FRAMEWORK FOR DAILY MANAGEMENT DIGITALISATION

Lappeenranta–Lahti University of Technology LUT

Industrial Engineering and Management, Master’s thesis

2025

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ABSTRACT

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LUT School of Engineering Science

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Keywords: digitalisation, manufacturing industry, daily management system, data-driven decision-making, organisational culture

This thesis investigates the effects of digitalisation on operational daily management in the manufacturing industry. This research aims to support organisations both considering digitalisation and those already progressing on their digitalisation journey. The objective is to provide information of digitalisation's impacts and factors contributing to successful digital transformation by building a framework for operational digitalisation.

This research uses qualitative research approach with features of constructive research. Literature review is integrated with a real-world case study from a focal company within the medical technology industry. Empirical data is collected through observations, process construction, and eight semi-structured interviews with the focal machine's management chain and an external consultant. The resulting construction, operations digitalisation framework, summarises the main findings with a special focus on digitalisation effects on data-driven decision-making.

Digitalisation is found to enhance real-time information availability, visual management, and communication. It increases transparency and shifts daily management decision-making from retrospective analysis to proactive intervention while reducing repetitive manual work. Digitalisation outcomes are moderated by data quality, systems interoperability, workforce skills and training needs, and organisational culture. Clear change communication, employee involvement, training, and management support can mitigate the change resistance.

The study provides research-based perspectives and findings for manufacturing industry organizations considering the digitalization of daily management practices.

TIIVISTELMÄ

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VIITEKEHYS PÄIVITTÄISJOHTAMISEN DIGITALISOINTIIN

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Tämä diplomityö tutkii operatiivisen päivittäisjohtamisen digitalisoinnin vaikutuksia tuottavassa teollisuudessa. Tutkimus tukee digitalisaatiota harkitsevia sekä toimintaansa jo digitalisoineita organisaatioita. Tavoitteena on tuottaa tietoa digitalisaation vaikutuksista sekä onnistunutta digitalisaatiota edesauttavista tekijöistä diplomityön tuloksena esitettävällä operatiivisen digitalisoinnin viitekehyksellä.

Tutkimus käyttää kvalitatiivista tutkimusmenetelmää, ja sisältää myös konstruktiivisen tutkimuksen piirteitä. Kirjallisuuskatsaus yhdistyy reaalimaailman tapaustutkimukseen terveysteknologia-teollisuusalan tehtaasta. Empiirinen aineisto on kerätty havainnoinnilla, prosessikonstruktiolla sekä seitsemällä tehtaan henkilöstön ja yhden ulkopuolisen konsultin puolistrukturoidulla haastattelulla. Työn tuloksena esitettävä operatiivisen digitalisoinnin viitekehys kokoaa tutkimuksen keskeiset löydökset erityisesti tiedolla johtamiseen liittyvistä vaikutuksista.

Digitalisoinnin havaittiin parantavan reaaliaikaista tiedonsaantia, visuaalista johtamista ja viestintää. Se lisäsi läpinäkyvyyttä ja siirsi päivittäisen päätöksenteon retrospektiivisestä analyysistä ennakoivaan toimintaan sekä vähensi toistuvaa, manuaalista työtä. Digitalisoinnin tuloksiin havaittiin vaikuttavan datan laatu, järjestelmien yhteentoimivuus, henkilöstön osaamistaso, koulutustarpeet sekä organisaatiokulttuuri. Muutosvastarintaa havaittiin lieventävän selkeä viestintä, henkilöstön osallistaminen, koulutus ja johdon tuki.

Tämä diplomityö tarjoaa tutkimuksellisia näkökulmia ja löydöksiä tuottavan teollisuuden organisaatioille, jotka harkitsevat päivittäisjohtamiseen kohdistuvaa digitalisointia.

ACKNOWLEDGEMENTS

With this research, I am concluding my studies in Industrial Engineering and Management at LUT University, with gratitude. During my university years, I built friendships I believe will last a lifetime. Above all, I would like to thank my friends for the unforgettable experiences across Finland, and carefree times at the Kaplaaki guild room. These are memories I will always remember with warmth.

For this thesis, I would like to thank the focal company and all the interviewees for their time, insights and conversations. Special thanks to Marjut for all our valuable conversations and your guidance throughout this research. I would also like to thank my examiner, Timo Kärri, for insightful guidance and valuable perspectives during this research process.

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Finally, I would like to thank my family for their constant support and encouragement throughout my studies and this thesis. Special thanks also to Jonas for your support.

I close this chapter of life with unforgettable memories and dear friends made along the way.

ABBREVIATIONS

AI	Artificial Intelligence
DIKW	Data – Information – Knowledge – Wisdom
DMM	Daily Management Meeting
DMS	Daily Management System
ICT	Information and Communication Technologies
IoT	Internet of Things
LO	Line Operator
PSM	Production Scheduling Manager
RCA	Root Cause Analysis
ROI	Return on Investment
QI	Quality Inspector

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ANNOUNCEMENTS

Turnitin

This master's thesis originality has been reviewed with Turnitin's similarity check service.

Artificial Intelligence

The author of this thesis, Mimmi Parjanen, has used the following AI tools in the preparation of this thesis:

1. Microsoft Copilot
   a) Purpose of the tool: Searching previous research to find relevant sources, transcribing the interviews, and improving the language and writing style of the text, all in accordance with LUT University's practices regarding the use of artificial intelligence tools (LUT, 2023; LUT, 2025).
   b) Explanation of the use of the tool: Finding relevant academic and professional sources that may have not been found with the traditional search methods, enhancing clarity, coherence and academic tone of the written text, and transcribing interviews.
2. ChatGPT-3.5
   a) Purpose of the tool: Searching previous research to find relevant sources and improving the language and writing style of the text, both in accordance with LUT University's practices regarding the use of artificial intelligence tools (LUT, 2023; LUT, 2025).
   b) Explanation of the use of the tool: Finding relevant academic and professional sources that may have not been found with the traditional search methods and enhancing clarity, coherence and academic tone of the written text.

Responsibility

The author, Mimmi Parjanen, takes full responsibility for the content of this thesis and has checked and edited any content generated by artificial intelligence tools.

1 Introduction

This research examines the background and importance of digitalisation within operative environment, clarifies its impacts on data-driven decision-making in daily management, and presents a corresponding framework built upon both theoretical and practical key findings. The following chapters of Introduction clarify the background and context of this research, its objectives, scope, and both research problem and research question. Lastly, the research methods and structure of the thesis are presented.

1.1 Background and research context

Organisation are forced to continuously refine their processes and strategies to thrive in the agile, dynamic industrial environments (Valamede & Akkari, 2020). Digitalising daily operations allows decisions to be made based on real-time data and helps use information efficiently, which in turn improves competitiveness (Heilala, Helaakoski, Kuivanen, Kääriäinen & Saari, 2020). Digitalisation offers new opportunities for the development of operative management, but its impacts – particularly from the perspective of data-driven decision-making – remain partly unclear. While it may appear self-evident that digitalisation enhances data-driven decision-making, this study investigates how it truly affects decision-making and the underlying information base, what are the moderators influencing the digitalisation effects and outcomes, and what are the digitalisation drivers from businesses' point of views.

Digitalisation is relevant as companies operating in manufacturing environments are gathering data on manufacturing machines around the clock and are starting to realise its value and capabilities, internalising the Value of Data concept. There have been many pioneers of digital technologies in Finnish manufacturing industry, such as ABB and Mantsinen exploiting AI (Artificial Intelligence) and intelligence of IoT (Internet of Things) (ABB, 2019; Hämäläinen, 2018), but within industrial environments, it cannot be taken for granted that operational processes have been modernised through digitalisation. Several factors may explain this, including limited resources, complex bureaucratic structures of organisation, and strict requirements related to process or quality standards that are difficult to change. Another problem mentioned in the study of Heilala et al. (2020), is the lack of IT professionals and general IT skills. In Finland, there is a wide range of digitalisation maturity within the manufacturing industry: from highly digitalised companies to manufacturing plants lacking the skills, means and tools required for successful digitalisation (Heilala et al., 2020). According to European Commission's Digital Economy and Society Index (DESI) indicating the digital performance and tracked progress of EU member states, Finland was the leader still back in 2022 (European Commission, 2024). If only focusing on the indicators related to digital transformation of businesses from DESI period 2024, Finland is number one within the following indicators:

- SMEs with at least a basic level of digital intensity,
- SMEs using two or more social media platforms, cloud computing, and AI, and
- Cloud or Data analytics,

when measured as the percentage of enterprises (Eurostat 2024a; Eurostat, 2024b; Eurostat 2024c, Eurostat, 2024d). DESI period 2025 was not statistically usable, because there were data missing from various countries on some indicators. In general, Finland performs very well on the digitalisation of businesses when comparing on other EU countries (European Commission, 2023).

The daily operative management state of Finnish manufacturing industry was studied within a private, non-profit research institute Elinkeinoelämän Tutkimuslaitos (ETLA) in 2017. This study focused especially on the floor level management of a factory and the results claimed that the floor-level management of Finnish factories are of a good, international standard. According to the study, Finland is stronger on production follow-up and monitoring than incentives and setting clear targets. (Maliranta & Ohlsbom, 2017)

It is important to clarify the effects of digitalisation, combining both scientific and academic insights, and the real operative daily life of manufacturing sites. This enables the understanding of how digitalisation of daily management changes the everyday reality of management, especially in terms of data availability, sharing and use in supporting decision-making. This research aims to support organisations in making decisions about digitalisation investment and implementation by providing scientific findings and perspectives.

This research uses a focal company and one of its plants in a form of case study to create the empirical foundation for this research. The focal company's factory unit used in this research is a plant of a global leader in the medical technology industry, producing products and related services for the health care industry. The company is performing on a proficient level within the daily management system and is implementing Lean practices in some of its operations. The plant unit uses digitalisation in some of its functions and practices, but overall, its level of digital maturity remains relatively low. Still, the factory has a strong drive towards digitalisation and is motivated in the efforts towards digitalisation. This factory unit's journey towards digitalisation is used in this thesis in the form of interviews, observations and a production planning process construction. An organised change project including digitalisation efforts was executed on one of the production machines of the focal company. This production machine is crucially important for the company, producing complicated products, and employing five line operators and their managers each shift, running 24 hours per day, 7 days a week. This production machine produces a variety of various products, most of them crucial key products for the factory. Within this research and case study, the focal company's focus factory is called "Focal factory", and the production machine is referred to as "Focal machine".

1.2 Research objective and research question

As described in earlier chapter, digitalisation within the manufacturing industry of Finland still has a lot of potential. In manufacturing industry, the digitalisation possibilities within daily operative management enable real-time information-based decision-making and effective enhancement of data and information. Digitalisation offers a lot of possibilities for the development of daily operative management, but its impacts on data-driven decision-making are still partly unclear. It is important to understand how the digitalisation of operations changes the everyday life of daily operative management, especially the accessibility, sharing and enhancement of information, enabling data-driven decision-making. This is the foundation of this research's objectives.

This research examines how the digitalisation of daily operative management affects information availability, real-time accessibility, and the visual presentation of data. It also investigates how operative decision-making and situational awareness evolve as daily management becomes digitalised, how data is transformed into decision-making insights in line with the DIKW model, and what factors affect the change resistance towards digitalisation.

The primary objective of this research is to develop the operations digitalisation framework that explains the impacts of daily management digitalisation on data-driven decision-making within operative environments. The specific focus is on how digitalisation influences the information basis of daily operative management decisions. To achieve this, the study produces the following outcomes:

1) A framework grounded in relevant research, academic theories and models, benchmarking study from literature and focal company's case study through observations, interviews and process construction.
2) A thorough analysis of the effects of daily management digitalisation on data availability, visualisations, real-time access, and decision-making practices in industrial operative contexts, and to clarify the factors affecting change resistance towards digitalisation.

To address both outcomes, the research question examines the framework created to explain the topic:

What are the elements of the operations digitalisation framework?

This research question contains identifying the digitalisation drivers, digitalisation process components, digitalisation effects, and the moderators influencing the digitalisation outcomes, such as change management and organisational culture- related factors. The thorough analysis of the digitalisation outcomes and the factors affecting the change resistance towards it are presented within the framework.

1.3 Scope & terminology

The research is scoped both from the theoretical and empirical parts. The theoretical scope is limited within three areas: Data-driven decision-making - explaining how digitalisation enhances the data foundation that supports decision-making in operative management, Daily management – explaining the impact of digitalisation on daily operative control and visual information presentation, and lastly, Digitalisation on manufacturing industry – describing the effects of digitalisation on industrial environments and day-to-day operations on operational environment. This research does not explore in detail the technical aspects or details of software architecture, extensive organisational culture change processes, big data analytics or the utilisation of artificial intelligence. From the empirical part, the research is scoped within daily operations management and has a focus on the post-implementation phase of digitalisation as visualised in Figure 1. The presented focal company case study's digitalisation construction is scoped within the production planning process. The study does not address quantitative metrics of productivity or efficiency. Instead, it focuses on the perceived impacts identified through the theoretical framework and the interviews. The empirical scope is described in further detail within the following Figure 1.

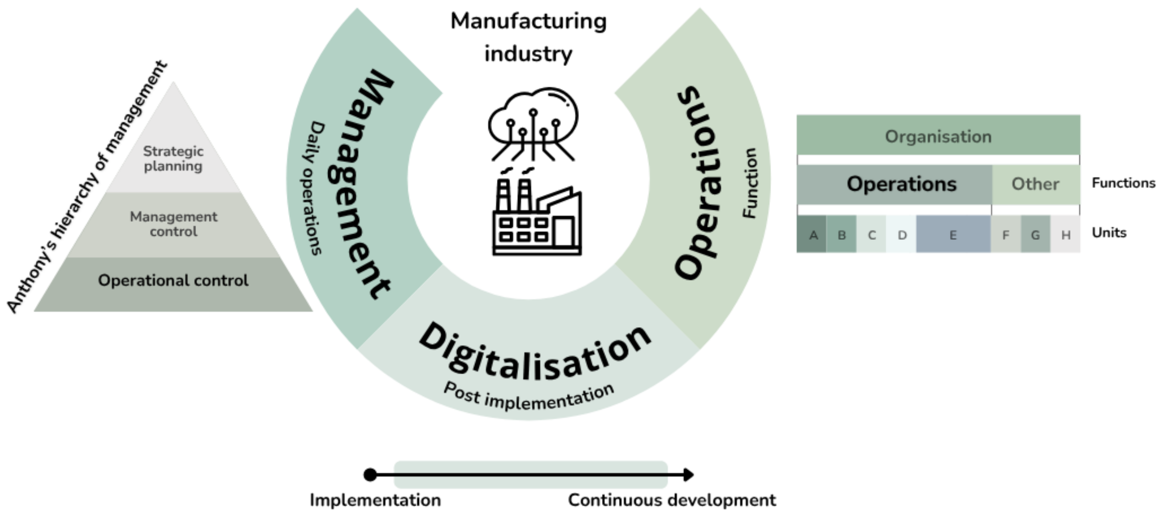

Figure 1. The scope of research (Adapted by Merad, Verdel, Roy & Salmon , 2003)

The empirical scope and focus of this research are divided into three scope areas: the digitalisation process focus, the organisational function limitation, and the level of management. The first scope area, digitalisation, is its own entity that can be enhanced by organisations in different industries. This study examines digitalisation efforts within the manufacturing industry, with a particular emphasis on the **digitalisation post-implementation phase**. It specifically explores the challenges faced and outcomes observed after digitalisation has been implemented. To provide important context, organisational drivers and barriers to digitalisation are also briefly covered and the interviews include discussions of the pre implementation and implementation phase of digitalisation as well. The second scope area restricts the research within organisational functions. This study is specifically focused on the **operations function** of organisations, examining the digitalisation initiatives carried out within their operational units. This means that digitalisation efforts and their effects on the support functions of organisations are not covered in this research. The third scope area limits the research within the management levels executed within organisations. Inside each organisation there are different levels of management, in the Figure 1 visualised by Anthony's hierarchy of management (Merad et al., 2003). This research is scoped within the **operative level of management**, defined as daily management. From the empirical side, the daily management is also scoped within the daily management chain of the focal machine within the focal company. This research uses constructive methods to visualise the production planning process digitalisation and its effects on data-driven management and decision-making within the empirical part of this research.

It is important to understand the differences between the related terminology as concepts related to digitalisation, data-driven decision-making and daily management are often confused. Heilala et al. (2020) define the digi-related terminology as:

> "For us digitising is the way to provide a digital presentation (model) of an entity i.e. converting information from a physical format into a digital one. Digitalisation means the implementation of processes or services via information and communication technologies (ICT). Digital transformation is the way to digitalise your product, services or processes; i.e. how to proceed with digitalisation."

