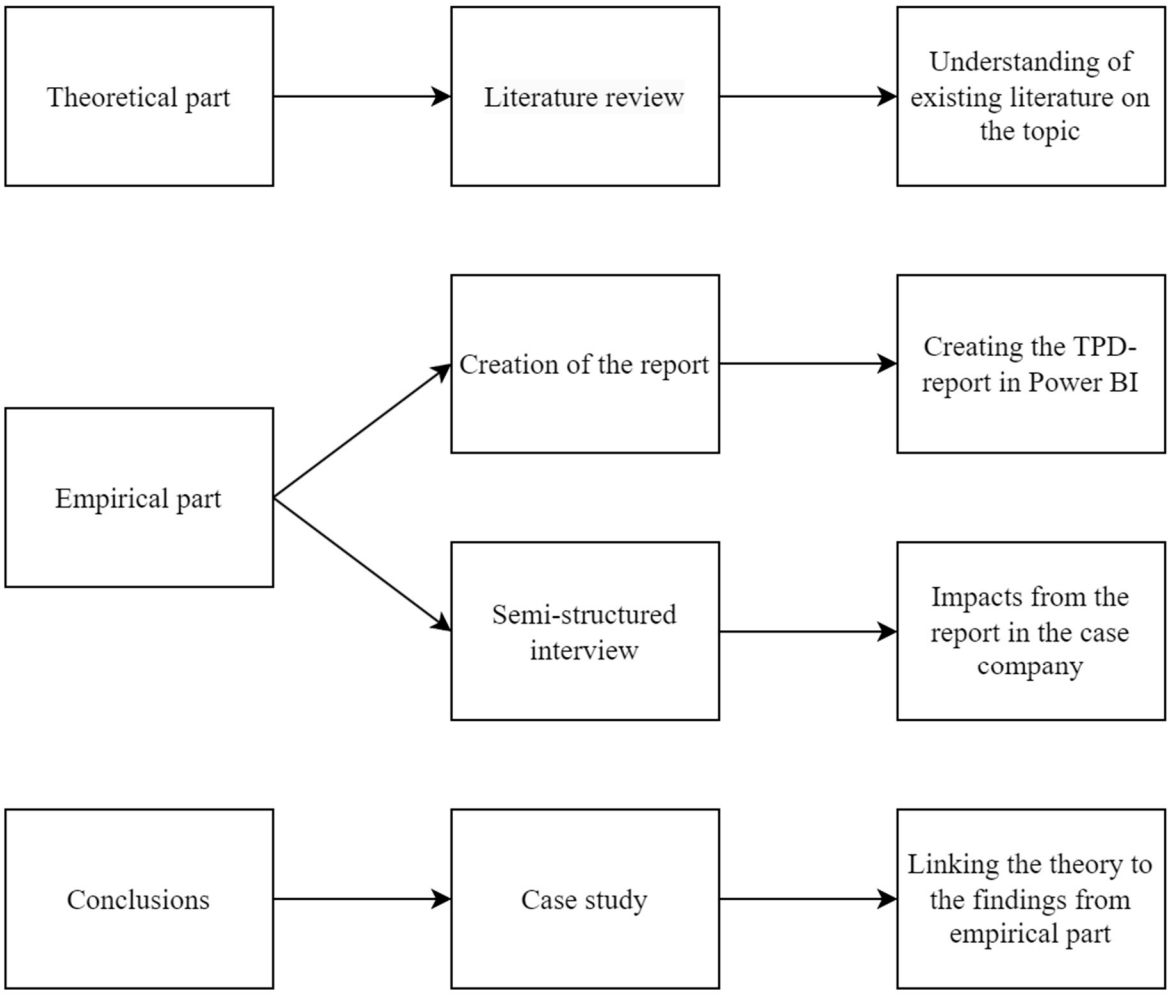

Figure 3. Main parts of the research process in this study

The methodology in this thesis combines qualitative methods and a case study approach. Qualitative methods involve collecting non-numerical data through interviews to understand the research topic in-depth. The conducted interviews with participants gave detailed insights into their experiences and perspectives around the topic. The case study approach was used to examine specific cases aligned with the research questions. It

allowed for a thorough analysis of the contextual dynamics and relationships within the selected cases. Data from interviews and observations were collected and thematic analysis was applied to identify recurring patterns and themes in the qualitative data. By utilizing qualitative methods and a case study approach, together with narrative literature review in the theoretical part, this research aims to provide a comprehensive exploration of the research subject and answer to the research questions.

3.2 Case company

The case company in this study is a multinational electrical equipment manufacturer and more specifically its after-sales business unit's purchasing and inventory management activities. The company operates in over 100 countries and has 110 000 employees in total. In Finland, this company has around 5 000 employees, four manufacturing plants, and about 20 locations. The company wished to stay anonymous in this study and some data and information will be withheld from this report.

Due to its size, the company has divided itself into various divisions, and the division under research in this study primarily operates in Finland. This division focuses on manufacturing products that enhance the efficiency of electric motors and are widely utilized in different industries. In Finland, this division operates a factory, a factory warehouse, and a warehouse for the service business operation. Specifically, the study was conducted within the after-sales department of this division. The after-sales department is responsible for managing activities such as warranties, spare parts, and small-scale production, as well as other service-based business offerings.

3.3 Case

The case company started to produce their own material reporting a few years ago. This report was formed once per quarter, four times per year, as a spreadsheet that combines key material data from the company's ERP system. This report was used mostly as a basis report for other analyses, as it has already combined the mostly needed information from different sources. There was quite a lot of manual work involved when combining this TPD-report, as the required data is scattered between multiple ERP tables that need to be

loaded for the report. This process took about one working day, as the loading of the data was quite slow and the combination of data from the sources was manually done on the spreadsheet.

This spreadsheet version of the report also lacked some functionalities that the users had wished for during its use. One of the main criticisms was that it was only created once every quarter, and therefore by the end of the lifecycle of every quarterly version, before the next one was being created, the information on the report could be vastly outdated. Also, many users had wished for better usability and clearer presentation of information, which could not be achieved with the spreadsheet version. The responsibility of creating this report mostly landed on trainee workers in the team, so it would not take time from the other workers, as this took a minimum of one day of work to be compiled. This led sometimes to situations where data was compiled incorrectly, and thus the published reports may have had incoherent information.

The case in this thesis aims to make the TPD-report more functional by transferring it to the Power BI paltform. To achieve this, the necessary data tables will be moved from the company's ERP system to the company's SQL server. Once a day, the required data for the Power BI report will be retrieved from the SQL server, ensuring that the information on product, procurement, and consumption of actively sold spare parts is up to date for analysis. By transitioning to the Power BI report, the process of updating, using, and sharing the report will become more agile and accessible to those who need it. Additionally, new functionalities can be incorporated into the report, such as weekly tracking of material availability and inventory levels, and data validation capabilities.

The need for modernizing the TPD-report has been evident for some time due to its growing popularity beyond the Supply & Inventory Management team. Users of the report have desired for some time now for a visually appealing, user-friendly, and automatically updating version for this multi-purpose tool, that has all the needed information which can also be trusted. Furthermore, there is a requirement for weekly monitoring of the material situation, particularly during supplier meetings, to enhance transparency in order scheduling and escalation processes.

3.4 Power BI platform

This case is built around the Power BI platform, which is a business intelligence and data visualization platform developed by Microsoft. It enables users to retrieve data from a variety of sources, create interactive dashboards, and generate visually appealing reports and data visualizations. Power BI provides tools for data preparation, modeling, exploration, and collaboration, allowing users to gain insights from their data and make informed decisions. The Power BI platform's main components are Power BI Desktop and Power BI Service. The desktop version is more focused on dataset and report creation, and it has tools for data modeling as well as data visualization. Power BI Service is a cloud-based service, mostly used for report and dashboard sharing within an organization. From the Service, user can create their own data visualization dashboards for their needs, from the reports and data models created in the Desktop version. (Microsoft 2023a)

Power BI has great built-in tools for performing calculations and data re-shaping within the platform. Calculations in Power BI are done by using Data Analysis Expressions (DAX) language, which provides a set of tools like functions, operators, and constants. These tools can be used to create formulas or expressions that perform calculations and generate results in the form of values or data transformations. DAX is mostly used when creating measures or calculated columns that are used for calculation with the data from the dataset. (Microsoft 2023b)

The Power Query tool allows the report creator to define a set of actions or rules to transform and shape the retrieved data to a more optimized and usable format. These rules involve tasks such as renaming columns, sorting the data, merging, or removing columns, eliminating outliers, and filtering out specific rows based on set criteria. This option to filter out unnecessary rows and remove unused columns reduces the total volume of data in the report and speeds ups, for example, report loading times. (Microsoft 2023c)

Power BI was chosen as a platform for this TPD-report as the company has been using it for multiple years and they have also utilized it in other reporting. Company personnel are familiar with the mechanics needed to use the reports in their daily work and other infrastructure, like data source connections, have been made to suit Power BI for most of the needed data for this project. Also, this platform offers the needed tools to create

reporting that combines data from the company's sources and displays it in visually appealing reports.

3.5 Creating the automated report

The creation of the automated TPD-report started in late 2022, although the planning for this report automation was idealized during the summer of the same year. The rough plan for the process of the creation of the automated report is presented in Figure 4. This plan was carried out from January to June during the year 2023.

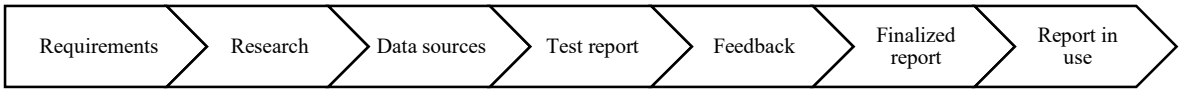

Figure 4. The process of creation of the automated report.

The first steps were the planning and requirements gathering. Requirements were gathered from the main user groups of the report, including the after-sales sourcing and procurement teams. Most of these requirements were about how the earlier spreadsheet version of this report could be improved and the main requirements were that the report is automated and updated daily. Some of the other requirements were that the report needs to be easily sorted to show the information that the user wants to see and that the report should be easily scalable for new items and new data fields. It was agreed that the report will display the main data in matrix table visualization, and this will be accompanied by other more informative visualizations, like bar charts for material consumption over time and gauge charts for current stock availability in contrast to the determined safety stock value.

Some research was needed in regard to how these types of projects are carried out in the case company and what is needed to start the development process. As I had not done Power BI reporting in this scale for the case company, first we had to sort out the needed permission to access the company's data in their SQL database. This included two databases where four different data tables were accessed and loaded to be part of the report. Permission was also needed to access their Power BI service workspaces in order to

make the report public to users in the report testing phase as well as publish the final report later in the process.

After the requirements were gathered and all the needed permissions were granted, started the building of data model and the report dashboard. Most of the needed data comes from the company's ERP system where it is uploaded to the SQL database daily, and this data is complemented with data from the company's online directory in spreadsheet format. The use of these spreadsheets in the report is not ideal, as the data in the spreadsheet is static, which means it will not update automatically. To get over this problem, only supplementary information is used from static sources.

During the development, some of the necessary data was used from spreadsheet workbooks in the company's online directory in order to test out the code and visualization in use. This data in spreadsheet workbooks was easily on hand from the previous spreadsheet versions of the TPD-report. When the initial test report was published for users to use and give comments about, the consumption data of the items was not yet built to be automatically updated daily like the rest of the report. This was later changed, as the needed data tables from the company's ERP were uploaded to the SQL database where consumption data was used from in the finished report.

Data sources were connected to the report's data model and the queries underwent pre-processing in the Power Query tool, where a set of rules was created. Some of the data tables in the SQL server included data for after-sales materials as well as data for materials that are solely used in the factory side. Rules were created to filter out any unwanted rows from the tables that weren't needed for this report. Unused columns from the tables were removed to minimize the amount of information that was pulled into the report. Data was also correctly labeled and formatted in the Power Query to ease up the creation of the report. These rules are automatically executed each time the data is refreshed from the data source into Power BI.

DAX was used in multiple instances in the report creation phase. All the calculations that were needed for this report were done with DAX, either as a calculated column or as a measure. The more complicated DAX expression took some time to get them to work as intended and to get them to output information that can be relied on. Reliability of the data

in the report was one of the main requirements in the project, as business-critical decisions will be made using that data, so the DAX calculation needed to be correct.

DAX expression from the TPD-report, which is used to calculate last year's consumption:

```
Last Year's Consumption =
CALCULATE(
    SUM(Stockturn[Total Usage Quantity]),
    FILTER(
        Stockturn,
        Stockturn[Day of Consumption] >= DATE(YEAR(TODAY())-1,1,1)
         && Stockturn[Day of Consumption] <= DATE(YEAR(TODAY())-1,12,31)
    )
)
```

This DAX expression above is an example from the report, and it is calculating the last year's consumption for materials. The dataset used for this calculation displayed every negative inventory transaction for each material as a row, including information for the day of the transaction and total usage per transaction. This DAX expression filters all the stock transactions by date to match the set time frame and sums up the usage quantities of those transactions to calculate total consumption within the time frame.

Visually the main part of the TPD-report was made quite similar to the earlier spreadsheet version to keep the known layout of the data in the report. This matrix table style of reporting is most suitable for this application as there is a vast amount of material data to be presented for the users of the report. Also, this report works as the basis for other material analyses, and this matrix table allows the information to be extracted in spreadsheet format for further processing, for example sharing information with external stakeholders. The main view of the TPD-report is presented in Figure 5. All of the figures presenting the report have been gray-scaled, and some parts of the figure have been blurred or redacted in order to maintain the anonymity of the case company.

Figure 5. Main view of the TPD-report.

One of the main functionalities in the revised TPD-report is the filtering possibilities. These preset filtering options are displayed on the main view of the report and those allow the users to filter the table according to their needs. Data fields for the preset filtering options were selected to include the most used data fields, so the filtering options would be as efficient as possible. These filters include data fields like:

- Material code, which also acts as a unique data field in the report.
- Vendor code of the material's fixed vendor.
- Availability Class of the material.
- Profit Center of the material, which links the material to product family information.
- MRP Controller, which determines how the MRP calculations are done to the material.
- Supply Planner and Buyer responsible for the material planning and purchasing.

The main view of the report includes the count of the materials in the current filtering scope. This visualization is helpful when listing out materials in a specific filtering group, for example, how many materials are ordered from one vendor or how many materials are in a specific availability class. The main view also has a bar chart visualization of total yearly consumption in relation to the current filtering on the page. More detailed consumption statistics for each material can be found in the main table, but this fore mentioned visualization gives perspective to the total consumption.

From the main page of the report, users can choose to drill down to a more detailed material info page. This can be done when an individual item is highlighted on the material data table and clicking the “Material Info” button on the main page. This detailed material info page shows the key information of the material as well as a more comprehensive yearly consumption line graph. Also, current stock balance in relation to materials safety stock is shown as a gauge chart. On the page there is a “Material in allocation” indicator, which shows if the material under observation is currently being allocated within the company, meaning that the material’s distribution is controlled manually. This material info page is presented in Figure 6.

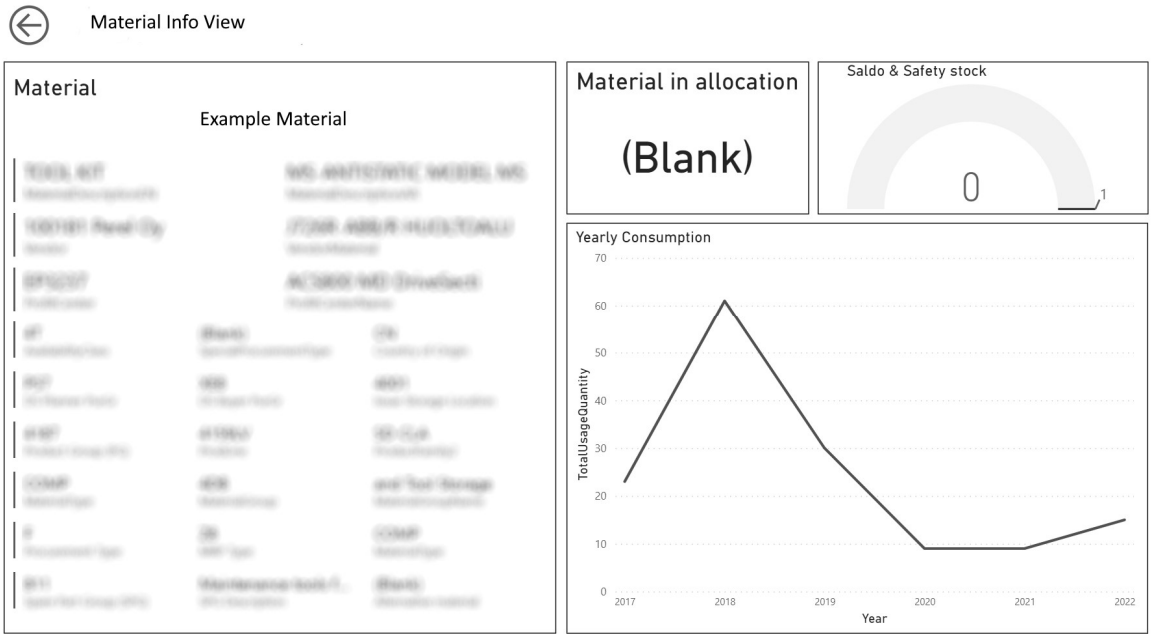

Figure 6. Material Info View of the TPD-report.