Wynn and Felser (2023) similarly describe digital transformation to include deploying digital technologies within the products or services companies are offering, acting as the difference between digitalisation and digital transformation. Using the terminology explained above, this research focuses on digitalisation, which plays a key role on digital transformation and can include digitising.

Another terminology essential to clarify is the concept of data-driven decision-making. In this research, data-driven management refers to decision-making and management that relies on actual quantitative or qualitative information, rather than knowledge relying solely on the decision-maker's personal experience or memory.

Daily management refers to the operational oversight conducted on the shop floor and the management chain of a factory unit. Daily management ensures communication and information flow and is the beginning of production problem solving and functioning production flow. Whether it is about a quality problem or bottleneck on the production lane, daily management is where the information is brought up. Within this research, daily management is defined as all activities related to day-to-day decision-making and management within operational processes, whether these decisions occur within the Daily Management System (DMS) meetings or outside them: during supervisory guidance at production machines or within line operator's decision-making situations.

In the empirical section, this study examines a focal company whose digitalisation efforts are still relatively recent. Consequently, the company has not yet experienced the long-term effects of digitalisation. For this reason, the empirical analysis is limited to examine the short-term, qualitative impacts of digitalisation efforts.

1.4 Research methods

This research is a qualitative study, that has features of constructive research. In the nature of qualitative research, the phenomenon – digitalisation's impacts on data-driven daily management and decision-making – is explored throughout a literature review including a benchmarking study, and a focal company's case study including interviews, observations and a supporting process construction, with a goal of understanding and describing digitalisation-related real-world impacts and experiences. The focal company's process construction created within this research describe focal company's production planning process, its transformation within digitalisation, and the effects of this change, acting as the foundation for reader to better understand the organisational changes described in the interviews. Another process construction is also built upon the benchmarking study from literature. Lastly, the framework is built upon the literature review, interviews, observations and findings of the process construction to conclude the findings of this research. The process constructions and the framework act as the constructive part of this research.

The literature review creates theoretical background and gathers the latest available information for the topic and the framework developed as the main objective of this research. The literature review of this research is strongly built around the scientific models and frameworks used in the research: DIKW-model, Kotter's model, Value of Data- concept and

DMS. Also, a benchmarking study from previous research is presented to bring volume for the empirical findings of this research. Relevant sources for the literature review were gathered using general key words that developed more filtered along the process. The key words were mostly related on operations digitalisation, change management, information development, data-driven decision-making and daily management system. The sources include journal articles, conference proceedings, books, reports and white papers, relevant high-quality websites, and datasets and statistical sources. The databases utilised for information gathering included databases for scientific research: Scopus, Elsevier ScienceDirect, Google Scholar, SpringerLink and LUT Primo. Also, search engine Google was used to find web-sources.

The interviews and observations are part of the case study within the focal company, relevant for qualitative research, providing empirical insights to support the literature review. Interviews were conducted for seven key persons from the management chain of the focal machine, and one external management consultant, also strongly involved within the change executed at the focal machine. These interviews are described in more detail in the third chapter about Research methodology. The observations gathered before and during the research create foundation for the constructive research part, where a construction of focal company's production planning's digitalisation is visualised and described in a process before- and after format. These observations were also used in the interviews, providing significant background information and depth for the interviews. Observations are crucial to ensure the relevance of the findings within the organisational context and can give valuable information to support the interviews (Ojasalo, Moilanen & Ritalahti, 2015, 114-115). The framework developed as the primary objective of this research enhances both qualitative and constructive research methods. The data collection, including interviews are described in further detail in the third chapter about Research methodology.

1.5 Structure of the thesis

This research is structured within the Introduction chapter, Theoretical background, Research methodology description, Empirical findings and analysis, the framework description chapter, and finally, the conclusions. The research structure in a form of input-output- visualisation is presented in Figure 2 below.

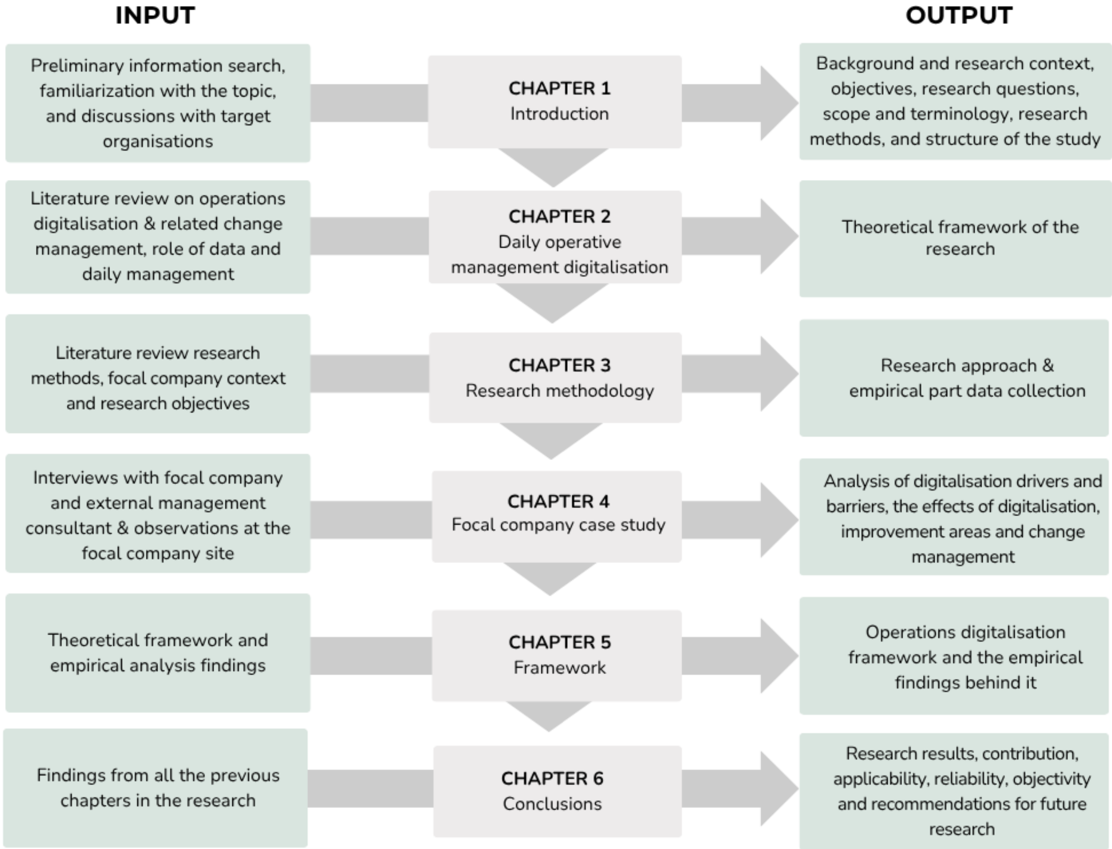

Figure 2. Research structure

The first chapter, Introduction, familiarises reader with the subject by a broad background and research context chapter, describing the importance of this research and giving insights about the current state of digitalisation within Finnish companies, focusing on the manufacturing industry. Also, the research problem, research question, objectives and scope are described within the first chapter. Introduction chapter also includes a synopsis of the research methodology conducted throughout the study, and lastly, the structure description of this research. The second chapter delves into the theoretical background of the research and acts as the literature review part of this thesis. The theoretical background of this research is divided into three categories: digitalisation in the manufacturing industry, the role of data in operative decision-making, and lastly, the change management related to digitalisation. The first category of theoretical background further introduces reader within the topic – what is the state of digitalisation within Finnish companies and the manufacturing industry. The second category familiarises reader with DIKW Model and the Value of Data concept in the context of manufacturing industry; where does the data come from, how should it be developed, processed and used, and how do companies embrace the value of data. Lastly, the change management related to digitalisation is emphasised throughout Kotter's change management theory, and the cultural and organisational preconditions related to change management. A benchmarking study is also included within the theoretical background of this research. The third chapter familiarises reader more thoroughly to the research methodology used in data collection and analysis. The fourth chapter presents the empirical findings gathered through the observations, interviews, and process construction. The findings described in this chapter are visualised and added to the theoretical framework, generating the operations digitalisation framework built as the main objective of this research and presented in the fifth chapter. Lastly, the key findings, contribution and applicability, reliability and objectivity, and suggestions for future research are presented in the sixth chapter of this research.

2 Daily operative management digitalisation

The second chapter of this research builds the theoretical framework by first explaining the relevant topics in a form or literature review. The first subchapter introduced reader to the background of this research: digitalisation, its drivers and outcomes. The role of data in decision-making is discussed in the second subchapter by introducing the DIKW model and the Value of Data- concept. The third subchapter introduces the Daily Management System and visual, digital daily management. Fourth subchapter discusses change management related to digitalisation by introducing Kotter's model. A benchmarking study related to the topic is introduced in the fifth subchapter and finally, the theoretical framework is introduced in the sixth subchapter.

2.1 Digitalisation in the manufacturing industry

As summarised in a paper published by World Economic Forum in collaboration with Kearney (2024), Manufacturers are shifting from "doing" digital to "being" digital across end-to-end operations. Still, being digital in the operational functions of organisation, especially in the manufacturing industry, is not self-evident. Digitalisation as a part of digital transformation has been an important theme on organisations' business strategies for over decades (Bharadwaj, El Sawy, Pavlou & Venkatraman, 2013). Bharadwaj et al. (2013) defined digital business strategy as:

"Organizational strategy formulated and executed by leveraging digital resources to create differential value."

Although now in 2025, over 10 years have passed since, but this definition remains relevant. This chapter addresses digitalisation within Finnish manufacturing industry and raises the question: are digital business strategies just empty talk, or is the digital development within operations truly prioritised?

In general, Nordic countries have a high level of readiness for the future of manufacturing and production (Heilala et al., 2020). Nordic countries have good digital skills and readiness, spend most on research and development, have optimal culture and workplace development and strong ICT-sectors (Nordic Council of Ministers, 2015). This chapter studies whether this readiness is showing in the form of quantitative numbers.

When studying the state of digitalisation among different industries in Finland, in 2023, the manufacturing industry placed fourth among the general TOL industries (Tilastokeskus, 2024). As the 2024 data was incomplete for several indicators at the time of analysis, the 2023 data was chosen for use instead. The dataset of industries and different digitalisation indicators was processed for better visualisation: the indicators were generalised into broader parent categories by calculating averages. Note, that the data of indicator "Documentation for AI technologies" is year 2024's data since the data was missing from year 2023. The results by industries can be seen in the following Figure 3.

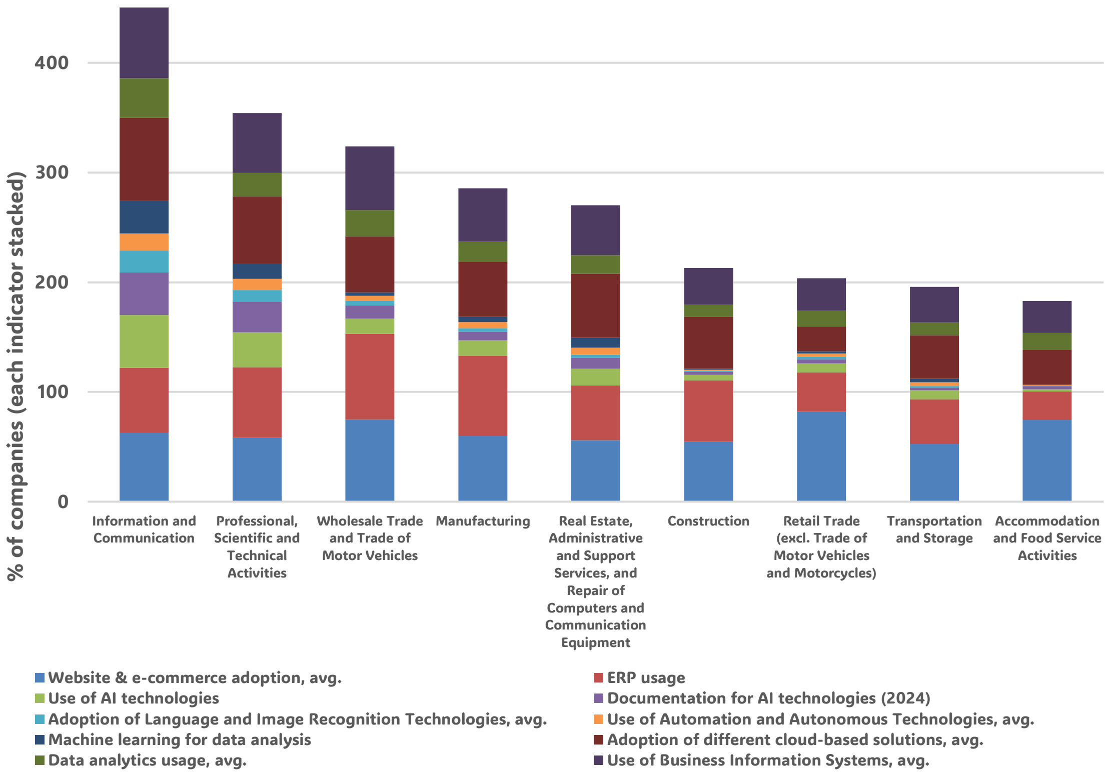

Figure 3. Adoption of digital technologies by industries on 2023 (Adapted by Tilastokeskus, 2024)

The data visualised in Figure 3 above shows that the top 4 industries exceling the most among the analysed digital technologies were Information and Communication industry, Professional, Scientific and Technical activities industry and Wholesale Trade and Trade of Motor Vehicles industry (Tilastokeskus, 2024). Figure 4 below represents the different technologies adoption-% within the manufacturing industry in Finland, to gather a deeper understanding of the manufacturing industry itself.

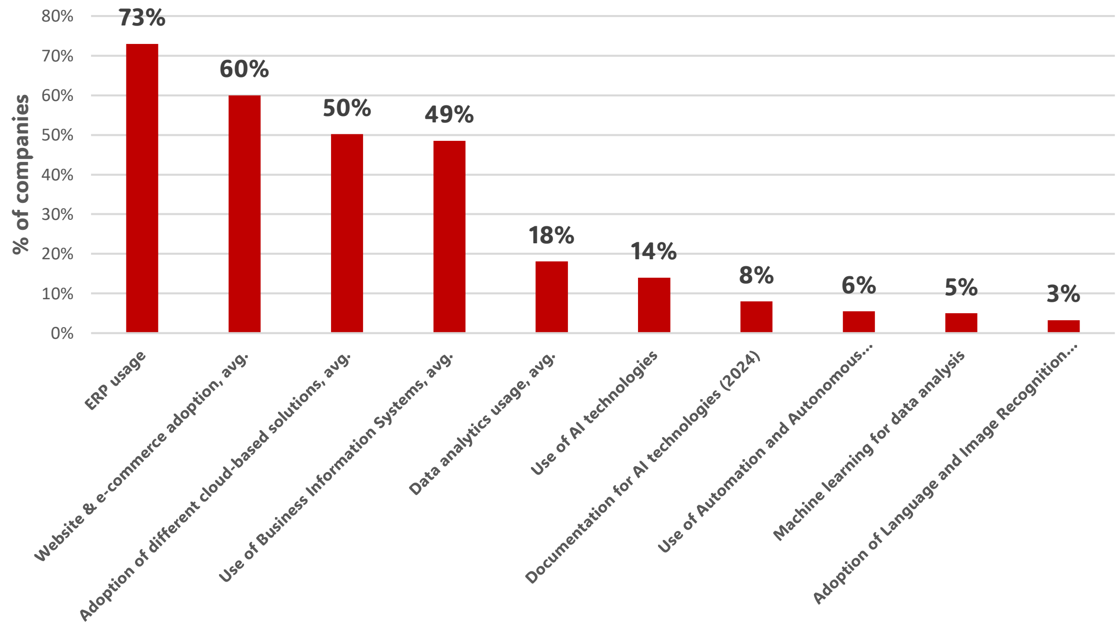

Figure 4. Manufacturing industry adoption of digital technologies (Adapted by Tilastokeskus, 2024)

As seen in Figure 4 above, most manufacturing industry companies have adapted ERP usage, websites and e-commerce and different cloud-based solutions, such as CRM, databases and email. Still, a minority of manufacturing industry's companies are using Business Intelligence solutions, Data analytics, Automation and different autonomous technologies such as Robotic Process Automation, Machine learning, Language and image recognition technologies, or AI technologies with or without usage documentation. (Tilastokeskus, 2024) Data-driven manufacturing is an enabler of smart manufacturing, and the convergence between cyber and physical world is already seen in the manufacturing industry (Tao, Qu, Liu & Kusiac, 2018).