3.6 Data collection and analysis

Primary data for the empirical part of this research was collected through semi-structured interviews. In a semi-structured interview, the selection of interview questions is not fixed and may vary between interviews. In the interviews, same themes are discussed but the questions are not identical, and they act as guiding questions rather than a strict script for the interview. Interviewees are given the freedom to elaborate more extensively on the theme that is being studied. These types of semi-structured interviews are commonly associated with qualitative research methods. (Saunders et al. 2016)

In contrast, structured interviews consist of precise and consistent questions that are the same in every interview. This approach is typically used in quantitative research methods. (Saunders et al. 2016) For this study, a structured interview format was not suitable due to the diversity of interviewees who hold different positions in the team, have diverse responsibilities, and use the report differently in their day-to-day work. Thus, a semi-structured interview format was more appropriate as it allowed for open discussion and provided a broader overview of the topic.

The primary data for his study was collected through 7 semi-structured interviews with the case company's personnel that are currently working with spare part purchasing and inventory management. Interviews were held in May of 2023 and all of them were conducted using the company's preferred online voice communication platform. The interviewees were chosen to cover a diverse range of different purchasing activities within the company. For the final interviews, two persons in the manager position and one team leader were chosen to be interviewed as they use the TPD-report mostly for analyses and reporting. To accompany this view, three supply planners and one project buyer were interviewed, as they use the TPD-report in their day-to-day work to monitor and maintain material availability.

To keep the flow of the conversation, all of the interviews were held in Finnish, but the topics and guiding questions were formed in English. There was a total of six topics that were discussed during the interviews, but with some interviewees not all of the topics were touched due to those not being relevant to the nature of their work. Each topic had a few guiding questions that were used to get the discussion flowing. Discussion topics were:

1. Issues stemmed from data.
2. Data correctness.
3. Data availability.
4. Impacts on material availability.
5. Benefits from the use of the report.
6. Improvement ideas for this report.

During the interviews secondary data from company's ERP system was used to validate and expand the topics, and some ideas from the theoretical part of this study were presented to give more insight on the topics. More detailed information about the interviews, including topics that were discussed and the length of interview, are presented in Table 1. Topic numbers in the table are explained in the list above with the topic descriptions.

Table 1. Compilation of the interviewees and interviews.

No.	Title of the interviewee	Topics	Time
1	Team Leader Supply & Inventory Team	1-6	1h 22 min
2	Supply Planner	1-6	43 min
3	Global SCM Manager	3, 5, 6	38 min
4	Supply & Inventory Manager	1-6	36 min
5	Project Buyer	1, 3-6	39 min
6	Supply Planner	1-3, 5, 6	53 min
7	Supply Planner	1, 3-6	43 min

All of the interviews were recorded, and the recording was transcribed afterward to turn the interview results into a more usable form of data. Not all parts of the interview were transcribed, meaning the necessary data was sampled from the mass (Saunders et al. 2016), and as the spoken language was Finnish, key parts of the interview were translated into English. Also, this means that the interviews were not transcribed strictly word-for-word. For the transcribing, the possibility to turn spoken conversations into text automatically was used. This function was part of the platform that the interviews were held on, and it sped up the transcribing process, but it did not eliminate the need for manual transcription.

Once the data was made ready for analysis, which involved transcribing it, the transcriptions were carefully reviewed again to obtain a thorough understanding of the collected data. After reading each transcription, a brief summary was written, aiming to sum up the extensive data and make it easier for analysis. These summaries included relevant statements from the interviewees and their key opinions. Although writing the summaries took some amount of time, it proved to be a valuable effort as it reduced the time required for the actual data analysis and enhanced its reliability.

4 Empirical findings

The theoretical structure of work plays a crucial role in the realm of material knowledge by offering a framework designed to enhance the discoverability and efficiency of information. Its primary objective is to provide a systematic approach that enables individuals and organizations to access and utilize relevant data effectively. By doing so, it aims to optimize resource utilization, further better decision-making processes, and eventually lead to better material availability.

One important aspect of this theoretical structure is its focus on resource efficiency and reporting automation. By adopting a perspective that prioritizes resource optimization, it encourages individuals and organizations to identify and implement strategies that minimize wasted time and enhance overall productivity. Furthermore, by incorporating automated reporting systems, it simplifies the process of gathering, analysing, and presenting data, enabling quicker and more accurate decision-making.

In addition to resource efficiency, the theoretical structure also recognizes the importance of monitoring and managing materials in the context of the spare part supply chain. It considers the challenges associated with materials that have low availability and emphasizes the need for proactive measures to address this issue. By closely monitoring the availability of materials throughout the supply chain, organizations can identify potential bottlenecks, plan alternative sourcing strategies, and take timely actions to mitigate any disruptions. This proactive approach ensures the smooth flow of materials and reduces the risk of delays or shortages, ultimately contributing to improved operational efficiency.

By integrating these perspectives into the theoretical structure of work, it enables a comprehensive understanding of material data-related challenges and what are the opportunities that TPD-report will create. It encourages individuals and organizations to adopt a holistic approach, considering both resource efficiency and supply chain dynamics. This integrated framework not only enhances the effectiveness of decision-making processes but also contributes to sustainable practices, promoting responsible material management and supporting long-term material availability.

The main part of this thesis is the empirical part where the findings from the interviews are reflected. This chapter is divided into three main topics based on the interview topics and the theoretical part of this study. Firstly, we discuss about what kind of impacts data management has on the spare part availability. This includes the problems that have arisen from poor quality data in the company's operation as well as how these problems could be avoided by using the TPD-report.

The second topic in this chapter is the impacts of automated reporting. This topic includes the gained benefits from using reports that have been automated and what kind of impacts does it have on the party using it in their daily work. Lastly in this chapter, the future ideas for the TPD-report are discussed and how this report and database can be utilized in the future to streamline the work of the users of the report. These three topics have the same goal, to further ensure material availability by streamlining operations and giving better access to information, which allows for more focused actions on the materials that need them. In Figure 7, these topics or dimensions are presented.

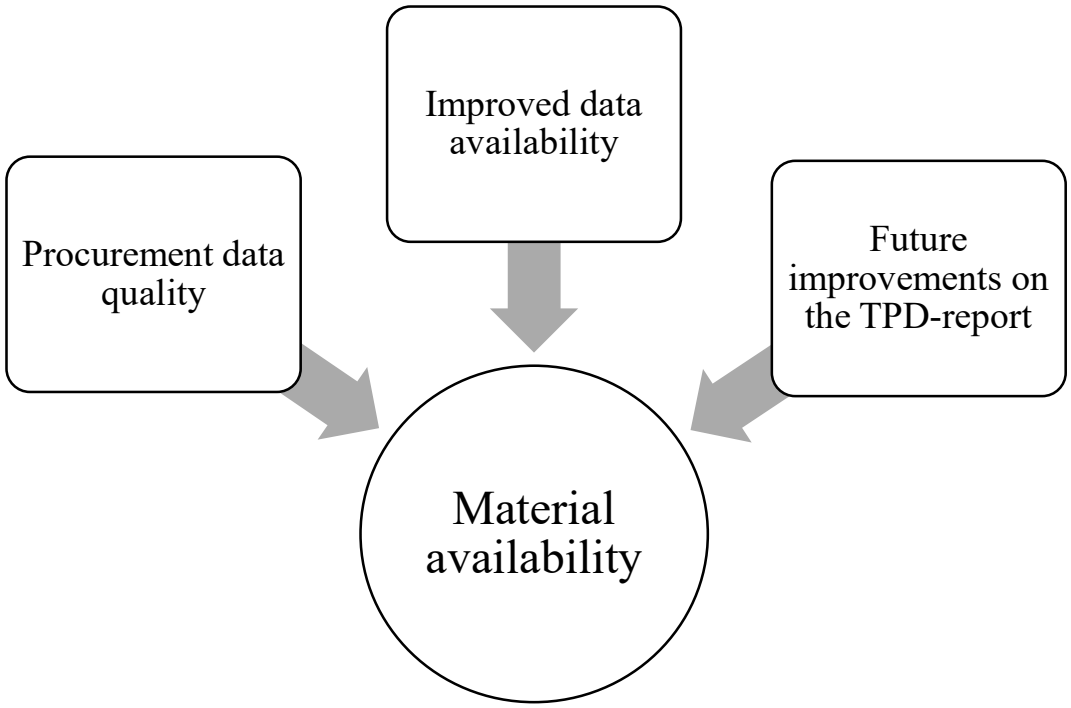

Figure 7. Dimension from the TPD-report to improve material availability.

4.1 Procurement data quality on material availability

Optimal data quality management plays a big role in the company's procurement data input, revision, and usage processes. The need for better systems to input and monitor this data has been recognized and some corrective measures have been done to improve the quality. These actions in the company have focused on the correction of the current material data in the systems and building processes for inputting the material data in a way that the possible data errors could be limited.

The main problems with procurement data in the company's ERP systems are caused by the need to input data into two different parts of the of the ERP. Procurement data is a part of the material master table, which stores all of the data for materials in the ERP, including other information that is not used for the procurement processes. This means from the procurement point of view, the material master is loaded with information that is not relevant to the purchasing or inventory management activities. Particularly in this case, the Planned Delivery Time (PDT) information stored in the material master is used in various activities, like in MRP calculations and in promised shipping dates for outbound deliveries to customers. This means that the PDT information must be up to date in the material master in order to keep the material availability and promised customer deliveries.

The other part of the ERP system for materials procurement information is so-called procurement info records, which combines the vendor information with the materials. Info record data, for example, vendor PDT, is used in purchase order creation when ordering materials from external vendors. The desired situation is that the PDT value matches in the material master and in the info records, as that value guides the material sales and purchasing processes.

The issues with the PDT values were highlighted during the interviews with the company's personnel. During the six interviews, that the topic of issues that have stemmed from incorrect data, all of the interviewees raised the current issue with the PDT incoherencies. During the last few years with the pandemic and availability challenges that it brought to the technology and manufacturing sectors, delivery times increases were common. Some vendors had to double their delivery times in order to combat the raw materials and semi-finished goods availability. This was especially severe in the semiconductor material categories.

During this year, the material availability from supplier has improved considerably, and delivery times have been returned to prior material availability challenges levels. This back and forth with the delivery times in this volume has had the potential to mess up the consistency in PDT values in the company's ERP system. And from these inconsistencies, material availability problems can arise. From Figure 8 we can see what the real-world case is when there is incoherent PDT information between the material master and the info record.

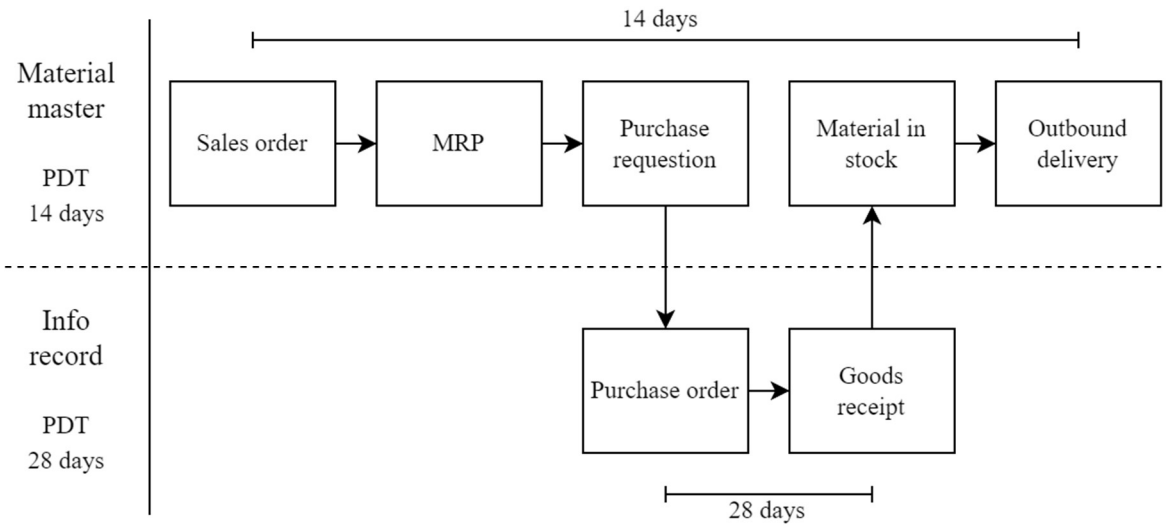

Figure 8. Effect of incoherent PDT information between material master and info record

This demonstration is looking at the spare part material, sold as a delivery time item, order to delivery process from the purchasing point-of-view. When the customer has placed an order, a sales order document is created in the ERP system, and the delivery date is set based on the materials PDT in the material master, in this example 14 days. The MRP calculation will create a purchase requisition, which will get processed into a purchase order. The purchase order takes the PDT from the info record and the material is ordered from the vendor based on that, in this case 28 days. Thus, in this case the delivery from the vendor will be late 14 days, meaning the customer will get their ordered material later than was promised.

From this, the problem can be seen easily, that if the PDTs are not the same in both tables it influences the material availability to the company's customers. The PDT problem also

works to the other way, meaning the material will arrive too early taking up space in the company's warehouse. Of course, the customer service team together with the procurement team are working to minimize the delays in the outbound deliveries and communicating with the vendors to get the materials to arrive at the company's warehouse in the optimal time window.

The company has tried to reduce the number these kinds of problems as they have recognized the problems that can arise when incoherent data is in the systems. Preventive measures have been introduced to the data input processes and company-specific ERP modifications have been made to make the material information change process more reliable. Also, when these types of problems, that has already affected the material availability, are noticed, they are corrected reactively. The conducted interviews brought up the possibility to use the TPD-report for this data quality monitoring and periodical proactive checks to ensure that the material procurement data is coherent in the systems.

This planned delivery time problem case was the most important topic from the interviews, but the data quality monitoring possibilities are not limited to that with the TPD-report. Interviewees also pointed out the possibility to use this report to monitor the material procurement data for these problems:

Country of Origin (CoO) information. This is another data field in the ERP system that is stored in two different tables. Similarly, to the planned delivery time information, this is both in the material master and in the info record. CoO information is important for the materials as the duty rates, trade sanctions, preferential trade agreements, and import quotas are regulated based on the country of origin. If the country code is wrong in the shipping documents, this can lead to the shipment being stopped at the customs and this will delay the material delivery to customers. During the interviews, few participants pointed out that these types of errors are quite frequent and the importance of keeping the CoO values up to date and matching in the two tables cannot be overlooked.

MRP controller and availability class. These two data fields are important as they guide the material in places like MRP calculations, external inventory management tools, and customer order interfaces. During the recent availability challenges, the company started to allocate spare parts with limited availability from the vendors and this requires making changes to these fore mentioned data fields. For example, when stocked material has a

threat of running out of stock, its availability class is changed to delivery time material, and the MRP controller is changed to a dedicated allocation controller. Interviews pointed out that these manual changes leave a room for error, and especially for the change reversion, TPD-report offers a tool to monitor that these data fields are correct.

Missing buyer or planner info. In the company, all purchasing materials are assigned to planners, who are responsible for keeping the materials information up to date and planning the material purchasing, including tracking the material availability and making corrections if needed. If this info about the planner is not found on the material, there is no one to make the corrections for the material if that is needed. The same goes for the buyer information, as that data is used in the purchase requestion creation and that person is responsible for creating the purchase orders. As the TPD-report takes into account all of the materials that are opened for the after-sales purchasing, it shows the materials that does not have this information, and corrective actions can be done.

The consensus that the interviews gave was that the current procurement data quality is considered to be at a good level in the company's systems, but there can be outliers that have not yet been noticed. This statement was supported by an analysis that was made on the company's previous years outbound deliveries. The case company keeps track of and identifies all delayed deliveries and the root causes that have led to them being delayed, and one of these categories is linked product information, which includes also data used in the procurement. The result of this analysis was that only less than one percent of delayed outbound deliveries were late due to incorrect procurement data. It should be noted that other delayed deliveries may have been caused by data quality problems, but the root cause has been categorized according to more easily seen reasons. This TPD-report gives the company a way to find these outliers or missing information that would have gone unnoticed with the existing tools.

4.2 Improved data availability on material availability

A major reason for the company to start using this TDP-report in the first place was to make it easier and more efficient to find the relevant information about actively sold spare part materials. The company's current ERP system has limited capabilities to produce reporting on this scale, especially in the of case procurement information. For the

individual materials, the company has created their own ERP transactions to make it easier to look at all the relevant information in one glance. One of the main principles in the creation of the TPD-report was to create a similar tool, but one that would allow the viewing of multiple materials at the same time.

The current way of finding out the needed information about multiple spare part materials in the company's ERP system was time-consuming and sometimes even difficult, according to the interviews. Another aspect relating to this was the need to create reports that combine data from different parts of the ERP, which was also found unnecessarily complicated and time-consuming by the planners. Particularly one of the interviewees was delighted to get this tool to their daily work in report and analysis creation. They used to manually create reports for vendors about the materials that need the special attention from them. This report would consist of data exported from three different places in the ERP and manually combined into a spreadsheet with additive supportive calculation columns. It was discussed during the interview, that the TPD-report already has these data sets built in, and with the addition of the calculated columns, this weekly made manual report can be just exported straight from the Power BI service and forwarded to the vendor.