2.1.1 Digitalisation drivers

According to a Policy Links (2013) research paper from the University of Cambridge, the driving trends of digitalisation can be divided into four categories: customer demand trends, industry pressures and drivers, technology trends and lastly, policy and regulatory aspects. Customers demand the companies to have a wide product variety with personalised products and services, fast responses and agility, added-value services such as order status tracking and automated emails and notification when products are back in stock, and most importantly: environmental sustainability enabled by digitalisation. Especially cyber-physical systems, cloud computing, big data, AI (Artificial Intelligence), machine learning and IoT can create significant value in manufacturing environments (Heilala et al., 2020). All these aspects come together in the concept of Industry 4.0, where smart factories are controlled with data and statistics, enabled by sensors, diagnostics and finally, big data (Sunagar, Dashana & Shruthi, 2022; Wynn & Felser, 2023). This can also be called the new industrial revolution, as stated in Monino's (2021) paper.

The industry pressure comes from the increasing need for asset and resource efficiency to succeed in the market competition, the need for traceability on the supply chain to meet the customer needs described earlier, to manage increasing security risks – considering databases versus paper archives room, and to manage the increasing manufacturing complexity of products, production and data (Policy Links, 2013; Butt, 2020). German automotive industry is an example within manufacturing industry, where digitalisation has forced companies to continuously reassess their business strategies and -models, core processes and organisational structures (Wynn & Felser, 2023). As Monino (2021) states in his research paper from 2021, data is an asset that companies have a drive to use. Coyle and Manley (2024) summarise the data-driven change of economies by highlighting, that seven out of the top 10 companies by stock market capitalisation were data-driven. In addition to more efficiently using digital technologies, there is great economic potential seen in labour productivity by applying automation technologies. The price of human resources is high in Finland, which drives manufacturing companies to effectively enhance robots or robot process automation, which will eventually become cheaper than human work (Heilala et al., 2020). In Finland, Sweden and Denmark this can be up to 15 % increase in productivity (Kromann, Rose Skaksen, Sørensen, 2012). The amount of manual work within daily management and its automation possibilities is discussed later in empirical interviews chapter 4.2.

For companies to succeed in the competitive environment, they must follow, study and, when possible and beneficial, implement the emerging technologies and systems available to reduce manual, automatable work, and to gain shared data, effective data analysis and control of manufacturing system elements (Policy Links, 2013). Improvements in ICT, and the ability to gather, process and transmit data are often behind the rapid growth of companies (Heilala et al., 2020).

The policy and regulatory aspects drive companies to implement digitalisation as it can be required for quality, safety, and sustainability standards and regulatory guidance. (Policy Links, 2013) The sustainability side and environmental impacts of digitalisation is double-edged: while the ICT sector can support sustainable solutions, for example the data centres and the electricity demand of digitalisation may have a net negative impact on the environment, depending on the energy source used (Sähköinsinöörit ry, 2020).

2.1.2 Digitalisation outcomes

According to Heilala et al. (2020), the goal of digitalisation within manufacturers is to achieve intelligent systems and analysis with partner networks. There are valuable possibilities within digitalisation, such as monetising the collected data as products or services, or using it as a competitive advantage (Monino, 2021)

A Marginal Cost Analysis executed in a research paper from 2024 proves that implementing digital tools to production lines, decreases the cost per unit produced, which will eventually lead to a lower marginal cost of production. The same study states that implementing digital tools will reduce both fixed and variable costs by reducing the need for physical infrastructure and enabling automation and process optimisation. It was stated to eventually also lead to improved efficiency and better teamwork. As a conclusion, digitalisation increases operational efficiency by maximising the optimisation of cost structures and resource allocation. (Bondar, Tolchieva, Bilyk, Slavkova & Symonov, 2024) Data enables companies to gain productivity advantages and growth opportunities (Coyle & Manley, 2024).

Information is continuously available, thanks to real-time data availability enabled by digitalisation (Bondar et al., 2024). Real-time data access enables data visualisations in forms of Power BI reports or other data visualisation systems and reports. Digitalisation can have a positive impact also on the management methods by improving the quality of decisions by providing more information to base the decisions on (Bondar et al., 2024).

Digitalisation makes companies rely more on the technical facilities, which makes technical issues to become more severe for the organisation (Bondar et al., 2024). Even a short breakage on the dataflows can lead to problems on reporting systems or other information visualisation systems, such as production plan visualisation tools, which causes a lot of daily management related problems.

The need for continuous learning is also often highlighted as the main issue of digitalisation. Lack of digital skills causes problems, so the staff and managers need to continuously learn to use new systems and to understand the reasons for digitalisation. (Bondar et al., 2024)

2.2 Role of data in operative decision-making

Digitalisation has changed management and decision-making radically. With digitalisation, decision-makers can access data in real time and use predictive analyses to optimise supply chains and effectively allocate resources. Managers can foresee patterns and events, enabled by historical data and found correlations and causalities. (Bondar et al., 2024) This is crucial in the manufacturing environments where history data can be used to, for example, recognising patterns of manufacturing machines data in problem situations. Now the daily operative management can foresee what happens before the machine gets in error mode and use this information to better prepare for these situations and even avoid such situations in the future. Better decision-making is the most often cited benefit of digitalisation according to the literature review of Bondar et al. (2024).

2.2.1 DIKW model

As explained by Peters, Jandrić & Green (2024), the DIKW (Data-Information-Knowledge-Wisdom) model explains the route for the evolution of understanding: data to information, information to knowledge and knowledge to wisdom. The roots of the model lie on 1980s first explained by Zeleny (1987) and further developed a few years later by Ackoff (1989) (Peters et al., 2024; Sharma, 2008; Frické, 2019). Some sources even state that the basics of DIKW model were present already in 1934 (Monino, 2021). This model is not perfect and has been criticised to overlook, for example, the impact of creativity, critical thinking and deductive reasoning in the context of learning and knowledge acquisition (Peters et al., 2024; Fricke, 2019). The model has its limitations but is still a valid tool to bring clarity and create foundation for understanding how data visualisation enabled by digitalisation brings information alive and how data is the foundation of data-driven decision-making. This paper is not focusing on the criticism of DIKW model, but to use it as a tool to create understanding on the topic of data-driven decision-making, by acknowledging the limitations of the model. DIKW model is also used later within this thesis to explain the digitalisation efforts impact to the daily management system, and the evolution of information within DMS.

DIKW model can explain the role and development of data enabled by digitalisation. The building blocks of DIKW model can be analysed in depth, and from different point of views, more philosophical or more logical and straightforward. Words data, information, knowledge and wisdom can have different meanings, depending on the context, and this leads to the philosophical aspects of the DIKW model and its accuracy, analysed in depth by, for example, Frické (2019), and Hoppe, Seising, Nürnberger & Wenzel (2011). In this paper, the model is analysed from the data evolution point of view, in the context of data digitalisation in an operative environment. The core of DIKW model is the pyramid of information, visualised below in Figure 5.

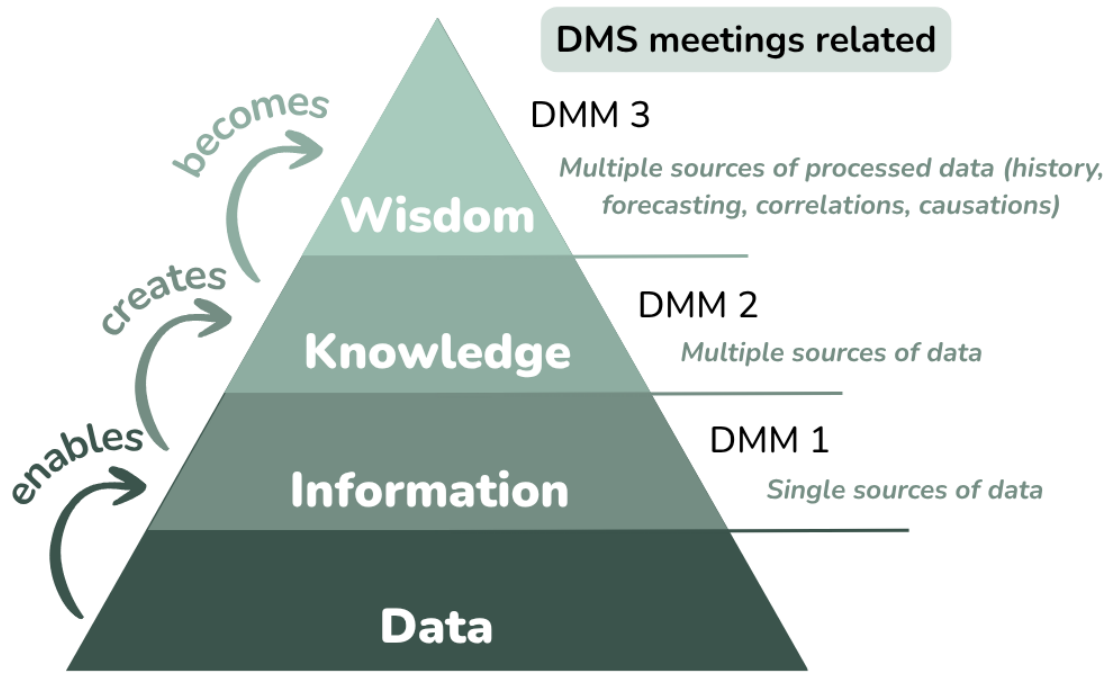

Figure 5. The pyramid of information (Adapted by Ackoff, 1989; Zeleny, 1987)

Figure 5 presented above connects DIKW model with the Daily Management Meetings (DMM) and gives examples of concrete information sources of each level. It is good to notice that the DMM meetings attached to the DIKW model in Figure 5 are only examples, as decision-making is happening daily also on the production machine- level. The information needed in each level of DIKW model, or in each DMM meeting can differ according to different situation, industries, or organisations. According to Ackoff (1989), without understanding the difference between data, information, knowledge, and wisdom, people:

“Not only don’t know, they don’t know what they don’t know”.

This means that managers don’t know the information they could have in their hands. The information should filter and develop within diverse levels of decision-making as it is obvious that the type of information needed can be different in the top management level and production machine level. This forms the path of decision-making. Monino (2021) concludes this as:

“It is the use of data that empowers decision-making.”

And Coyle and Manley (2024) support this stating that:

“With the growing use of digital technologies, data have become core to many organizations’ decisions, with its value widely acknowledged across public and private sectors”

In an operative environment, the manufacturing machines and the entire product lifecycle are constantly creating input for data-driven decision-making, and this can be called big data. In the context of manufacturing, big data characteristics can be explained by the 3 Vs introduced by Doug Laney (2001): data volume, velocity and variety.

- **Volume** refers to, as the name “big data” suggests, a large amount of data, where storage units used are terabytes and petabytes.
- **Velocity** indicates the high speed of the entire data process including data creation, collection and processing.
- **Variety** describes the wide scale of different data types gathered and processed continuously. (Laney, 2001; Li, Tao, Cheng & Zhao, 2015; Monino, 2021)

This big data is later analysed in big data analytics (Butt, 2020). In the context of DIKW model and manufacturing industry, data refers to the raw, unstructured input gathered and stored from the product lifecycle (Monino, 2021). This resource is acting as the foundation of the DIKW pyramid, visualised as the bottom level, in Figure 5. This foundation enables the construction of information, the second level in Figure 5, defined by Ackoff (1989) as:

“Information is contained in descriptions, and it answers to questions that begin with such words as who, what, when, where, and how many.”

In the context of manufacturing industry, this can refer to organised, structured and visualised data in an organised format, such as KPIs or production plan (Monino, 2021). Real-world examples of this kind of information could be, for example, “What was produced, and by which machine and shift?”. These are questions that are usually highlighted in DMS meeting structure’s level 1 meetings.

As moving higher in the DIKW pyramid, into the third level visualised in Figure 5, information creates knowledge by analysing trends, correlations, causalities and relationships to answer the ‘how’-questions, such as: “How did the latest shift actually do?”, “How are we succeeding in the production of this specific product?”, or, “How is the production planning succeeding in making a realistic production schedule?” (Hoppe et al., 2011). These questions are relevant in DMS meeting structure’s level 2 meetings.

By reflecting on existing knowledge and joining contexts, becomes wisdom (Hoppe et al., 2011). Frické (2019) explains this as bridging the pyramid’s lower levels to human beings and their actions. In manufacturing, this could be, for example, making a successful decision based on the existing knowledge in DMS meeting structure’s level 3 meetings.

This brings us back to the core of this research: data-driven decision-making. Data-driven decision-making cannot exist without all the building blocks of DIKW Model.

2.2.2 Value of data

Like established in the previous chapter, the path of data-driven decision-making starts from data. If existing, data is a resource that the company already owns. Collecting and processing the data is never free – either the company is continuously paying for system that generate it, or the data comes bundled with the original production machine investment. In both cases, data is part of the company’s assets. Leaving it unused is like ignoring raw materials, equipment, or any other resource you've already paid for. Why not unlock the full value of what you already have?

Monino (2021) expresses this by stating that today, data is a form of asset equivalent of oil and a white paper by the World Economic Forum (2021) supports it by stating that:

"Data is cited as the most valuable resource in the digital age."

And bringing out the numbers: in 2021, up to 90 % of companies' valuation lies in intangible assets such as data, intellectual property and brand, where in 1975 tangible assets presented up to 83 % of company's valuation (World Economic Forum, 2021). The change has been intense and fast. The OECD report from 2022 highlights, that in 2019, on average only 15 % of European enterprises analysed big data (OECD, 2022).

Using data is also getting cheaper as digital sensors and data storing costs are decreasing and digital economic activity is increasing (Carrière-Swallow & Haksar, 2019). The volume of data, also called big data, is what makes it so valuable strategically. Companies can monetise the data they have collected, using it as their competitive advantage in the tough markets of today. (Monino, 2021) In addition to its value in the competitive advantage, data is a profound core to organisations' decisions, which is highly valuable (Coyle & Manley, 2024). What affects the value of data is, for example the interoperability and quality of data (Coyle & Manley, 2024). The quality of data can be something that the company cannot fully effect on, as it can be dependent on production machines, and for example, their sensors.

Now the question returns to, how do companies use this resource? The value of data depends on how it is used. Although the volume of data is what makes it valuable, companies should not be content with just having existing big data, but to use it as their advantage. Companies should put effort on their analytical competence, ability to understand and manipulate large amounts of data, and translating findings into useful insights to support decision-making. Concrete ways to turn data into input, are using data insights to carry out business strategies more efficiently or transforming data into products or processes. (Monino, 2021) According to World Economic Forum's (2021) white paper from 2021, it is the companies' inability to measure the actual potential and value of data, and its unclear evolution to economic impact that makes companies comfortable with their current state of data management. This returns to Ackoff's (1989) statement about "not knowing what is not known" in the previous chapter.

If companies don’t truly know their data, they cannot know its potential and possible economic value.

2.3 Daily management in operative environment

The terminology, “Daily management” has roots in the Lean methodology, but it became common in the literature only around year 2000 (Nicholas, 2023). Daily management is the daily operative management taking place in the factory unit’s shop floor and the entire daily management chain. According to Pereira and Bittencourt (2020):

“It is the ongoing process to ensure that work is done in the right way and at the right time so that business success can be achieved as defined by the company’s strategy”.

Whereas Nicholas (2023), summarises daily management as:

“DM (Daily Management) happens day-in, day-out throughout the organization and among ‘floor’ associates.”

There is no clear, one-way definition of daily management, but it is a form of executing shop floor management, typically associated with the lean methodology. Continuous improvement and respect for people are described as the key features. (Nicholas, 2023) Typically, the visible side of daily management is the short DMS meetings issuing in the production area. All problems can often not be solved in these short daily meetings, but the problems can be brought up to ensure the beginning of problem solving and learning how to avoid the problems in the future (Leanthinking, 2025; Nicholas, 2023). Daily management is often the beginning of learning from mistakes and communication to various levels of organisation. This means that the short DMS meeting is, as said before, only the visible part of daily management that is happening in the background (Leanthinking, 2025). Daily management ensures communication and information flow and is the beginning of production problem solving and functioning production flow. Whether it is about a quality problem or bottleneck on the production lane, daily management is where the information is brought up. Daily management should happen there, where the work is done. In the manufacturing context, this means the production area. This is where the managers can solve and predict the issuing problems immediately. The practices of daily management are listed in Table 1 below.