Data quality, which was discussed in the earlier chapter, is highly reliant on the planners and their usage of time assessing it. If the planner's time goes into retrieving the needed data and creating the analyses, the threshold to start the data quality assessing process is much higher. The planners in the interviews said that due to the recent global availability challenges, most of their time was taken to combat that issue, and the proactive material procurement data quality assessments were left out of their schedule. Now as the global material availability has gone in a better direction, and the introduction of this revised TPD-report, there is more time to perform data quality assessments and it is more efficient to do so.

One of the most requested and most beneficial features of the Power BI version of the TPD-report, which was brought up during the interview, was the daily updating capability. Compared to the previous spreadsheet version of the report, which had manual updates done once per quarter, this improves the reliability of the data as now the report has current information straight from the company's systems. This improved data reliability enables the decision-makers to make better-informed decisions to ensure the spare part availability, with the confidence of that the decisions are based on the relevant information.

Case company also utilizes other automated Power BI reports in their day-to-day operations. The most used one being the daily management report of the procurement team, which is used to monitor the open purchase order base. This report was also built to make the work easier and more efficient, as the ERP's built-in features do not allow as detailed reporting on this front as the company wants. Daily management report includes information about the purchase orders to vendors that are not confirmed by the vendor, that are late from the confirmed delivery date, and if stocked materials are not available for customers on their requested date. This report, accompanied with the customer service team's report about the sales orders and deliveries to customers that are late, forms the basis of the company's current material availability reviewing process. This process and its review levels can be seen from the Figure 9.

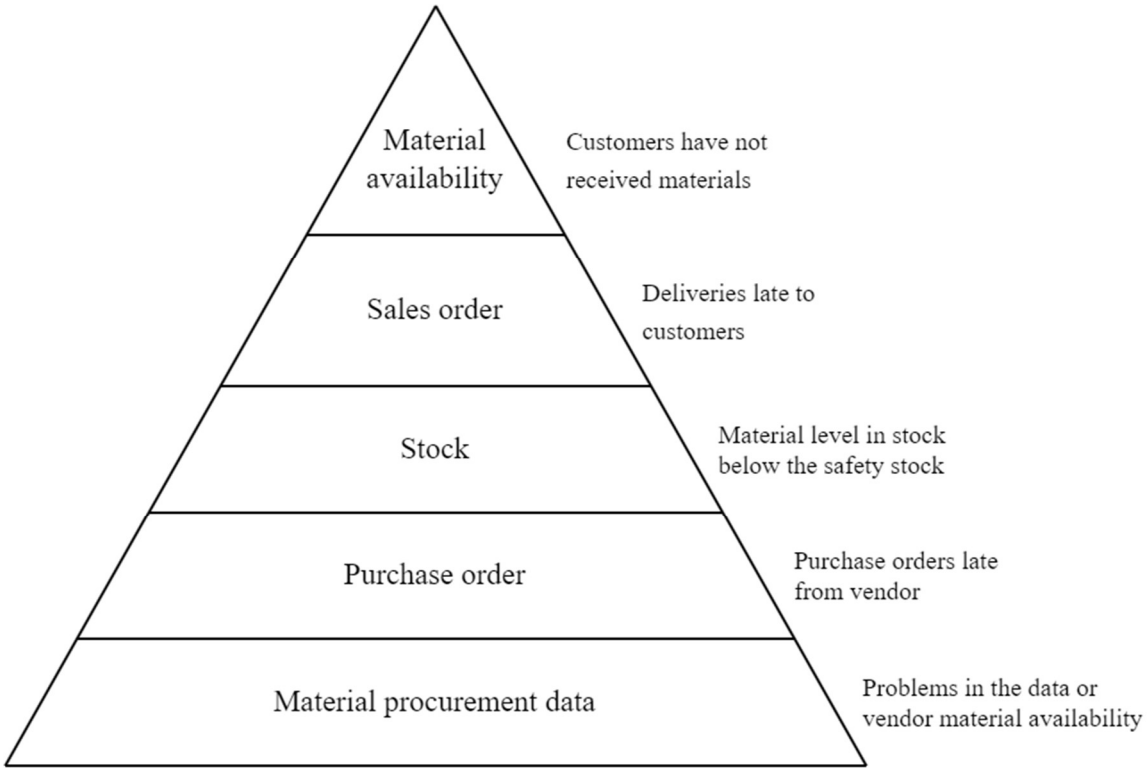

Figure 9. Material availability assessment process and its levels

This current way of reviewing material availability starts, in the most cases, from the top, when customers have not received their spare part material delivery on time or there is a probable risk of that happening. In the cases where the cause of the delay is material

availability, this leads to the investigation of the current stock situation and why there is not enough material for the customer deliveries. In most cases the reason for it is that the vendor has not delivered the purchased materials by the requested delivery date, which has caused that there are not enough materials to be sent out for the customers. These types of situations will then lead to further analysis on why this have happened and what could be done to correct the stock-out from happening again. This process could be defined as a top-down approach, where the process starts from to problems and flows down to root causes of the problem.

During the interviews, an idea for an alternative process to ensure material availability in the company was brought up which would not be efficient to do without the TPD-report. As established earlier, this report gives a great way to analyze and view the materials in their data level, meaning the lowest level we can get on the Figure 9. By doing so, any data poor-quality data associated with the material that should be corrected can be noticed and corrective actions can be done. The same goes for the availability ensuring, as the current stock, consumption, and other availability-related information can be analyzed from the report, and based on those, actions to ensure availability can be done.

By working from to down-up in this availability ensuring process, corrections can be done to ensure the sufficient material levels in stock. For the materials, that need this kind of special attention and have the risk of running out of stock, the planner can do actions like making tweaks to the PDT, creating additional purchase orders, and increase communication to the material's vendor. When these disturbances are found proactively, communication to the customer service team and through them to the customer is important. Customer service can inform the customers that there is a risk of their delivery being late, and by that keep the customer informed and engaged, which will desirably keep the customers as satisfied as possible.

In the end, all boils down to efficiency. This TPD-report makes the supply planners work more efficiently by providing new and better ways to do their daily tasks to ensure spare part availability in the company. The benefits gained from using the TPD-report save the planner time, by allowing the data to be more available to them when they need it and reducing the need for manual work when creating reports and analyzes. This report equips the planners with a full-range overview of the company's spare part availability, enabling them to optimize inventory levels, tweak materials procurement information, identify

potential bottlenecks, and make data-driven decisions that improve the overall resilience and efficiency of the spare part supply chain.

4.3 Future iterations of TPD-report on material availability

The interest towards this TPD-report has increased during this development phase, and new ideas for future evolution have been brought up. From the interviews, it became clear that this report has a lot of potential to work as a basis for other analyses in the Power Bi platform. This part of the thesis goes over all of the ideas presented during the interviews and how the report could be utilized in the future to ensure material availability and make the work more efficient in the company. TPD-report is owned by the supply and inventory management team, meaning that their ideas for improvements are the priority when going forwards. This does not close out the option to make developments that are proposed by other parties which are using the TPD-report to enhance their daily work.

The goal of this thesis was to find out how the TPD-report could be utilized in ensuring spare part material availability and improving efficiency in the daily work of the supply and inventory management team. As this report has proven itself to be useful in achieving these abovementioned goals, TPD-report will hopefully be incorporated into the team's work going forwards. This means that as now the report has most of the needed information included in its dataset, possibilities to expand this report are limitless in the purchasing and spare part material data quality assessment context.

The most requested improvement that came up from the interviews was to include the company's allocated material tracking to the TPD-report base. In short, spare part materials that are suffering from long-term availability problems are put into allocation, which limits materials outbound deliveries, and the distribution of the materials is manually controlled based on the business criticality. All of the planners that were interviewed hoped for a better allocation process, including adding materials to allocation, tracking those materials, and removing materials from allocation. This allocation tracking is currently done with a spreadsheet that the planners manually update weekly. Planners' tasks include making changes to the material data in the ERP, then adding that material to the spreadsheet, and keeping that information up to date, including information like the current stock, needs, and upcoming deliveries for the materials.

One change has been already made to the company's ERP system. To the materials MRP controller data field, an additional allocated material controller was added earlier this year. This MRP controller is used especially for the allocated materials and in the TPD-report it allows for filtering based on that controller, which allows for the viewing of the same materials that are listed in the allocation spreadsheet. TPD-report also has most of the data that is currently manually inputted into the allocation spreadsheet, the only one that is missing is the data about the upcoming deliveries of the materials. The possibility to export this information from the ERP to the SQL server is being investigated, and if that is viable to do, further developments will be made to move away from the allocation spreadsheet to the Power BI version.

As this allocation report will be rebuilt to the Power BI platform, similar to the TPD-report, the motivation for it will be to reduce the need for manual and work make the process more efficient, leaving the planners more time to do actions to resolve the material availability problems. The need to manually transfer information from the ERP system to spreadsheets was deemed by the planners as work they mostly dislike.

Other teams in the company that have shown interest towards the TPD-report, or the interviewees presented the possibilities to incorporate this report into their work including sourcing, product management, and customer service. These three teams are in daily contact with the supply and inventory management teams, so it is natural that this TPD-report would prove to be useful to them. Next, we will go through the ways other teams are using or may use this report and how this will lead to improved material availability:

Sourcing. One of the interviewees was the manager of the company's sourcing team, and they had been using the previous version of the TPD-report. Sourcing is responsible for vendor evaluation and selection, as well as price negotiations with the vendors. The main use case for sourcing with the report is to look at the materials consumption statistic and the current purchase and sales prices of the spare part materials. Also, this report can be used to export data that may be used in communication with the vendors to better validate the company's needs with reliable data.

Product management. In the company, material lifecycle management responsibility is on the product management teams. This team is responsible for deciding what spare parts are offered for each product family that the factory is providing. When the product family is

dropped from active manufacturing or the product family is made obsolete, they manage the spare parts offerings accordingly. From the TPD-report spare part material's product family and its life cycle status information can be found. Product management can use this report to look at the current spare part offering, material consumptions, and life cycle statuses to make informed decisions on what materials should still be offered as spare parts for customers.

Customer service. As this team is the closest to the customer, data availability regarding material availability information is highly needed in the day-to-day communication. The customer service team could use this report to ease their work by using the TPD-report to find out information from the material availability, especially with the materials that are currently in the allocation process. Purchasing receives a fair number of questions from the customer service regarding the current and future availability of materials, so by utilizing this report customer service could check this information their selves much more easily than before.

The main idea linking these three teams to the TPD-report is the possibility to create more useful customized views into the report that would better serve the needs of these teams. Currently, the main view of the report is clustered with procurement information, and it is displayed in a way that is beneficial to the supply and inventory management team. The report includes abbreviations that are not so common within the whole company and users outside of the main user group have found these to be difficult to understand.

5 Discussion and conclusions

In the final chapter of this study, the research findings and discussed and summarized. This chapter starts with a discussion on how the theoretical part of this study reflects the findings of the empirical section. Then the main research question and sub-questions are answered, and the research results are discussed. Following that, validity, reliability, and confidentiality of this study are evaluated. This involves discussing how reliable the study's results are, as well as the measures taken to ensure the confidentiality of the participating company and its personnel. After this, the suggestions for future research and the limitations of this study are presented. Lastly, the results and achievements of this study are concluded.

5.1 Reflecting theory into empirical findings

For the last few years global material availability challenges have increased the workload on the procurement teams, and the time for quality control of the purchasing data has been diminished. From the interviews, we can conduct that the poor-quality procurement data has a negative effect on the performance and the efficiency of the spare part procurement supply chain. And as mentioned earlier, problems in the procurement activities have an impact on other parts of the company's operations (Luukkainen 2019). This is especially important when dealing with spare parts, as if the materials are not available to the customer, their equipment or machinery can be out of operation for long periods of time, meaning production loss to the customer. As Kurata (2014) found out in their research, customer satisfaction is affected by the unavailability of materials, and a properly working spare part supply chain is important to keep customer satisfaction as high levels as possible.

During the interviews, the "1-10-100" rule for costs that occur from poor quality of data from Mahanti's (2015) study was presented. Interviewees recognized this cost structure and understood that it becomes exponentially more expensive to the company if procurement data is left unsupervised. The current way of dealing with procurement data problems in the company, based on the scale of activity levels introduced by Silvola et al.

(2011) in Figure 2, is reactive which means that the problems are fixed periodically or when they are already incurred in the operation. Procurement data input processes have been built in a way that some of the main data fields are proactively managed, but the possibility and the need for changing data manually have made this to be easily bypassed.

When the proactive data input process is bypassed, the procurement data problems are next time seen when they arise and have already possibly caused disturbances to the spare part procurement supply chain. There is a missing link between these two stages of the rule presented by Mahanti (2015), which is the active level. With the TPD-report, this active data quality management can be done, and the empirical results support this view. Especially for the most critical data fields, like planned delivery time and country of origin, the TPD-report can be used to validate the correct data and that way correct the errors before problems arise. The best case scenario of course would be to get the proactive methods working with greater efficiency to minimize the costs, but the active correction of existing data before problems arise is more cost-efficient than reactive corrections.

One of the key parts of data quality is the data availability dimension, and the importance of it has been stated in multiple previous studies (Mahanti 2015; Österle & Otto 2015; Miller 2017; Williams & Tang 2020). If the data quality is good when looking at it from other quality dimensions, but the data cannot be found or used in decision-making due to poor data availability, it is the same as there would be no data at all. The case company has had problems with data availability, as that has been found to be a complicated and time-consuming process to gather data from the company's systems. The empirical part recognizes the need for better tools in the company for making this data-gathering process easier. This need was combated with the initial implementation of the spreadsheet version of the TPD-report. As the usage of it increased, better ways to achieve greater data availability were idealized, which meant transforming that report to the Power BI platform.

Automated reporting is beneficial for the company in various ways and in this case, where RPA is being used to automate the report creation for a highly useful and needed report, these benefits multiply. Marciniak & Stanisławski (2021) have recognized in their study that companies using RPA benefit as the employees have reduced amounts of manual and repetitive tasks in their day-to-day work, which will lead to benefits like increased work satisfaction and increased productivity. The empirical part also suggests that by utilizing automation, employees have more time to do the work that they are supposed to do, and in

the case of procurement of spare parts, they have more time to ensure the spare part material availability.

The automatization of TPD-report enables the report to be refreshed daily with updated data from the company's systems. This would not be possible to do manually as the process of it is extremely time-consuming and manual work leaves room for errors in the process. Marciniak & Stanisławski (2021) recognizes this type of RPA use as a principle-based process, where the process follows a strict set of steps to produce this report, which were used to be done manually. This has allowed the procurement planners to have access to a report that has current and valid information, which then can be used in decision-making straight from the Power BI report, or planners can choose to extract the data from it easily and further develop and analyze the report for their needs.

One of the main principles when making the Power BI version of the TPD-report was to make it more visually pleasing compared to the previous spreadsheet version of the report. The Power BI platform is a great way to visualize data, as it offers powerful tools for creating visualizations (Kusleika 2021). As Miller (2017) stated, the goal when visualizing data is to make a complex topic to appear in a way that is more easily understandable. Visualization also enhances the readability and understanding of the data, and it makes the information to be available from larger audiences (Lee et al. 2020). The result from the empirical part prove the ideas mentioned above. Interviewees were pleased with the current use of visualizations in the report and stated that those help in seeing the trends and main points from the data. Also, the consensus was that visualizations help the report viewers outside the procurement team to comprehend the information better.

As Chae (2009) states in their study, on-time delivery KPI can be used to measure supply chain performance. Currently, one of the case company's most looked at supply chain KPIs is the on-time delivery for outbound deliveries. This is measured and tracked on a daily basis, and all of the delayed deliveries are categorized based on the root cause what has caused the delay. Data gathered from the previous year regarding this KPI, procurement data problems were the reason for delivery being late for less than one percent from the total delivery rows that were sent out late. For all rows, including deliveries that were on time, this drops below significance, it being less than 0,05 %.

This means that the procurement data quality is not a major problem in the company and this statement got support from the interviews. There is a possibility that all of the delays in deliveries that the real root cause would be the procurement data are not recognized as that. Delivery can seem to be late based on other reasons, but the underlying root cause was incoherent data in the company's systems. The real reason for delivery being late can be difficult to track down as the data behind the material and its procurement process is quite complex, and other disruptions may occur that are more easily seen.

By making the procurement data more available, the quality of the data increases, which increases the value of the data (Miller 2017). Also, by making the data more available, incoherent data can be found more easily and those instances can be corrected to avoid possible problems that would otherwise incur from that data quality problem. More easily accessible data also helps to reduce the time that it takes to find the desired information from it, which leaves more time to perform value-adding tasks. In this case, these are tasks that have positive effects on the spare part material availability, for example, communication with the vendor to keep up the buyer-supplier relationship and focusing corrective actions on spare part materials that have availability risks.

5.2 Discussion of the research questions

The main objective of this study was to answer to the research questions that were set at the start of the study. There was one main research question and two sub-questions that revolved around material availability and the benefits gained from the TPD-report. In order to answer to these questions, an understanding about these topics was needed. In a key role in this study was the interviews with the case company personnel, which gave valuable insight into the company's spare part procurement operations and the benefits that they can gain from the TPD-report. The theoretical part together with the interviews in the empirical part of this study made it possible to provide answers to these research questions.

In order to answer to the main research question, the sub-questions need to be answered first. The first sub-question was "*How does automated material reporting improve the accessibility to the material data and efficiency in the use of the report?"* This question has its answer from both theoretical and empirical parts. The theoretical part suggests that by using RPA in the form of Power BI to automate reporting multiple benefits can be gained.