Table 1. Daily management practices (Adapted by Nicholas, 2023; Hertle, Siedelhofer, Metternich & Abele, 2015)

	DAILY MANAGEMENT PRACTICE	ACTIONS
1	DAILY SHOP-FLOOR MEETINGS	Short meetings in the production area with managers and employees
2	KPIs FOR VISUAL MANAGEMENT & CONTROL	Visualising goals, performance, issues and solutions
3	DAILY STATUS CHECKS & PERFORMANCE AUDITS	Managers continuously gathering and reviewing performance data and identifying possible problems and development areas
4	DAILY ROOT CAUSE ANALYSIS OF PROBLEMS	Managers starting and monitoring the root cause analysis of problems
5	DAILY FACTORY WALKS	Managers should be present on the production area as much as possible, to make observations, and supporting employees in their work
6	MANAGEMENT STANDARD WORK	Management should be able to also execute the standard work of monitoring process routines and improvements, and leading and coaching employees
7	ESCALATION MEASURES	Not everything can be solved at the daily management level, and these issues should be escalated to higher management levels

The seven daily management practices listed in Table 1 above summarise the concept of daily management. In addition to the standard management work, daily managers should be able to run the daily meetings with employees at the production area, upkeep KPIs for visual management and control, execute performance audits, maintain the status of production area performance, launch and monitor root cause analysis of disruptions, be present at the production area for observations, guidance and coaching, and finally, escalate unsolvable measures to higher management levels (Nicholas, 2023).

As seen from the practices, daily management is a demanding entity, and for that reason, usually includes multiple managers in bigger factories. In this research, daily management is described as all relevant daily decisions that need to be done in the operational function, such as the daily guidance taking place at the production machines and the daily decisions made within production planning. Still, daily management is not only restricted to apply the daily activities, but to include also longer-cycle activities (Nicholas, 2023).

2.3.1 Daily Management System

The Daily Management System is a mechanism using daily management practices to address daily issues. Hertle at al. (2015) define shop-floor management system as:

> "An integrated managerial system that facilitates the communication, control of performance, and implementation of lean methods on the shop floor".

Hertle et al. (2015) describe the system to have six main areas: empowering and coaching employees, presence at the production area, using visualisations, introducing new forms of actions, embracing improvement and problem-solving processes, and facilitating competency on the production area (Hertle et al., 2015). This definition is also ideal for Daily Management System, described by Wahjoedi (2023), as follows:

> "The Daily Management System (DMS) is a system that lets everyone in the organization or company know about what they have to do to make the organization run smoothly."

Having a system for daily management helps organisations reach their goals efficiently (Wahjoedi, 2023). The seven practices of daily management presented in the former chapter in Table 1 define what is executed within the DMS. This chapter dives more into the framework and boundaries that these practices are executed within. Each organisation has their own ways to execute DMS and DMMs, but core of DMS is the communication cascade and escalation process within different management levels, visualised in the following Figure 6.

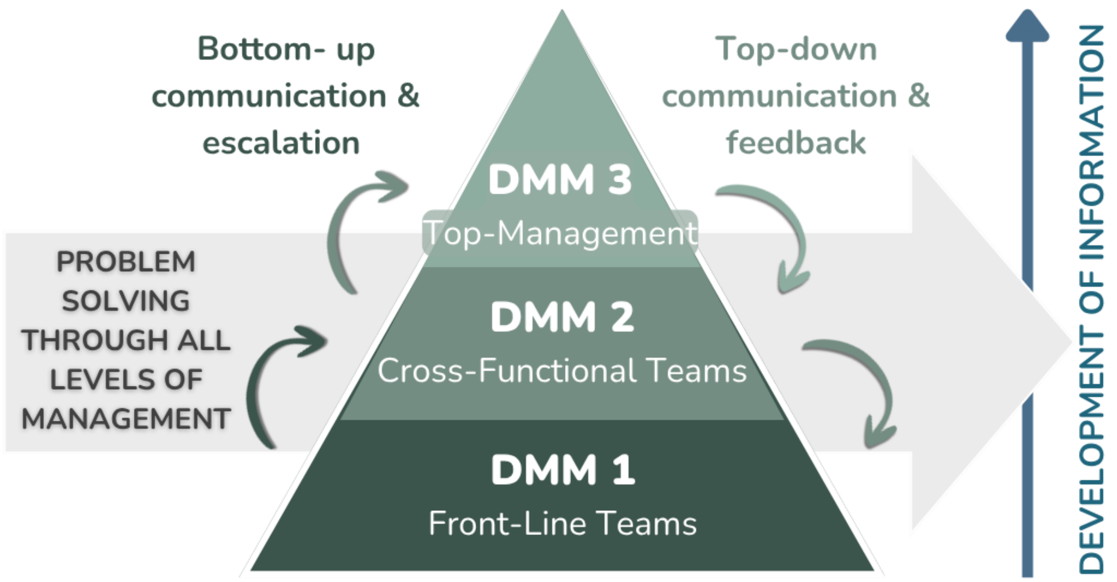

Figure 6. The escalation and communication development within DMS (Adapted by Tervene, Bisson & Metivier 2025; Ackoff, 1989; Zeleny, 1987)

The DMMs content and meeting names can vary among different organisations, but the meetings are commonly known as Tier-meetings. This research refers to them as Daily Management Meetings (DMMs). With the communication and escalation model visualised in Figure 6, managers and supervisors can share ideas, issues, and observations with higher management by escalating disruptions above, when needed. The top management, again, should give feedback and support back to lower levels of management. (Tervene et al., 2025) Escalating issues higher in the management doesn’t mean the issues would only be on higher management’s responsibility, as problem solving usually takes place through all levels of management as visualised in Figure 6.

Although a triangle visualisation of hierarchy can often be seen as old-fashioned, here it can be quite relevant as it also visualises the development of information within DMS (Ackoff, 1989; Zeleny, 1987). Each level of management needing different kind of data for their decision-making brings us back to the DIKW model. The information should be processed on its way from one management level to another as it is obvious that the information needed at DMM 1 at the production area can be different than the information needed in top management’s DMM 3. Organisations should have a clear view on which information is needed within each level of management, and this should be strongly linked to the organisational management system.

2.3.2 Digital and visual daily management

Digital daily management, also called DDM, began during the wave of Industry 4.0, when computers, devices, smart materials and intelligent machines were put to communicate with each other and interact with the environment (Ghobakloo, 2019). Instead of using whiteboards and collecting individual excel spreadsheets from multiple sources, managers could also use data-driven approach with well visualised data of the production, processes, bottlenecks slowing the production and parts that are working well to support their daily operations management (Pereira & Bittencourt, 2020).

Implementing digitalisation into daily management means using digital tools, software, data analytics and visualisation in the management, ideally through a system providing visualisations directly, for example a well-defined and developed Power BI report. Digitalisation is needed for digital daily management and smart production lines are the key for digitalisation. Smart production lines have been proven to improve operational efficiency by reducing lead times, reducing energy consumption by sensors detecting whether a machine was in use or not, and, for example, reducing production stoppages and waiting times, this leading to better delivery times and production downtime reducing (Orellana & Torres, 2019). It is good to remember, that digitalising daily management doesn't change the location: daily management should still happen where the work is done. Digitalising daily management does not mean transferring it into an online form, but to bring digitalised tools to support daily management.

Daily visual management is a key element of Lean methodology, creating transparency in the production system by making performance excellence metrics visually available. By visual management, people can understand the status of production area in 5 minutes or less through a simple observation. (Pereira & Bittencourt, 2020) The core of visualised daily management is the KPI boards enabling visual monitoring (Nicholas, 2023). Different visualisations in daily management reveals uneven workloads, bottlenecks and quality problems (Leanthinking, 2025). Visual management has roots far in the history of Egyptian's construction projects ca 2500 B.C. and Gantt Chart's beginning in 1917. Today, visual management serves to bring transparency to production processes, discipline to maintain correct procedures, management by facts and data and simplification of information flow, for example. (Tezel, Koskela & Tzortzopolous, 2009) Visual daily management has become increasingly important in the modern world with high competition from smart, data-driven factories. It is a vital factor of good daily management, making communication easier and faster, and situation visualisations easy to read and understand. Overall, visual management is important for production teams and their management when achieving operational excellence (Orellana & Torres, 2019). According to Lo Duca and McDowell (2024), effectively communicating by using visualisations requires design skills, technical knowledge and experience from the presenter. This is part of data story telling – transforming visualisations into data stories to effectively communicate to the audience (Lo Duca & McDowell, 2024) Concrete examples of digital daily management visualisations are presented in the following Table 2.

Table 2. Digital daily management visualisation examples

	VISUALISATION	DESCRIPTION AND USE-CASE
1	DAILY PRODUCTION TRACKING	Enables the understanding of production status with just a quick look, or if needed, a deeper analysis.
2	PRODUCTION SCHEDULE DAILY	Daily production schedule showing what will be produced next, updating according to the changes made by production planning, also indicating the reason for change to employees.
3	PRODUCTION SCHEDULE LONGER	Production schedule in a longer form, enabling, for example ordering or producing materials for upcoming production in time.
4	SAFETY KPIS	Visualisation of the safety numbers of organisation: has there been safety incidents, what kind of incidents and what were the consequences.
5	QUALITY KPIS	KPIs visualising the quality factors of production, such as reasons for the rejection of production & quality disruptions.
6	WASTE KPIS	KPIs visualising the waste numbers in different units such as pieces and euros.
7	REPORTING ACTIVITY KPIS	KPIs visualising the reporting activity from the production machines, if manual reporting is used.

These visualisations are common examples of digitalisation enabled visualisations to support daily management to better monitor goals, performance and possible disruptions, which is one of the key practices for daily management, as stated previously in Table 1 (Nicholas, 2023; Hertle et al., 2015).

2.4 Leading digitalisation-related change

Change is inevitable for organisations. Appelbaum, Habashy, Malo, and Shafiq (2012) argue that change has no clear beginning or end, as it is a continuous process. Similarly, Butt (2020) concludes that:

> "In the digital age, with the accelerated developments and technological advancements, there would be no end to change management, as it would be an on-going effort."

To keep up with the competition and continuously developing environments of digitalisation, artificial intelligence and other megatrends, organisations need to be agile, flexible and fast (Butt, 2020). In the context of digitalisation related change, this is not always an easy task. Digital transformation is perceived difficult by organisations for several reasons, such as the lack of standardised implementation models, managing digital development measures separately from other business activities, and implementing large-scale digitalisation without a realistic view of the return of investment (Butt, 2020).

Moving towards digitalisation is a substantial change for organisations, and this change should always be implemented carefully, focusing on the people (Butt, 2020).

2.4.1 Kotter's Model

Kotter's Model is a one of the most widely recognised change management theories presented by John P. Kotter in his book Leading Change (1996) (Pollack & Pollack, 2014). Although the theory itself has roots far in the history, it has been announced to still be relevant and widely used in businesses among industries (Appelbaum et al., 2012). Kotter's Model consists of eight steps described below in Figure 7.

Figure 7. Kotter's steps for change (Adapted by Kotter, 1996; Appelbaum et al., 2012; Pollack & Pollack, 2014)

The first step of Kotter's model, creating a sense of urgency within the project team and the people affected by the change, is crucial to effectively start and support the implementation of the change. The pressure created by the feeling of urgency makes the change real among the people affected by or carrying the change. (Kotter, 1996; Appelbaum et al., 2012; Pollack & Pollack, 2014) The second step in Kotter's change management model is forming a project team to manage the change (Kotter, 1996; Appelbaum et al., 2012; Pollack & Pollack, 2014). According to Gupta (2011), this project team acts as the catalyst for change. This project team should represent the organisation change is implemented at, not only the management (Gupta, 2011). For this reason, project teams should feature not just external experts, but also members who are well-known within the organisation. The change is less threatening when it comes delivered by familiar faces. The project team should include a diverse mix of empowered individuals from middle management and operations, without ego (Gupta, 2011). Thirdly, there needs to be a vision and strategy to create a common environment of credibility for the project success, and the implementation of change (Kotter, 1996; Appelbaum et al., 2012; Pollack & Pollack, 2014). This vision should be logical and appealing from experiential point of view (Gupta, 2011). Communicating the change vision is the fourth step of Kotter's change management model. This reduces uncertainty and increases motivation towards the change. (Kotter, 1996; Appelbaum et al., 2012; Pollack & Pollack, 2014) The communication of change vision needs to be frequent and clear for it to be reliable, and in line with employees' point of view (Gupta, 2011). According to Gupta (2011), the communication can be done in diverse ways, but eventually helping employees to see the vision and its benefits will inspire and engage them to the change. The next step is to empower actions to make people get involved in the project and think about the project changes (Kotter, 1996; Appelbaum et al., 2012; Pollack & Pollack, 2014). According to Gupta (2011), hearing the word "empowering" said from management to employees, can cause an adverse effect as it is received as a buzz word. What empowering employees means within change management, is being open for feedback from employees, investing in their education and training and making them responsible for accomplishments related to the change (Gupta, 2011). This kind of empowerment makes the change take place bottom-up, pushing decisions down to where the change happens (Paper, Rodger & Pendharkar, 2001). Sixth step is about generating short-term wins to make the changes and their successful effects visible to increase the positive vision of change (Kotter, 1996; Appelbaum et al., 2012; Pollack & Pollack, 2014). The key result of step six is to encourage a spirit of change (Gupta, 2011). As the seventh step, Kotter recommends consolidating gains to produce more change by using measurable results to fuel the following changes (Kotter, 1996; Appelbaum et al., 2012; Pollack & Pollack, 2014). The short-term wins described in the sixth step function as a launching pad for more change and success (Gupta, 2011). Lastly, anchoring the new approaches in the corporate culture and keeping in mind that the change management never ends, makes the implemented changes last and not fade away in time after the official project ending. This step is crucial for a sustainable change.

As digitalisation, even only as a word but especially when connected to transformation, can create tension, carefully planning, implementing and further elaborating the change is even more important. These Kotter's steps are important in successfully bringing digitalisation efforts or transformations alive and root them into organisations.

2.4.2 Organisational culture's effects

The shift towards digitalisation needs to be done with a good focus on the people. Digital transformation naturally causes resistance and restlessness in the whole organisation, not necessarily only on the team or organisational unit it considers. People are afraid of losing their jobs, not getting promoted or refusing to change the way of working they are used to do. (Butt, 2020) Multiple papers suggest that the way change is delivered has a key impact on the change's actual results (Paper et al., 2001; Cole, Harris & Bernerth, 2006) Acknowledging that change is difficult is not enough. Paper et al. (2001) state, that change, and its communication should be the top priority of top management. It was also highlighted that the management should aim to create a facilitative management style to successfully deliver the change and minimise the possibilities of conflicts, but this kind of behavioural change can be the most difficult to achieve (Paper et al., 2001).

To tackle the cultural and organisational preconditions, and to achieve sustainable change, the team managing change should be aware of the cultural and organisational landscape beforehand. As organisational culture cannot be defined as a thing or two, Gupta (2011), listed 16 items that can play part in defining an organisation's culture, the most important of them being: organisation's vision and objectives, bureaucracy, rules and standards, work atmosphere and its ability to recognise success. Paper et al. (2001) recommends creating empowerment, ownership and culture of dissatisfaction among the change target to create inner motivation towards the change and reduce the organisation culture's effects. Change implementation is at a risk to fail if the change is not endorsed by staff. The endorsement can be increased by effectively communicating the change's utility. (Small, Gist, Souza, Dalton, Magny-Normilus & David, 2016)

Gupta (2011) also states that running a company with long-term targets develops its risk-taking culture, acceptance of failures and work atmosphere as employees start hoping to contribute to their organisation's success. Managing company for short-term goals, again is told to make the environment tense, competitive, and eventually, destructive as employees are afraid of layoffs, become numb of stress and often feel disrespected (Gupta, 2011). The effects of organisational culture can be lowered by incorporating opinions from the change target, enabling the staff to leave their marks on the change. Also, empowering the staff within the change, can create ownership and adoption of the change. (Small et al., 2016; Paper et al., 2001)

2.5 Benchmarking study from literature

The benchmarking study from literature brings emphasis to the findings of the empirical part by showing concrete effects of another daily management digitalisation process. This benchmarking study was chosen to the research as it includes a similar production planning change that is presented from also the focal company, and the benchmarking study's focus company is also within manufacturing industry. The before- and after format constructions of the processes are presented and described within this chapter.

Things2i guided a manufacturing company through a manufacturing process monitoring and production planning digitalisation. The manufacturing company, founded in 1970's and headquartered in Italy, is producing thermoplastic hoses for high pressures in hydraulic and industrial segments and air conditioning and refrigeration. The main actors involved in the benchmarking study are the PSMs (Production Scheduling Managers) controlling and organising the production schedule, QIs (Quality Inspectors) performing continuous checks on products and semi-finished products and LOs (Line Operators) running the production machines according to the production schedule. (Belli, Davoli, Medioli, Marchini & Ferrari, 2019)

Daily Operative Management is dependent and effected by the Production Scheduling Processes. Production Scheduling manages what is produced, and when, considering, for example, the resource management and production demands. The Line Operators execute the production schedule, and this work is often managed by the daily operative management. When quality issues arise from the Quality Inspectors, these should always be addressed by the daily operative management. The digitalisation process conducted in the benchmarking company was targeted to daily operations, creating efficiency, reducing errors and saving time.

The benchmarking company procedures caused information delays and did not scale with the growing production workload. The production planning had become extremely time-consuming and the professionals scheduling the production needed to have extreme amounts of knowledge and use inefficient amount of different information sources when creating the production plans. When product disruption was noted in the production monitoring, the information flowed unnecessarily slow. When an order needed modifications, it could have taken hours for the process to finalise and information to reach the correct people. The production monitoring process was based on manually taken and scanned pictures so basically, no data of production monitoring existed. The manufacturing company had one employee dedicated to print, distribute, fill forms, collect data and scan documents. (Belli et al., 2019) It is clear, that a change was needed and digitising these processes was a solution. SmartFactory application was implemented to streamline the production planning and process monitoring processes. The manufacturing process monitoring before and after the digitisation is visualised in the following Figure 8.

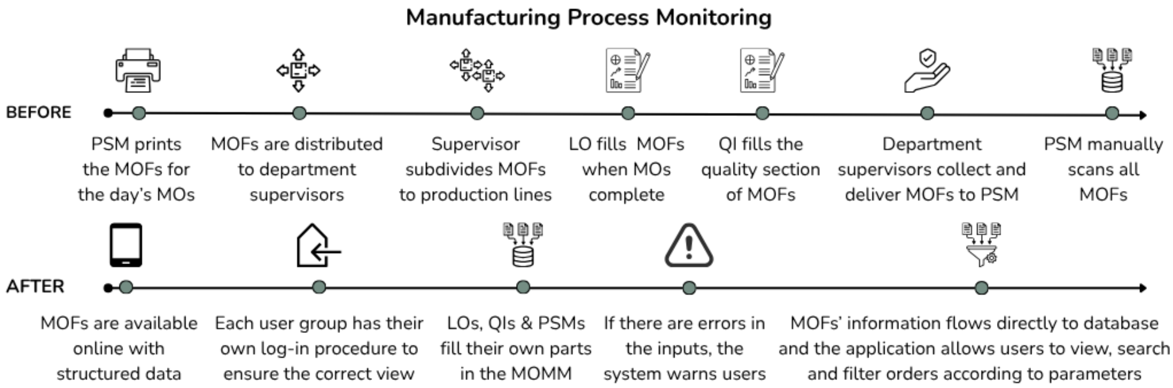

Figure 8. Manufacturing process monitoring before and after digitising (Adapted by Belli et al., 2019)

Digitising the manufacturing monitoring led to extreme time savings, since papers were no longer printed on paper sheets and manually scanned to databases. The filling of Manufacturing Order Forms (MOF) became easier since all actors: QIs, LOs and PSMs were able to fill the forms simultaneously. These forms were now stored in a digitised form, allowing structured data to be constantly stored. SmartFactory application enabled data to be visualised in real-time, reduced paper consumption, enabled a log of processing activities and traceability for production history, reduced errors and non-conformity reduction creating savings up to 20 000 € per year, and improving of the digitalisation know-how of the company. (Belli et al., 2019)

PSMs get the articles to be produced from a module that retrieves this information directly from ERP, acting as the starting point of production scheduling. Other modules give PSMs vital information about LOs shifts and connecting the workforce with required production. PSMs can then create the production plan with a simple, drag-and-drop user interface. Lastly, SmartPlanner interacts with company ERP and SmartFactory application to make production plan live in the production system and create Manufacturing Orders (MO). The production planning process before and after implementing the SmartPlanner application is described in the following Figure 9.

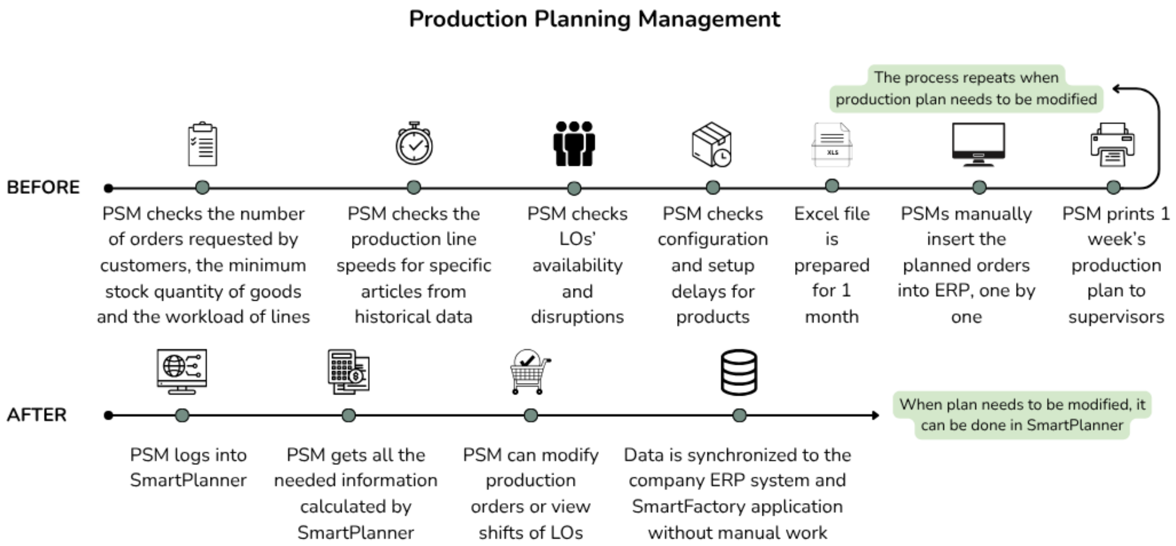

Figure 9. Production Planning Process before and after digitising (Adapted by Belli et al., 2019)

The development of SmartPlanner was still under development in the time of the report, but the expected advantages were listed on the report. As seen from Figure 9, using SmartPlanner instead of manual production planning supported by the spreadsheets saves time from production planners and from training new people for the task, since the SmartPlanner is doing all the calculations, instead of people. Using a production planning system like SmartPlanner creates transparency to processes, which is always a good thing. Now the process and its outcomes are visible for all people interested inside the company. Through time saving the company expects savings from switching from hand-made planning to production planning with SmartPlanner. (Belli et al., 2019)

These digitalisation processes highly effect daily, operative data-driven decision-making by enabling data digitalisation and collection and information availability, accuracy and transparency. SmartFactory enabled information gathering, storing and analysing and made reducing errors possible by its smart features reviewing the information input. These applications also use visual management by alerting users from inaccurate inputs in MO forms. (Belli et al., 2019) As a conclusion, digitalising changed data-driven decision-making by transforming the manually written, scattered and unanalysable information to digitalised, structured and ready-to-use data, creating fundamentals for data-driven decision-making.

2.6 Theoretical framework

Digitalisation and its effects on data-driven decision-making in daily management context is a wide concept. To integrate the different models, theories and literature findings and to visualise their interconnections, the following structure within Figure 10 was created for theoretical framework.

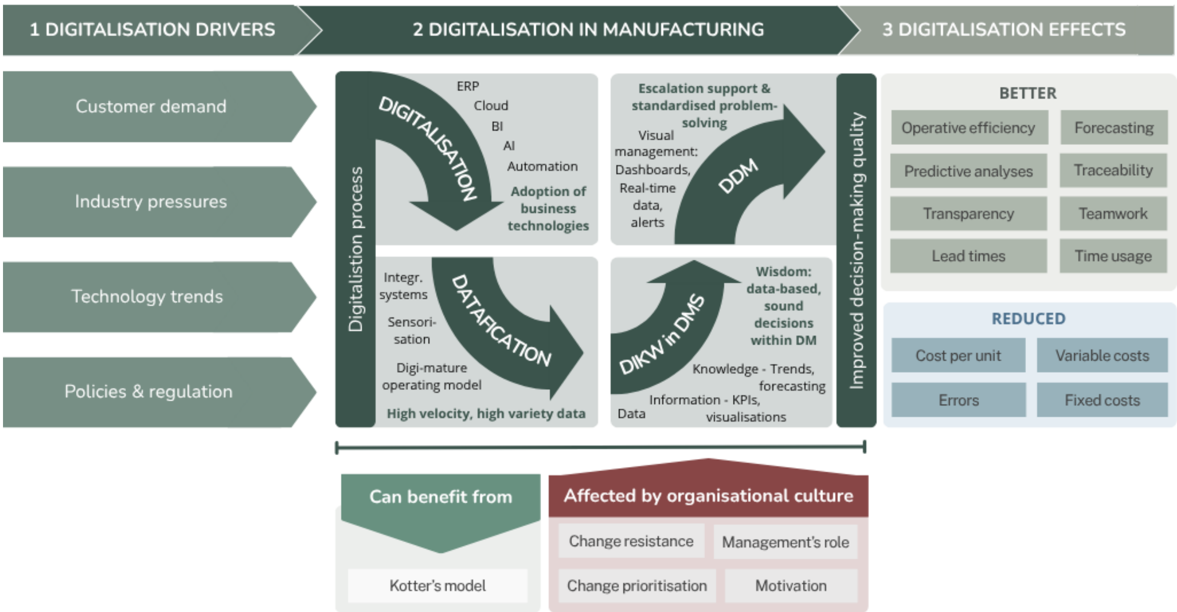

Figure 10. Theoretical framework

The Figure 10 above visualises how digitalisation in manufacturing leads to improved decision-making quality and other digitalisation effects. Digitalisation is drivers can be divided into four categories: customer demand, industry pressures, technology trends and policies and regulations as visualised in Figure 10's part one on the left side and on chapter 2.1.1. These drivers create the motivation for digitalisation process implementation. The path toward digitalisation effect can be divided four stages as visualised in part two of the theoretical framework visualisation. First, digitalisation is created by the adoption of different business technologies such as Enterprise Resource Planning solutions, Cloud solutions, Business Intelligence technologies, Artificial Intelligence or automation solutions. These technologies allow the second stage, which is big data creation from the supply chains, its warehousing and processing. Datafication supports the third stage of digitalisation in manufacturing by integrating information processing and development into daily management systems as described in chapter 2.2.1. The fourth stage describes how the DMS turns into visual and digital daily management by using the dashboards and real-time data processed according to the DIKW model. DMS and digital, visual daily management are described in chapters 2.3.1 and 2.3.2. Digitalisation related change benefits from Kotter's change model, explained in chapter 2.4.1, and is affected by organisational culture, mostly by the change resistance, management's role, change prioritisation and inner motivation, explained in chapter 2.4.2. After the four stages within digitalisation, it leads to improve the decision-making quality and has other insightful effects, such as increasing operational efficiency, forecasting possibilities, predictive analysis creation, traceability increase, transparency, enhancing teamwork culture, better lead times, more efficient time usage, reduced costs and errors eventually leading for better quality, as discussed in chapter 2.1.2.

3 Research methodology

The research methodology of this paper is presented in two subchapters. The first subchapter describes the research approach used in this research. The second subchapter presents the data collection methodology and lastly, the third subchapter concludes the reliability and objectivity of this research.

3.1 Research approach

The research approach chosen for the research has a significant impact on the direction of the research (Hirsjärvi, Remes & Sajavaara, 2004, 114). This research is a qualitative study, that also uses features of constructive research. An actual case study is presented from the focal company, and a supporting benchmarking study from literature is presented within the theoretical background. Qualitative research approach was chosen as the topic demanded real-world observations and interviews. Qualitative research often includes interviews and observations, as also does this study (Hirsjärvi et al., 2004, 127). Corbin and Strauss (2008) define qualitative research as:

> "A process of examining and interpreting data in order to elicit meaning, gain understanding, and develop empirical knowledge".

It is a research approach that produces findings without focus on statistical procedures or other quantification (Corbin & Strauss, 2008). And here this research is also aiming at. To assess the impact of daily management digitalisation, interviews were conducted with key stakeholders and observations were made in relevant settings and at the focal machine. Other typical qualitative research features that are present in this research are: comprehensive information gathering, data collected in natural, real-world situations, with a focus on humans as a source, and qualitative methods in data collection (Hirsjärvi et al., 2004, 155). A multi-method approach was used to enhance credibility and improve the researcher's understanding in this qualitative study (Saunders, Philip & Adrian, 2015, 169).

Interviews are a typical method used in qualitative research (Ojasalo et al., 2015, 105; Saunders at al., 2015, 391). Interviews were chosen as one of the research methods as they allow the data collection subjects to freely express their findings, with different interview focuses between interviewees. It was also pre-known that the answers to be gained from the interviews would be wide and complex. A possibility to ask deepening questions was needed. (Hirsjärvi et al., 2004, 193-195) The interviews and observations were targeted to the focal company, with a focus on the focal machine that has gone through a digitalisation-related change. An external consultant also linked to the focal company and the change project at the machine, was interviewed. The interviews were conducted acknowledging the possible challenge within interviews as a method: gaining only socially accepted answers from the interviewees or having various kinds of biases within the interviews (Hirsjärvi et al., 2004, 195; Saunders et al., 2015, 397).

Hirsjärvi et al. (2004, 125) describe case studies as method including detailed, intensive information of a particular case. This feature is present as this research includes one benchmarking study from literature, and one case study of the focal company. Without the information-intensive case study of the focal company, including both interviews and a process construction, multiple benchmarking studies from literature would have been needed to achieve a certain level of reliability for the focal company's case study conclusions. Now these two studies and their conclusions support one another so that the findings achieve the academic weight needed. The focal company's case study strongly built on observations was also done to create concreteness to the change that was implemented at the focal machine, in a form of process construction. This case study acts as an independent method that demonstrates one of the changes implemented at the focal machine, and its effects. The case study and process construction also function as interview background information for the reader. The constructive approach was needed to visualise the change within the process construction. The constructive approach is also used in the main goal of this research: the framework. Constructive approach was chosen as a supportive approach to the qualitative approach as the main objective of this research is to build a concrete result (Ojasalo et al., 2015, 66).

Observations were chosen as the one of the data collection methods as they allow the researcher to gain data and information of the real-world, natural environments of the research target. It also allows the researcher to gain information that would normally not be told to the interviewer. In this research, the observations were made keeping in mind its possible challenges within objectivity – the observator changing the natural environment.

(Hirsjärvi et al., 2004, 201-203) The observator's role was mostly what could be described as the middle ground of what Saunders et al. (2015, 359-360) describe as the observer-as-participant and participant-as-observer, as the observer was involved in planning and implementing the changes, although from an external's role. Observations are a typical method within constructive research approaches (Ojasalo et al., 2015, 68). The objectivity is not endangered in this study, due to this research variety of methods: observations, interviews and process constructions. The following Figure 11 visualises the process of constructive research approach applied in this research.