It enables the reports to be done with a higher level of accuracy, reducing possible human errors, and making the reporting more reliable (Marciniak & Stanisławski 2021). It enables the possibility to add visualizations, that enhances the understanding of information and communication (Chen & Edwards 2020), as well as support in finding trend and outliers in the data (Miller 2017). These benefits will lead to increased productivity and competitiveness in the markets, which are also financially beneficial to the company utilizing these technologies.

Accessibility of the data is improved, as the data is made more available by combining the otherwise scattered data into one unified place. The case company had problems with data availability and accessing data regarding multiple spare part materials was found unnecessarily difficult as it is used in day-to-day work in procurement and supply planning. Empirical results suggest that this will increase the efficiency when using the report. This report can be used as a base for other reports and analyses, which will reduce the need to manually extract and combine data from the company's systems. This reduced need for manual work leaves more time to do value-adding tasks based on the information gained from the analyses.

The second sub-question was "*How does automated material reporting decrease data errors and improve the reliability of the material data?"* Increasing the data quality is adding value to that data, and it resonates with more reliable and valuable decision-making based on the information derived from the data (Miller 2017). The importance of data quality was pointed out by Mahanti (2015) in their study, as the cost of data can be exponentially higher if it leads to problems in a company's operations. Results from the empirical study also indicate the need from managing the procurement data quality. From the interviews, the consensus was that the TPD-report can be used for data quality auditing, and it makes the process of doing it easier and less time-consuming.

This way of automatically generating reports from large quantities of data, outliers, and other possible data problems can be seen easily, and corrective actions can be done. Automated reporting by itself does not have an impact on data quality, but it can be used as a tool to seek out the possible problems that would otherwise go unnoticed. Automated reporting makes data quality auditing much easier and the possibility to do it without the need for constructing data quality analyses for each individual topic enhances the efficiency and willingness to do so. In after-sale business spare part availability is

important and that is why procurement operations need to function as efficiently as possible. Any disturbances in the spare part supply chain can affect customer satisfaction and lead to a loss of revenue.

The main research question in this study was "*What possible impacts does automated material reporting have on ensuring spare part material availability?"* This question concludes the answers from sub-questions, as the impact on material availability from automated reporting comes from the possibilities it has in ensuring data quality and enhancing data availability.

The correlation between the possible use cases for the automated TPD-report in the case company and the ensuring of the spare part materials to a customer can be drawn based on this study. As mentioned earlier, by itself the report does not have an impact on material availability, but it enables the procurement team to do the needed actions more efficiently and better targeted to the spare part materials that have availability problems. The causes for these problems can be seen from the report and by utilizing it, corrective actions can be done, before the unavailability of spare parts affects customers.

This report works as an additional layer of defense when combating the material availability challenges, and it can be used together with other processes and tools to better ensure the material availability. In the interviews, the ways of using this report to help the procurement team were discussed, and if these actions are taken, it can be concluded that automated material reporting has a significant positive impact on ensuring the spare part material availability. The report will not do the availability ensuring for the company, but it helps the planners to take the right actions more efficiently to keep the spare part supply chain in its most optimal way possible.

5.3 Reliability, validity, and confidentiality of the study

Case study as a study method has been criticized for its tendency to have a bias toward the researcher's preconceived opinions and that the case studies are not executed in controlled environments. It has also got criticized for its limitations to smaller sample groups and for its target to expand and generalize theories. (Yin 2009) To reflect these criticisms to this study, despite this not being executed in a controlled environment, data used in this study

was collected from professionals in the spare part procurement field, so the data can be relied on, and the study was done as objectively as possible. That said, the sample size for this study was quite limited and it only involved one company, which means that the results of this study cannot be generalized without limitations. Saunders et al. (2016) measure the reliability of the study as to how well it could be repeated and would the results be consistent. In this case, other companies may create similar material reporting tools based on this study, but the effects from it on the material availability are subject to change.

Another aspect of the reliability is the validity of the study. This means are the used data collection methods suitable and correct for this type of study (Saunders et al. 2016). In this study, the interview questions were constructed based on the theoretical part and based on what additional information was needed from the report using party. Interviewees were informed beforehand about the topic of the interview, and they were given a task to use the report with a critical mindset to also test the report. Interviews were tailored based on the interviewee's position in the company and how they use the report in their daily work.

In this study. the confidentiality of the case company and the interviewees was ensured. This means that the raw data from the interviews and the secondary data that was from the company was not seen by anyone else but the author of this thesis. Also, the interview result has been generalized in a way that individual opinions or statements cannot be excluded. Recordings and transcripts from the interview were deleted after the study was over. The company's confidentiality was ensured by describing it at a general level and redacting some information from data as well as from the figures in this thesis.

5.4 Limitations and suggestions for future research

This study focuses on after-sales spare parts purchasing from the original equipment manufacturer company's point of view. As this is quite a niche part of the industry, the study is fairly limited to it. This kind of material reporting could be done in other organizations and the benefits would be quite similar. The report automatization would yield similar results in enabling more efficient work when the data is more easily accessible. It is the same for the impacts of the poor-quality data in the organization and

the benefit gained from visualizing data. Differences would come in the spare part availability ensuring, as that topic is specifically tailored for this study's case company.

For the automated reporting and for use of the TPD-report as a basis for other reports and analyses, this study can be suitable for other companies. The ERP system that the case company uses is one of the biggest software in the market for the manufacturing industry. This means that for other companies using the same ERP, the data availability and report creation problems in the ERP are similar to this case. By creating a base report that incorporates multiple data sources from the ERP, other companies may also improve their efficiency in data availability and report creation, leaving more time to focus on the actions that provide value to the company.

Future plans to expand and improve the TPD-report within the company are already being discussed and improvement ideas have been presented during the interviews. There are possibilities to improve other areas and processes in the company in addition to spare part material availability, data quality, and data availability. The most awaited expansion of this report is the allocation tracking, that was presented earlier. To implement this, additional data from the company's ERP is needed to present the more detailed stock balance and stock transaction information.

Also, the expansion in the user groups of the report was presented. Possible use cases for this TPD-report are not limited to the company's purchasing activities, and many interviewees suggested that it could be used in other teams in the company to ease their work. Complementing studies on the effects could be done to increase the knowledge about the importance of data quality and availability. Also, as this report was made only for the after-sales department, the factory side of the company has expressed their interest in a similar tool to use in the material planning.

An interesting area to further study regarding the TPD-report is the real effects of the report after a longer time in use. A more quantitative approach could be taken to validate the result of this study, as now the approach was qualitative through the interviews. The on-time delivery KPI result could be studied within the company, to further validate the theories presented in this study. This will possibly give more concrete evidence if this report has the effects that this qualitative study presented.

5.5 Conclusions

It can be concluded that data availability is an important part of data quality as almost every aspect of today's work involves the use of data. Procurement does not differ from this and as the purchasing can be seen as a critical activity for the company's operation, it needs to work as efficiently as possible. Problems in procurement data can cause disturbances in the supply chain, which will in the end seen as a delayed deliveries to customers. The importance of this is highlighted in the after-sales business, where spare part availability is crucial to keep the service level that is agreed upon with customers.

Data quality has a correlation to the successful purchasing of spare part materials, and the management of this data quality is important to keep the material availability and costs under control. Also, data availability plays a big role in the data quality, as if companies have pristine data, but it cannot be found or accessed when it is needed, it would be the same as if there were no data at all. By combining the procurement data quality management with automated reporting, a powerful tool was created for the case company.

This so-called TPD-report that was created with Power BI, and it combines the company's data from multiple sources to create the spare part material master report. This report can then be utilized in various ways to ensure spare part availability. Report can be used for data quality validation, by seeking out the possible data outliers and correcting them before they have a chance to cause disturbances in the spare part supply chain. This increases the procurement data quality. TPD-report benefits the company with RPA capabilities, as the report updates daily with the current information, and the report users have easier access to view data from multiple materials from multiple different sources simultaneously. This increases the procurement data availability.

In the end, these affect the spare part material availability, as there are less poor-quality data in the systems to disrupt the purchasing, and the procurement planner can better focus the corrective action on materials that have a risk of poor availability. The easiness of the tool will save time from the planner allowing them to do the value-adding tasks and which will increase the overall productivity.

In conclusion, this study met the expectations that were placed on it. The TPD-report was proved by the results from the theoretical part and empirical part to be a beneficial and

effective tool that helps to ensure the spare part material availability in the case company. With the future plans for improvement and expansion of this report, this will be a valuable tool for the company to improve spare part material availability as well as spare part procurement data quality and availability.

References

Ackoff, R. L. (1989). From data to wisdom. Journal of Applied Systems Analysis, 16, 3-9.

Bienhaus, F. & Haddud, A. (2018). Procurement 4.0: factors influencing the digitisation of procurement and supply chains. Business Process Management Journal, 24(4), 965–984.