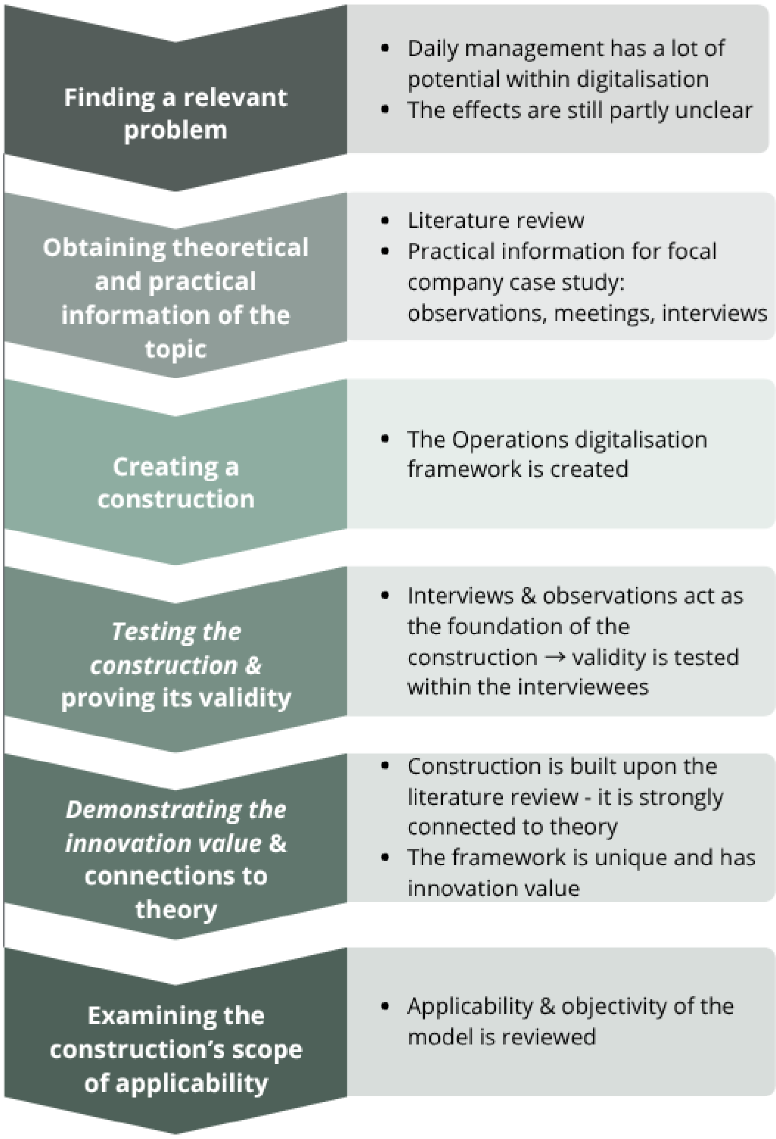

Figure 11. The constructive research process applied in research (Adapted by Kasanen, Lukka & Siitonen, 1991; Ojasalo et al. 2015, 67)

This research mostly follows the constructive research process visualised in Figure 11 above. The research problem - unclear decision-making effects of daily management digitalisation

– was found as a relevant problem for research. Obtaining relevant theoretical information was executed in a form literature review, and practical information was gathered in forms of observations, meetings and interviews. Finally, the objective was set to create a visual construction, the operations digitalisation framework, around the research problem. In this research, the framework is not tested, but as it is built around the findings of both the literature review and the empirical part, the validity is proven. The innovation value of the model is not proven, as this kind of models are theoretically not unique. Still, similar models have not been built before upon this research's interviews and observations made. In this sense, the model also brings innovation value for its users. The connections to theory are described in chapter 2.6., as the model is built upon the theoretical framework. Finally, the model's applicability is described in chapter 6.2.

3.2 Data collection

Data of the empirical part of this research was gathered through interviews and observations. The interviews were conducted to the entire management chain of the focal machine. The interviewees were selected based on their close operational involvement with the focal machine and their participation in the changes implemented on it. Some of the interviewees have more sight on the operational, everyday life of the line operators at the machine, and some engaged in the change from a more managerial point of view. The external interviewee engaged in the change as an external project manager.

The interviews were conducted online, in a form of semi-structured interviews. In semi-structured interviews the questions have been planned beforehand, but the order and specific wording of questions can vary. The semi-structured interview was chosen as they work well in situations where the research aims to clarify a phenomenon's meaning to interviewees. (Ojasalo et al. 2015, 108-109) Before all interviews, a brief introduction of the research topic and the models and theories used in it, were presented by the interviewer. Key terms—data-driven decision-making and daily management—were also defined, as their precise definitions can differ among professionals. The interviewees also received a brief introduction to theme of the interview questions beforehand. The core questions were the same for each interviewee, but part of the questions varied, according to the interviewee's area of excellence. The questions were roughly themed as in the following Table 3.

Table 3. Interview themes

	INTERVIEW THEME	PARTICIPANT GROUP	PARTICIPANT
1 & 7 - 8	Digitalisation, change management, information development model	External	External management consultant
		Internal	Plant manager & Operations manager
2 - 6	Digitalisation & change management	Internal	Technical operators (2)
		Internal	Production team leader
		Internal	Supervisor
		Internal	Production manager

The interview questions were divided in four categories and the two themes shown in Table 3 above. There were 19 interview questions in total from the following categories: Basic information, Digitalisation, Information development model and change management. The interview focuses, dates and durations for each participant can be seen from the following Table 4.

Table 4. Interviews conducted

	INTERVIEW FOCUS	DATE	PARTICIPANT GROUP	PARTICIPANT	DURATION
1	Information evolution, Daily management, Change resistance & management	29.09.2025	External	External management consultant	56 min
2 & 3	Digitalisation effects & possibilities in technical problem solving, Change resistance & management	29.09.2025	Internal	Technical operators (2)	56 min
4	Digitalisation effects & possibilities in daily management, Change resistance & management	29.09.2025	Internal	Production team leader	35 min
5	Digitalisation effects & possibilities in daily management, Change resistance & management	30.09.2025	Internal	Supervisor	47 min
6	Digitalisation effects & possibilities in daily management, Change resistance & management	01.01.2025	Internal	Production manager	37 min
7 & 8	Information evolution & utilization, Digitalisation & Change resistance & management	02.01.2025	Internal	Plant manager & Operations manager	42 min

All interviews were recorded and transcribed by Microsoft Teams and Copilot. The transcription errors were manually corrected before the analysis.

Observations were conducted in the focal company during a change project, so most of the observation situations were unorganised. Observations were made from the focal machine's everyday life before, during and after the digitalising. These observations provided valuable insights into the practical effects of digitising on the production floor, different daily management meetings and different workshops and training sessions. These observations were an important part of the empirical part, revealing the immediate reactions and personal adaption processes of both the management chain and line operators, also highlighting the challenges and benefits arising throughout the process. Although these observations are not highlighted as a separate part of this research, to maintain its objectivity, they are still an important part research, acting as the background information for the interviews and process construction, offering a more holistic understanding of the focal company's journey through the digital change.

4 Focal company case study

This chapter presents the results of data collection for the empirical part of this research. The first subchapter presents the focal company's production planning process and its changes through a process construction. The interviews of both the management chain of the focal machine and the interview of an external consultant involved are presented and analysed second.

The focal company's focal machine struggled with poor operational performance, lack of reporting activity, delay of information transfer related to, for example, the production plan and its changes or modifications, and uneven distribution of workload among operators. These issues were resulting in non-existent transparency, expensive mistakes in the production and tensions and dissatisfaction among line operators. New operating model was implemented to the focal machine to cover these issues. The new operating model included new operative roles for the line operators, daily meetings digitisation, and new guidance creation and updates. Along the operating model a data visualisation tool was created for the machine, bringing together data from the machine's audit trail log and production monitoring system. This tool enabled support for the machine disruptions problem solving and created transparency for the production machine's daily life. The company also developed their ticketing system related to quality issues, bringing information from multiple sources into one ticketing tool. Also, a new production planning tool digitalising and visualising the production plan and improving the production planning process and its transparency, was implemented to the focal machine. The new operating model was implemented to the focal machine five months before the thesis publication, so no long-term results could not be analysed, but in short-term, there were a lot of qualitative results to be detected.

4.1 Process construction

This process construction focuses on focal company's production planning's changes and its effects. The focal company's production planning process, before the new operating model, used some digi-features, such as email, but it relied heavily on printed papers and manual work. This caused delays on the information transfer, leading to, for example, producing wrong products, ordering wrong materials and burdening the warehouse performance. The production plan process before and after the new operating model is visualised in the following Figure 12.

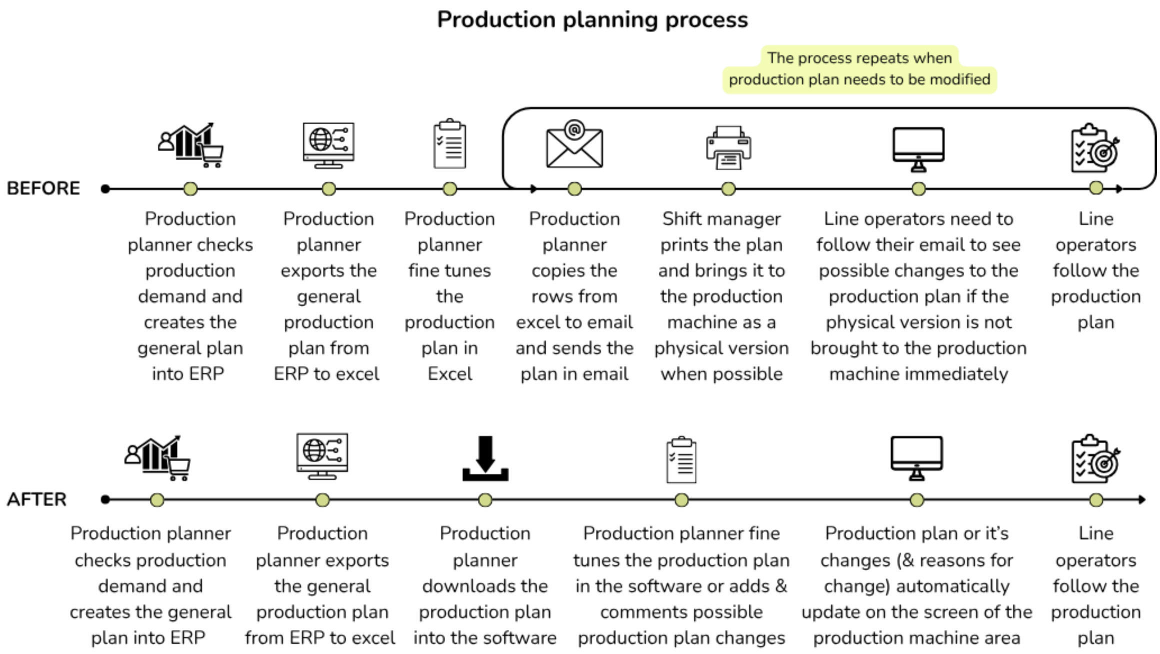

Figure 12. Production planning before and after digitalisation - Focal company

Before the new operating model implementation, the production planning process included a lot of manual work and information flow was slow. As visualised in Figure 12, the production planning process started with production planners requesting group-level production demand from another external system. After this, production planners created the plan into ERP and exported it as an Excel-file. Then, production planners optimised the production plan in excel and copied it to an email. This email was sent to the production machine and other relevant stakeholders every time a plan was created or changed. These changes could have been due to external or internal reasons. External reasons can include vendor's production or logistics problems, and internal reasons can be, for example, bottle necks in product's raw materials production. New production plans were printed and physically brought to the production machine. To get the plan changes in time, line operators constantly needed to be up to date with their email as the changed production plan's printed versions were not always brought to the production machine. Missing a production plan change- related email could possibly lead to expensive mistakes by, for example, producing the wrong products. Line operators used to follow the production plan as long as a change occurred. The line operators did not necessarily even get the reason for production plan changes, leading to frustration. Transparency was acutely needed, both ways.

A software module for production planning digitalisation and visualisation purposes was implemented as a part of the new operating model, and a large display was brought to the production machine area. This display is used for production planning software use, daily meetings and general production status view from the production monitoring system. Production planners still need to check the general group level demand from the external system, but after creating the plan in ERP, exporting it to an excel format and downloading the excel into production planning software, the plan can easily be fine-tuned with a user-friendly drag-and-drop interface. If a previously downloaded plan is changed, the software demands the plan changer to add a reason for the production plan change. This creates transparency, enables traceability and reduces the possible frustration caused by product plan changes. Now, the line operators can follow the production plan and its changes from the display and be constantly up to date about the changes happening in production plan orders, amounts, or batch information.

Implementation of the production planning digitalisation and visualisation software transformed the way production plan- related information is communicated and managed within the focal company. Real-time visibility to production plan and its updates from all stakeholders has minimised the risk of miscommunication, information delays and costly production errors. There is still room for development, for example to create interfaces between ERP and production planning software module.

4.2 Interviews

Case study's interviews were targeted for the decision-making chain of the focal machine, and the external project manager of the organised change project. Eight interviews were conducted, including interviews with the plant manager, operations manager, production manager, supervisor, production team leader, two technical operators and an external management consultant, who was the project manager of the organised change project, including focal machine's new operating model. The interviewees of the focal company were chosen as they all worked close to the project and its change management but also are relevant in the decision-making chain of this focal machinery. The external consultant was interviewed as the consultant was responsible for the project management of the development project in where the described digitalisation efforts were made. As noted in previously in Chapter 3.2, the interview questions varied slightly between interviewees due to the semi-structured nature of the interviews. For this reason, the interview results are not reported using exact counts or percentages of interviewees.

The first theme of each interview focused on interviewees' **role and background on daily management**. Most of the interviewees have worked in the current role for several years, had long careers in the organisation and many years of leadership experience, already before the current role. Among interviewees, the average time in current role was seven years, ranging from 1 to 17 years. The key work tasks differed among the focal company's interviewees as all of them worked in remarkably diverse roles, but all of them worked closely with daily management and the connective factor of these roles is management and guidance tasks at distinct levels.

Digitalisation was seen as an important development direction among all interviewees. Productivity increase and removal of manual work were seen as the clearest positive effects of daily management related digitalisation. Several interviewees mentioned that daily management has a lot of repetitive tasks that should and could easily be automated. It was also pointed out, that the fragmentation of information across different systems complicates management, and digitalising this information into one place would consolidate information and facilitate reporting.

Some of the interviewees identified a potential **barrier to digitalisation** in the limited alignment of the company strategic emphasis with operations digitalisation. Although digitalisation can be strongly present in the company strategy, several interviewees felt that digitalisation efforts can be mainly focused on the support functions of the company, not the operative level. Organisational culture was cited as one contributing factor, alongside the tendency for operational needs to receive less attention when current performance is considered sufficient. This is a humane tendency: why put effort on something that is already functioning on a proficient level, based on current knowledge. The future productivity possibilities can get hidden under the current, accepted level of productivity – who knows what kind of productivity possibilities lie behind it? One of the interviewees summarised this as follows:

"Although corporate group strategies may emphasise digitalisation, concrete actions and resources do not always meet operational needs, which slows down development."

Other barriers interviewees brought up were related to organisations' IT departments' actions restricting the digitalisation efforts and development. Whether it is about lack of support for change, missing licenses or slow, bureaucratic processes, they easily become a barrier, or a delay for change. Also, lack of technical competence and knowledge can become a barrier for change. In some situations, the technical side can become a problem: organisations may have chosen an unsuitable technical solution or tool that cannot be customised or adapted to fit the company's needs, although the suitable technology itself would be achievable. IT departments have a big responsibility to support organisation to choose the right technical solutions and make sure that they fit the needs of operations. It was brought up in the interviews that these issues are not human- or employee-related, but IT-management-related. This was summarised by one of the interviewees as:

"There are no people problems, only management problems."

These aspects are often related to companies' **organisational culture**, which plays a crucial role in how, and if, changes are started or delivered. Implementing new tools and systems usually requires group-level acceptance, which might slow down the change. Some managers experienced that the barrier for digitalisation is, indeed, the lack of efficient technical tools or solutions. Some interviewees, again, described the age of some production equipment to be so significantly old that integrating advanced systems for data collection is not possible. As production machinery often represents a major investment, its lifecycle in manufacturing industry is typically long, and as a result, such old and mixed machinery may no longer align with modern digitalisation requirements.

Like discussed in one of the previous chapters, **daily management** has a lot of repetitive tasks that can easily be automated by digitalisation. A concrete example of an easily digitised and automated task that was brought up by most of the interviewees was the information and data retrieval done repeatedly at the beginning of everyday. As all interviewees of the focal company are working concisely with the operative everyday life of the factory, or some specific responsible areas, all interviewees needed to gather status information from the last

24 hours of their responsible area's operations as the first task of the workday. This information may include disruption data or production KPIs. After the digitalisation efforts done at the focal company's focal machine, a transparency of the machine operations was created in a form of report. When needed, relevant people could go and see the report to understand what has been going on at the machine, how has the machine and different shifts succeeded, and what has happened at the machine before disruption situations. The managers were able to dive into different disruption categories, recognise the significant disruptions and target the needed measures and actions for them. Interviewees pointed out that the digitalisation efforts conducted at the focal machine led to save time and reduce manual tasks from their daily management work.

The interviewees highlighted that data availability enabled by digitalisation created a foundation for **data-driven decision-making**. Interviewees pointed out, that at the start of the workday, it is easier to check the events of the previous day and prepare for the DMS meetings when the information is accessible. Managers felt that they are now able to detect and address deviations quickly, unlike in the past when analysis was done in retrospective. Not only does the created transparency enable clarity and better data for the management, but it was also highlighted that it makes justifying the decisions easier when the data behind the decisions is available and visualised. Some interviewees also highlighted that decision-making became more transparent and faster now that all the data was available and visualised into understandable format. This brings out the importance of simple visualisations that are understood with just a glance.

The line operators experienced that digitalising the **production planning process** majorly streamlined their work since there was no longer need to continuously manually check emails and keep track of production with pen and paper. Production planning digitalisation had effects also on the entire management chain of the focal machine since overlapping and error-prone email chains were now history. Managers and line operators were now able to predict future production and, for example, plan the material orders and management accordingly. Overall, information became achievable after digitalisation and the contrast to other machines without similar digitalisation efforts was, according to multiple interviewees, major. Finding the information needed from other machines is more limited, the reporting is narrower and looking for the relevant information demands more manual work. Interviewees point out that similar digitalisation is now planned for other machines as well, after focal machine's successful piloting.

Targeting the improvement measures followed by the root cause analysis of disruptions developed along digitalisation. When working with problem solving and disruptions root cause analysis, interviewees addressed the importance of precise, original information. To efficiently solve problems at the focal machine, indirect, second-hand information is not enough as the possibility of humane misunderstandings and other errors increases. The interviewees considered that the most precise information usually comes from the line operators at the machine, or the production monitoring system at the machine. Interviewees highlighted that this information is not only important in disruptions problem solving, but also daily management, targeting guidance and future trainings need, and planning corrective measures or future investments. People working with the daily management of the focal machine need to know the problems and training needs of each shift to be able to eventually reduce these errors. As the disruption data and machine's audit trail was brought and visualised together in one disruptions report, disruption investigation efficiency was increased and the time spent on disruption investigations or reacting to them, was reduced since information became more easily achievable, and was transformed into a format where it is analysable to find correlations and causalities. The disruption data visualisations also enabled the efficient recognition of disruptions root causes, as one interviewee summarised:

"Previously, improvement measures were vague, but now it is possible to focus on individual problem areas and eliminate them systematically."

The **communication** development took a leap along digitalisation. Digitalisation developed information transfer and communication between different shifts. Interviewees pointed out that previously the line operators voluntarily started their shift a few minutes earlier to be able to communicate with the previous shift about the focal machine disruptions and production status. After the digitalisation efforts enabling a platform to visualise and present relevant data and shift change information, there was no longer acute need for the line operators to start their workday any earlier than needed. A tool for reporting quality issues also brought major benefits for keeping up with the issues and their development as now everyone involved knows the status and involved people of different quality-related tickets. This ticketing system enabled consistency and standardised operating procedures, so that information remains in the system, enabling continuous monitoring and improvement.

Despite the positive effects, digitalisation efforts were not implemented without **challenges.** To get reliable status data from the production monitoring system, the line operators needed to make change to their everyday work. The line operators needed to start to manually categorise different production disruptions into the production monitoring system. This was crucial for management to achieve the transparency of machine production disruptions, which were, a lot. This created some challenges in the change management, as this categorisation was perceived as extra work from the line operators' point of view. There were a lot of machine down-time, so there were a lot of rows to manually, continuously categorise. This categorisation had been demanded already before, but the percentage of uncategorised production errors was major. The new operating model, which included the high intensity categorisation, was implemented at the focal machine on week 23, coloured green in the following Figure 13 visualising the massive reduction of uncategorised production error hours by weeks.

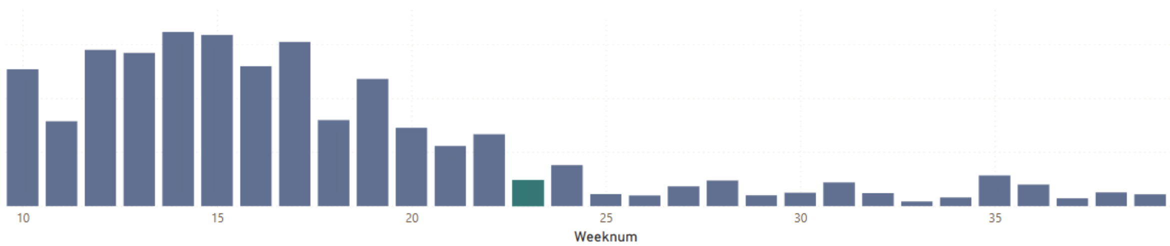

Figure 13. Weekly uncategorised production error hours at the focal machine

The Figure 13 above shows the weekly development of uncategorised production disruption hours and visualises the transparency that was created. Before the new operating model, the percentage of unrecognisable production disruption was up to 70 % of focal machine's down time. As shown in the picture, the line operators quickly understood the idea and motivation behind the demand of manual categorisation.

Another clear challenge brought up in the interviews is the **systems incompatibility**, and the need for manual categorisation by the line operators. One interviewee evaluated to spend around 10 minutes per day waiting for the production monitoring system of the factory to open, leading to almost one hour of waiting per week. This kind of system does not support agile work in reactive, fast-paced, challenging environments. Interviewees pointed out that process development and new solutions will be deployed to address these challenges.

Also, the lack of technical knowledge and general low level of expertise in work tasks among the line operators was highlighted to cause issues in digital change. Having enough project team's resources was told to become especially important when the seniority of change target group is lower. Some interviewees point out, that because of limited resources the immediate supervisors of line operators could not be present enough at the change. These interviewees pointed out that in retrospective, the presence of immediate supervisors would have been important to tackle the change resistance. Interviewees raise that highlighting the motivation and goals of change at the focal machine during the digitalisation efforts would have been beneficial, especially in the current situation.

When asked about **digitalisation and technical tools still needed** for interviewees successful workday, some interviewees pointed out that there is still room for development on efficiently using and further developing the current digitalisation digital tools in use. They felt that it is not always about the need to implement new tools, but to also learn to efficiently use the ones already implemented. At the focal company, the information is still shattered around different information systems, such as the ERP, the production monitoring systems, production planning system, and different communication channels and systems, without a tool or system bringing together this information from various sources. This makes it hard to find and use consistent information in decision-making. It was highlighted by most of the interviewees that there is an urgent need to gather this information into one report, allowing users to select and adjust the point of view and type of report, such as receiving production status for the entire factory or for specific machinery areas. The bare minimum, according to some interviewees, would be to make a data flow connection between the production monitoring system and the ERP to avoid the manual work shifting between these two systems. Overall, digitalisation is needed to collect and analyse data in real time to enable detecting and addressing deviations quickly, not in retrospective.

Some managers also mentioned the need for disruption solution library since the focal machine is so prone to disruptions. This would basically mean creating a tool for documenting and archiving occurring production disruptions, their root causes and problem solving. This would enable line operators and managers to use historical information of problem solving to find out the root causes and problem solving of occurring disruptions. It would not only make problem solving easier but would also extract the tacit information from people's own memory to documented data. This documentation is crucial to also avoid the loss of institutional knowledge undocumented in peoples' heads. This kind of production disruption history data digitalisation is not yet available but needs to be planned and implemented by the focal company.

Like described in the previous chapter, the production monitoring system's manual categorisation done by the line operators needs automation development. One interviewee expressed the wish for the Human Machine Interface system to automatically record the disruption categories to the production monitoring system to reduce human errors and make the data even more complete. A need for more detailed production data to help the technical operators in their development work and problem-solving was also brought up. This could be visualised real-time data of machine's production details, such as measurement data, trends and KPIs to further simplify observing the effects of small changes and adjustments made at the production machine, and to utilise further the historical data of the production monitoring system.

When discussed about the **DIKW model** and **development of information** in focal company's current daily management system, interviewees brough up, that the poor digitalisation level of DMS meetings is leading to general lack of information development. The information processed at DMS meetings is on the information-level of DIKW model. The unelaborated numbers gathered from DMM's first level are brought to next DMMs refined with explanations. This leads to the habit of explaining undesirable numbers, not followed by concrete measures and actions. Level 2 meetings of focal company's daily management system were mentioned to need digitalisation development the most. The data management should be reformed to better support the information development, the meetings would need visualised KPIs, and a new meeting system should be introduced to these meetings to reduce speculative explanations and to ensure that data processing leads to concrete measures. The information is transferred from DMM meeting to another, but the information development and processing is often lacking. Partly, the reason for this is that information development is not demanded by the daily management system. The meetings focus mostly on the disruption communication and explanations, and solution-oriented actions do not occur systematically. Consequently, the interviewees were asked: if the current state of information development in the daily management system is not ideal, what would the **optimal target state of information development** look like? The interviewees explained that there is need for information to flow to the right places and to be processed and developed accordingly as a daily basis. This is a bare minimum to achieving a state where proactive measures can be taken, executed and followed. With digitalisation, efficient management of actions is possible, and suitable tools support the problem solving and allocation of resources.

The literature review showed that the change associated with digitalisation is particularly demanding in nature. This makes digitalisation change management especially important. When discussing about **change resistance**, one of the interviewees brought up, that:

"As a baseline, a significant proportion of staff always experiences change resistance."

Learning and acquiring new skills always requires energy, but learning digitalised processes and new tools is an especially sensitive area. One interviewee brought up that within digitalisation, it is partly a generational issue whether the digitalised tools and processes are perceived as simplifying or complicating. Still, this is only part of the reason as digitalisation-related change resistance occurs in all generations. Interviewees addressed the importance of training and broad support provided for the target of change. It was not only important to create time for the trainings, but to ensure the documentation of trainings and to create clear instructions and guidelines for line operators to be able to implement and follow the new operating model. Due to limited resources, the change was conducted with minimal training and orientation for line operators due to resource problems. As a result, one interviewee noted that this inadequate amount of preparation for line operators was a key lesson learned from this process and in retrospect, would have used more time to thoroughly orientate the changes to the line operators. One of the managers interviewed summarised this as:

"Training and educating people is hardly ever a waste of time."

The importance to identify individual capabilities was also highlighted by interviewees, as a group always consists of individuals whose resistance to change and learning new skills always affects the progress of the change. These individuals can **slow down the change** and **negatively affect others in the group**. In a group of people, there are also individuals who may not be trying to actively slow down the change but need encouragement and motivation to really understand the reasons behind the change and to promote the change. It was highlighted, that one factor effecting the change resistance is the employee's, in this case, the line operators' seniority and resourcing. In the focal company, resourcing was already tight in the focal machine, and the line operators' seniority was on a low level in the bigger picture. Majority of the line operators had been in the company for less than a year, and the focal machine was exceptionally challenging in nature. Also, the timing of the change was pointed out to be significant. The change at the focal company's focal machine was executed during a time when there were a lot of resourcing changes by nature. This caused change resistance among the line operators. Interviewees raise that change resistance was present during the digitalisation efforts at the focal machine, but it mainly occurred in the beginning of change. Multiple interviewees highlight, that bringing the line operators along to plan the change and giving them the opportunity to affect the change, reduced the change resistance significantly. Several interviewees highlighted the importance of clearly communicating digitalisation's goals and benefits to line operators as a key lesson learned. This could have reduced the amount of change resistance and increased the understanding of the change benefits, although this communication was already prioritised in the change management. One of the interviewees summarised this as:

"The biggest task was to get those who were critical of the change to understand its purpose."

This is where **management's role** becomes especially important: management needs to remove obstacles, motivate staff, and, if necessary, compel the organisation to learn new ways of working. Clear change communication and management's support help project team to justify the need for change and enable rapid response to problems blocking the change. One of the interviewees highlighted the significance of having a clear plan and well-defined steps for change, enabling individuals to understand both what is expected of them and how the process will unfold. Thoroughly explaining the reasons and motivation for change and its targets and vision among the line operators was pointed out to be crucially important. One of the interviewees summarised this as follows:

"For a change to be successful, it is important that people themselves feel that they benefit from the change. This increases acceptance and reduces resistance."

One of the interviewees also brought up a case where a previously change resistant person came to the manager to ask for access to a digitalised solution after seeing its benefits from other users of the solution. The interviewee emphasised that **change agents** and **key**

personnel play a vital role in communicating the message throughout the organisation and getting users involved in the change.

Interviewees highlighted that the **fast-paced change implementation** was beneficial, although implementing many changes quickly and all at the same time, also caused workload for both the project team and line operators. Interviewees stated that eventually, this was probably only beneficial, as all development needs were efficiently implemented at once.

It was brought up, that organisational culture always affects the pace and readiness of change. One interviewee summarised this as follows: in companies that are used to function in a reactive environment, changes can be implemented more quickly, whereas in stable organisations changes require more planning and time. The focal company functions in a very reactive environment and therefore adapted to the changes quickly.

The key to **sustainable change** is, as was pointed out in the literature review, that the change management does not end when the project ends. The changed ways need to be rooted into the processes and organisation for them to become permanent. This was also highlighted by the interviewees. Some interviewees were concerned about the focal company's resources' adequacy for sustaining the change made at the focal machine, as the environment is reactive and many managers' workdays are highly allocated.

5 Framework

This chapter presents the operations digitalisation framework built as the main result of this research. The first sub-chapter brings in the findings of the interviews and observations made in the empirical part of the research. These findings are practically added to the theoretical framework, creating the operations digitalisation framework presented in the second subchapter.

5.1 Findings from the interviews and observations

A software to digitalise and visualise production planning was implemented to the focal machine to address several issues within the production planning process. Transparency and traceability created by the digitalisation were noted both in interviews and production planning- related observations. Transparency was created into the production planning by digitising the information flow and possible change communication related to production planning. The digitalisation led to reduce change-related frustration caused by unplanned modifications poorly communicated. Production planning digitalisation also created real-time visibility for all relevant key persons. This way everyone was now able to follow the production plan and its changes live from their own devices. Eventually, the transformation minimised risks for miscommunication, information delays and costly production errors. Digitalising the production plan majorly streamlined the work of line operators and received a lot of positive feedback from them.

Eight interviews were conducted within the decision-making chain of the focal machine, and an external consultant involved in the focal machine's change. All interviewees saw digitalisation as an important development direction. The key benefits of digitalisation were highlighted to be the removal of manual, repetitive tasks, and the consolidation of systems, better facilitating management and reporting. The barriers for digitalisation can be divided into three areas. First, the lack of prioritisation for operations digitalisation at the group level is leading to digitalisation taking place only at the support functions, not operations. The existing, accepted, level of operations performance was pointed out to hide the need for digitalisation. The second affecting area is IT department's actions. When talked about digitalisation, IT department's actions, such as lack of support, slow bureaucratic processes or missing licenses for technologies, can cause delays or even function as barriers within digitising. These are highlighted to be mostly management issues, not human- or employee-related issues.

While the long-term results of digitalisation could not be analysed due to the quite recent change, many qualitative results were already detected. Digitalisation has great potential in saving time and reducing manual tasks within daily management. And what comes to data-driven decision-making, the data availability created the foundation for leading with information: with data and visualisations, managers can detect and address deviations quickly, decision-making became faster and more transparent, and disruptions were investigated and solved more efficiently. Communication between different shifts of the focal machine developed majorly, and the need for starting the workday earlier to catch up of the status with previous shift's line operators, was no longer needed since the shift change could be done within the system.

One of the main challenges related to digitalisation is the change resistance. When discussing change management, digitalisation makes things even more complicated. Digitalisation can have a bad built-in tone and because of this, should always be implemented with extra care. The datafication phase of digitalisation often requires an extra mile from the front-line employees'' point of view. So was the case within the focal machine's line operators. Line operators were asked to manually categorise every production error row of the production monitoring system, as the focal machine is so prone to errors, that all these different errors had not yet been automated to the system. This kind of manual work is often perceived as extra work. However, the line operators of the focal machine quickly adopted the process, reducing the weekly uncategorised production error downtime from 70 % to 15 % in only a couple of weeks. Another challenge highlighted in the empirical findings is that training and supervisor presence is often not invested with enough resources. Also, the technical systems incompatibility and usability are an issue. When acquiring an IT system, companies make a commitment, and changing an ineffective system unplanned, can become expensive. One interviewee stated that weekly almost one hour of work time is spent for waiting these systems to function. Neither of these systems is exchanging information with another, so all these systems need to be used separately. Organisations should put effort on the planning and implementation of technical systems within future investments to avoid situations where the existing technology becomes a burden or barrier for digitalisation-related change.

Lastly, to create impact within daily management, the daily management and people's ways of working should be re-organised around the digitalised technologies and solutions available. Organisations should evaluate the digitalisation readiness of their ways of working, daily management and meeting structures, already before the digitalisation implementation. No matter how excellent the flow of information is, it creates no added value if the right information is not used for the right need, at the right frequency. When processes change, ways of working and daily management changes as well.