Cartwright, N. (2022). Internal and External Validity Issues in Case Study Research. In Widner, J., Woolcock, M. & Ortega Nieto, D. (Eds.), The Case for Case Studies: Methods and Applications in International Development (Strategies for Social Inquiry, pp. 27-116). Cambridge: Cambridge University Press.

Chae, B. (2009). Developing key performance indicators for supply chain: an industry perspective. Supply Chain Management, 14(6), 422–428.

Chen, M. & Edwards, D. J. (2020). "Isms" in Visualization. In Chen, M., Hauser, H., Rheingans, P., & Scheuermann, G. (Eds.), Foundations of Data Visualization. 1st edition, pp. 61-86. Springer International Publishing.

Dekker, R., Pinçe, Ç., Zuidwijk, R., & Jalil, M. N. (2013). On the use of installed base information for spare parts logistics: A review of ideas and industry practice. International Journal of Production Economics, 143(2), 536–545.

Dombrowski, U., Wrehde, J. K., & Schulze, S. (2007). Efficient Spare Part Management to Satisfy Customers Need. 2007 IEEE International Conference on Service Operations and Logistics, and Informatics, 1–6.

Flyvbjerg, B. (2011). Case study. In Denzin, N. K. & Lincoln, Y. S. (Eds.), The Sage handbook of qualitative research, 4, 301-316.

Frank, A. G., Dalenogare, L. S. & Ayala, N. F. (2019). Industry 4.0 technologies: Implementation patterns in manufacturing companies. International Journal of Production Economics, 210, 15–26.

Ghadge, A., Er Kara, M., Moradlou, H. & Goswami, M. (2020). The impact of Industry 4.0 implementation on supply chains. Journal of Manufacturing Technology Management, 31(4), 669–686.

Glowalla, P. & Sunyaev, A. (2013). Process-Driven Data Quality Management Through Integration of Data Quality into Existing Process Models: Application of Complexity-Reducing Patterns and the Impact on Complexity Metrics. Business & Information Systems Engineering, 5(6), 433–448.

Gordon, K. (2022). Principles of data management : facilitating information sharing (Third edition.). BCS, The Chartered Institute for IT.

Haug, A., Zachariassen, F. & Liempd, D. van. (2011). The costs of poor data quality. Journal of Industrial Engineering and Management, 4(2), 168–.

Heckmann, I., Comes, T., & Nickel, S. (2015). A critical review on supply chain risk – Definition, measure and modeling. Omega (Oxford), 52, 119–132.

Jahani, N., Sepehri, A., Vandchali, H. R., & Tirkolaee, E. B. (2021). Application of Industry 4.0 in the Procurement Processes of Supply Chains: A Systematic Literature Review. Sustainability (Basel, Switzerland), 13(14), 7520–.

Kallio, A., Pietilä, A.-M., Johnson, M., & Kangasniemi, M. (2016). Systematic methodological review: developing a framework for a qualitative semi-structured interview guide. Journal of Advanced Nursing, 72(12), 2954–2965.

Knapp, M. & Hasibether, F. (2011). Material master data quality. 2011 17th International Conference on Concurrent Enterprising, 1–8.

Kubernatova, P., Friedjungova, M. & van Duijn, M. (2018). Knowledge at First Glance: A Model for a Data Visualization Recommender System Suited for Nonexpert Users. Proceedings of the 7th International Conference on Data Science, Technology and Applications (DATA 2018). 208-219.

Kusleika. D. (2021). Data visualization with Excel dashboards and reports. Wiley.

Kurata, H., (2014). How does inventory pooling work when product availability influences customers' purchasing decisions? International Journal of Production Research, 52(22), 6739–6759.

Lee, B., Choe, E. K., Isenberg, P., Marriott, K., Stasko, J., & Rhyne, T.-M. (2020). Reaching Broader Audiences with Data Visualization. *IEEE Computer Graphics and Applications*, 40(2), 82–90.

Luukkainen, L. (2019). Ensuring material availability by portfolio models and supplier relationship management in after sales service business. Master's Thesis. LUT-University.

Machiraju, S. & Gaurav, S. (2018). Power BI Data Analysis and Visualization. DEG Press.

Madakam, S., Holmukhe, R. M., & Kumar Jaiswal, D. (2019). The Future Digital Work Force: Robotic Process Automation (RPA). Revista de Gestão da Tecnologia e Sistemas de Informação, 16, 1–17.

Mahanti, R. (2018). Data quality: dimensions, measurement, strategy, management, and governance. ASQ Quality Press.

Marciniak, P. & Stanisławski, R. (2021). Internal Determinants in the Field of RPA Technology Implementation on the Example of Selected Companies in the Context of Industry 4.0 Assumptions. Information (Basel), 12(6), 222–.

Microsoft. (2023a) What is Power BI? [web article]. Power BI Documentation. Microsoft Corporation. [22.2.2023]. Available: https://learn.microsoft.com/en-us/power-bi/fundamentals/power-bi-overview

Microsoft. (2023b) Learn DAX basics in Power BI Desktop. [web article]. Power BI Documentation. Microsoft Corporation. [20.1.2023]. Available: https://learn.microsoft.com/en-us/power-bi/transform-model/desktop-quickstart-learn-dax-basics

Microsoft. (2023c) What is Power Query? [web article]. Power Query Documentation. Microsoft Corporation. [17.5.2023]. Available: https://learn.microsoft.com/en-us/power-query/power-query-what-is-power-query

Miksch, S., Leitte, H., & Chen, M (2020). Knowledge-Assisted Visualization and Guidance. In Chen, M., Hauser, H., Rheingans, P., & Scheuermann, G. (Eds.), Foundations of Data Visualization. 1st edition, 61-86. Springer International Publishing.

Miller, J. D., (2017). Big data visualization (1st edition). Packt Publishing.

Mullakara, N. & Asokan, A. (2020). Robotic Process Automation Projects (1st edition). Packt Publishing.

Ng, K. K. H., Chen, C.-H., Lee, C. K. M., Jiao, J., & Yang, Z.-X. (2021). A systematic literature review on intelligent automation: Aligning concepts from theory, practice, and future perspectives. Advanced Engineering Informatics, 47, 101246–.

Paakki, J., Huiskonen, J., & Pirttilä, T. (2011). Improving global spare parts distribution chain performance through part categorization: A case study. International Journal of Production Economics, 133(1), 164–171.

Radke, A. M., Dang, M. T., & Tan, A. (2020). Using robotic process automation (RPA) to enhance item master data maintenance process. LogForum (Poznań, Poland), 16(1), 129–140.

Salminen, A. (2011). *Mikä kirjallisuuskatsaus? : johdatus kirjallisuuskatsauksen tyyppeihin ja hallintotieteellisiin sovelluksiin*. Vaasan yliopisto.

Saunders, M., Lewis, P., & Thornhill, A. (2016). Research methods for business students (Seventh edition.). Pearson Education.

Silvola, R., Jaaskelainen, O., Kropsu-Vehkapera, H. & Haapasalo, H. (2011). Managing one master data - challenges and preconditions. Industrial Management + Data Systems, 111(1), 146–162.

Ussik, J.-E. (2021). Ensuring material availability by using risk management process in power and automation industry. Master's Thesis. LUT-University.

Vayghan, J. A., Garfinkle, S. M., Walenta, C., Healy, D. C. & Valentin, Z. (2007). The internal information transformation of IBM. IBM Systems Journal, 46(4), 669–683.

Väre, T., (2019). Master data (1. ed.). Helsinki: Alma Talent.

Williams, D. & Tang, H. (2020). Data Quality Management for Industry 4.0: A Survey. Software Quality Professional, 22(2), 26–35.

Yin, R. K. (2009) Case Study Research: Design and Methods. 4th ed. Sage Publications, Thousand Oaks, CA

Österle, H. & Otto, B. (2015) Corporate Data Quality: Prerequisite for Successful Business Models. epubli GmbH, Berlin. ISBN: 978-3-7375-7593-5

Appendix 1. Topics and guiding questions for semi-structured interviews.

Topics:

1. Issues stemmed from data.
    a. What kind of problems you have had that stemmed from incorrect data?
    b. Can you estimate the costs that these may have brought?
2. Data correctness.
    a. How do you see our data correctness now?
    b. What could we do to improve data correctness?
    c. Should there be more checks to ensure our data's quality?
3. Data availability.
    a. What do you think about company ERP's data presentation?
    b. Is it easy to find the information that you need and extract it from company ERP's?
4. Impacts on material availability.
    a. Do you think data quality has impact on material availability? And how?
    b. What would you say are the main data problems that cause delays in inbound and outbound?
5. Use of the report.
    a. Why do you use this report?
    b. What benefits can be gained from this report?
6. Improvement ideas for this report.
    a. What could be added to the report?
    b. What could be done differently in the report?