5.2 Operations digitalisation framework

The operations digitalisation framework is built upon the literature review and finding from the interviews and observations. The framework traces how digitalisation, driven by both concrete drivers within manufacturing environment, and driver trends from the literature, creates operational datafication transformed as insights through the DIKW logic within DMS. Visual and digital daily management transforms this information as operational actions and higher-quality decisions. Also, the operational outcomes are presented. The operations digitalisation framework is presented in the following Figure 14

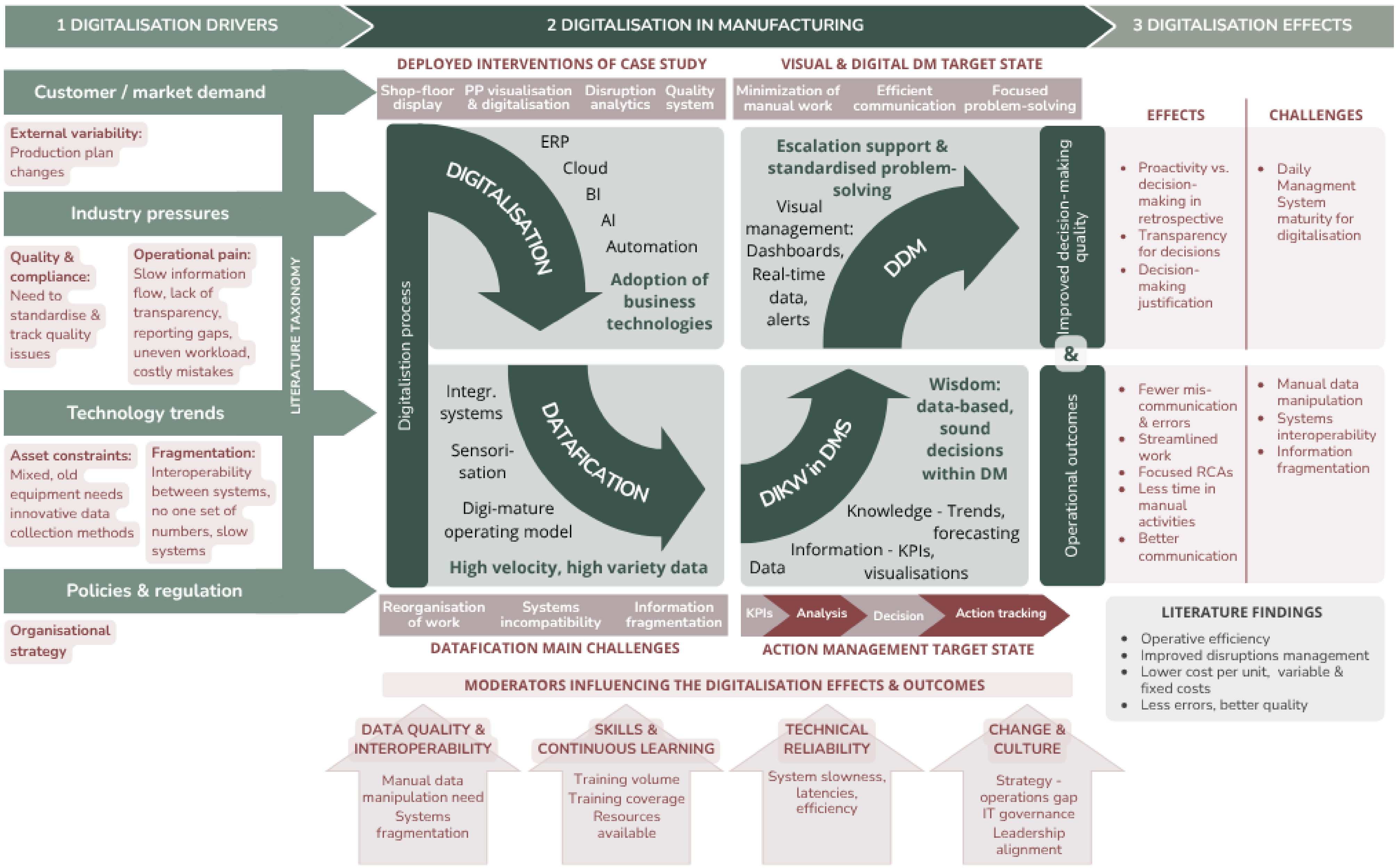

Figure 14. The operations digitalisation framework

In the operations digitalisation framework, red areas indicate empirical additions to the theoretical framework from the literature review. The left-to right mechanism visualised in begins with digitalisation drivers at the focal company. These drivers are presented with the taxonomy from literature: customer and market demand, industry pressure, technology trends, and policies and regulation. The taxonomy is further enhanced with the empirical digitalisation driver findings divided into external variability, quality and compliance, operational pain, asset constraints, fragmentation and organisational strategy. These drivers raised the need for main interventions deployed at the focal machine: production-planning visualisation, shop-floor display, disruptions analytics and a quality ticketing system.

These interventions increased operational datafication and enabled the DIKW progression taking place at the DMS meetings. The case evidence showed that a further developed meeting structure is needed for the more efficient data usage at the focal company's DMS. Finally, the DDM layer converts gathered information into faster, more transparent, and better-justified decisions, which also improve the operational outcomes: fewer mistakes due information delays, focused and targeted root-cause-analysis (RCA), time saved and smoother communication.

The moderators affecting the digitalisation outcomes are themed in four categories: Data quality and interoperability, Skills and continuous learning, Technical reliability, and Change and culture governance. The data quality and interoperability variable describes the data's abilities within datafication. The focal machine's production monitoring system demanded line operators to manually categorise every production error status row for managers to keep up with the focal machine's status. Also, the interoperability of systems can affect how the data needs to be processed to get actionable insights through datafication. The second factor visualised in the framework is current skills and need for training within the change target. This moderator describes the training needs and volumes dependent on the seniority and work tasks expertise within change target. If the expertise or seniority is lower, more training focus and resources is needed to successfully implement the change. Technical reliability describes the used systems latencies and common usability that directly affect the system's trust and day-to-day usage. The fourth moderator refers to the change management and organisational culture's effects to the digitalisation. The main actors of the fourth moderator are IT enablement the management's alignment with change.

6 Conclusions

This chapter concludes the thesis. The first subchapter describes the key findings of this research, the second subchapter describes the contribution and applicability of this research, the third subchapter highlights this research's reliability and objectivity, and lastly, the fourth subchapter describes the suggestions for future research, acknowledging this research's limitations.

6.1 Key research findings

The main objective of this research was to build the construction – Operations digitalisation framework - around the thesis topic. This framework focuses on the data-driven decision-making effects within daily management but also points out other relevant findings. The framework was created based on literature review, interviews, observations and a process construction. The second research outcome was to present a thorough analysis of the effects of daily management digitalisation on data availability, visualisations, real-time access, and decision-making practices in industrial operative contexts, and to clarify the factors affecting change resistance towards digitalisation. This analysis is included within the framework.

The research question was set as:

What are the elements of the Operations digitalisation framework?

The operations digitalisation framework is based on the theoretical framework, further refined with the empirical research findings. Although roots of the framework are in the scientific models and theories, the empirical part is strong and brings objectivity to the framework. The framework is structured into several interconnected elements, structured as chronologically proceeding phases: digitalisation drivers, digitalisation in manufacturing, and digitalisation effects.

Digitalisation drivers have a taxonomy of four areas. The first taxonomy label is customer and market demand, which includes the external variability creating need for digitalisation. The second taxonomy label is industry pressures, that origin from the need to thrive within the industry competition. This label includes quality and compliance related drivers, and the operational pain demanding digitalisation-related solutions. The third taxonomy label is technology trends creating need for the available technological tools and solutions. These solutions are needed to tackle the asset constraints and system fragmentation. The fourth taxonomy label is policies and regulation, which play a crucial role in how companies are operating. The bureaucratic needs originating from policies and regulatory can create the necessity for digitalised solutions, often included within the organisational strategy of the company. These digitalisation drivers are leading to the next element, digitalisation in manufacturing.

The second element, digitalisation in manufacturing, is visualising the process leading to improved decision-making quality and operational outcomes. The first step of the process is digitalisation including adoption of business technologies such as ERP, BI solutions and automations within different interventions deployed, such as visualisation and digitalisation, targeted analytics, or different tools creation. Digitalisation leads to challenge-sensitive datafication emerging from integrated systems, machine sensorisation, eventually creating high velocity, high variety data. The challenges related to datafication are demanded reorganisation of work, systems incompatibility and information fragmentation. Eventually, datafication creates information development within the daily management system, leading to data-based, sustainable solutions within daily management by enabling the action management leading from KPIs to action tracking. Implementing the DIKW model within daily management system enables digital, visual daily management creating escalation support and standardised problem solving by minimising manual, repetitive work tasks, improving efficient communication and focused problem-solving. The second element also includes a sub-element describing the moderators affecting digitalisation outcomes. These moderators have four categories: data quality and interoperability, skills and continuous learning, technical reliability and common change- and culture related moderators.

The third element is digitalisation effects, categorised within improved decision-making quality and operational outcomes. The digitalisation effects on data-driven decision-making within operative daily management are related to the information and data availability, visualisation possibilities, decision-making pace and transparency, and removal of manual, repetitive work tasks. The challenges found were related to systems interoperability and fragmentation, manual data manipulation within datafication, and the digitalisation-related development needs of DMS meetings.

The real-time information and data accessibility and transparency enable daily managers to base their decisions on real-time data and use the gathered data efficiently. This shifts the managers' affecting possibilities from retrospective to real-time interference. For example, digitalising the production planning process brought the real-time visibility to the production area and all relevant stakeholders, minimising the possibilities of misunderstandings, information delays and costly production errors. The faster, more transparent decision-making enabled daily management to detect and address deviations quickly, unlike in the retrospective decision-making mode executed in the past. The decision-making becomes faster and more transparent, and with data visualisations, the decisions were easier to justify as the data supporting them was available for all. The problem solving and RCAs run within the focal company evolved as disruption data and machine's audit trail log was brought together. This allowed improvement measures to be focused and targeted systematically, unlike before. Daily management contains a lot of manual, repetitive work done in the background of decision-making. Digitalisation led to time savings and reduced repetitive manual tasks within daily management. Digitalisation can also reduce repetitive manual tasks in the production floor. Lastly, also the communication between different key factors of daily management and different shifts of the production floor developed significantly. The operations digitalisation framework developed within this research explains how data transforms into decision-making insights following the DIKW model. The framework visualises how operational datafication enables DIKW progression within DMS, where the visual and digital daily management layer converts gathered information into faster, more transparent and better-justified decisions.

Digitalisation challenges are divided to four main factors. The system incompatibility and information fragmentation across different systems not operating well together, makes it difficult to find and use consistent information for decision-making. These issues lead to an environment without one-set-of-numbers as systems are not cross interoperating well together. Another factor causing challenges to outsource the effects of digitalisation is general poor technical reliability and usability of systems. Systems with slow loading times and poor usability for agile work can reduce the effects of digitalisation efforts. Manual work needed for datafication, for example the manual categorisation work for production monitoring system's disruption statuses can be perceived as extra work and therefore cause change resistance and restrain the effects of digitalisation efforts. The last factor is the digital readiness of companies' daily management systems. The generally low level of DMS digitalisation can lead to information processed in meetings often remaining at the information level, lacking the development towards knowledge, and often leading to speculative explanations rather than systematic concrete actions. Therefore, to seize the digitalisation effects within daily management, companies should examine the DMS functionality within digitalisation.

Change resistance was found to be a typical challenge especially within changes related to digital technologies, often increased when the change is perceived as additional work, or when communication of benefits is insufficient. Factors affecting experienced change resistance can be divided to two groups: factors causing and mitigating the resistance.

Six main factors causing resistance within digital change were identified. The first one is related to datafication, which is a phase visualised in the operations digitalisation framework. Datafication is the way data is enabled into a resource. Sometimes the datafication requirements or other changes implemented to work routines can be perceived as additional work, leading to a source of initial change resistance. The second factor causing change resistance is insufficient training and management presence. Change projects running on short resources can lack sufficient investment in training and orientation, and immediate supervisors' presence. Both supervisors' presence and training provided can restrain change resistance as change target group feels more prepared for change and understands the change motivation and objectives better. Low change target group's seniority can also cause change resistance. As low seniority and limited expertise in work tasks can make employees unsure about their current skill levels within work tasks, applying new work tasks, complicating the current ones or adding new systems to use can make employees resist the change. The fourth factor, organisational prioritisation, is closer to a digitalisation barrier, but also naturally causes resistance for change. If organisations don't sufficiently prioritise the digitalisation of operations, digitalisation is likely to focus on the support functions instead of operative level. The fifth factor causing resistance for digitalisation it the IT departments actions. This can be lack of support, slow, bureaucratic processes, or unsuitable technical solutions – all of them management problems at their core. Lastly, the timing of change has a significant impact on the change resistance rising from the change. Whether it is about missing resources or change taking place during a challenging time, timing can affect the change resistance experienced.

The change resistance mitigating factors are clear communication of goals and benefits, employee involvement, demonstration of personal benefit and management support and alignment. Clearly and frequently communicating the goals, vision and benefits of digitalisation is crucial to get those critical of the change to understand its purpose. The second factor is employee involvement. Bringing the change target into the planning phase and giving them the opportunity to affect the change can significantly reduce resistance. Thirdly, demonstrating change target's personal benefits from the change is important part of change communication. For the change to be successful, people should feel personally benefiting from it, eventually increasing the acceptance and reducing the resistance. The last factor is management support's and alignment's affects for change resistance. Management must remove obstacles, motivate staff and compel the organisation to learn new ways of working, ensuring a clear plan with well-defined steps in it. The long-term success of the change requires embedding the new ways of working into the processes and organisation, acknowledging that the change management never ends.

6.2 Contribution and applicability

The decision-making effects of operations digitalisation within daily management are not yet clear within companies and decision-makers. Companies considering digitalisation need concluded information about digitalisation effects. This research does not give exact Return on Investment (ROI) calculations for digitalisation investments, but it summarises the empirical and academic findings made within the topic. Although the expected income resulting from digitalisation remains unattainable, the findings of this research indicate that digitalisation can create meaningful change within companies. An exact ROI calculation could be quite challenging to determine as digitalisation effects depend on many factors as explained in previous chapters.

Within constructive research, it is important to create innovative, practical solutions to link into theoretical background of the topic (Lukka, 2003). In this research, innovative solution, the operations digitalisation framework, is the main objective and contribution of this research. This framework summarises the digitalisation drivers, four implementation phases, it's effects and moderators. The framework also illustrates how digitalisation enables information development in accordance with the DIKW model in daily management, supported by two process constructions from both literature based and real-world cases. This framework can be used to evaluate the operations digitalisations effects within daily management decision-making, supporting organisations in digitalisation investment and implementation related decision-making. Although profitability calculations are not provided, this research's findings indicate that digitalisation is creating notable change within companies.

6.3 Research reliability and objectivity

In Golofshani's (2003) paper, the reliability of qualitative research is roughly defined as the trustworthiness of the paper. Research methods, empirical background, the quality of literature and observations all affect the reliability of this research. The multimethod approach supported with wide empirical background and real-world observations from a long period of time prove this research's reliability. The methodology behind this research covered literature review, semi structured interviews, and process construction based on observations and interviews. These methods were chosen to gather the needed information with multiple perspectives for the reader to be able to gather the needed understanding as the background information of the model, and create validity and reliability (Golofshani, 2003). The literature review uses multiple diverse kinds of sources: scientific articles, books, reports, datasets, conference papers and online sources.

The interviews were targeted to different interviewee groups to achieve the desired level of objectivity. Interviews were conducted for both the focal machine's management chain and the external management consultant that can see how the topic and the company's change operations in the bigger picture, comparing them to other similar companies. Both interviewee groups worked closely within the change. Also, interviewees with a strong understanding of the line operator's perspectives were interviewed for the research to also cover the perspective of the shopfloor. The observations behind the empirical part are based on a long period of time, up to eight months in total. The observations have been done as an external to the focal company to support the objectivity.

The operations digitalisation framework is built strongly upon the empirical part of this research; its results being confirmed by the findings of the literature review. This enforces the research reliability, also supporting its practicability to not only support the theoretical, academic point of view. Still, the following challenges to objectivity should be addressed. Interviews are an effective method to gather information from different perspectives, but a controlled risk and a potential challenge within them is receiving only socially acceptable responses. The second objectivity challenge is within the scope of the research. The research only included one real-world case and did not include any quantitative KPIs of productivity. Also, the digitalisation efforts within the focal company were relatively fresh, so it was not yet possible to analyse the long-term finding and observations within the empirical part of the research. Although this research's framework is built upon manufacturing industry-specific themes, the Operations digitalisation framework can be applied to other industries by including careful consideration of the industry-specific factors of each industry.

6.4 Suggestions for future research

The empirical part of the research revealed several areas for development that provide a basis for future research. The most critical area for future research are the different roles' and team's ways of working, and the daily management system's maturity for digitalisation, truly internalising the DIKW model and Value of Data concept. One of this research's findings were related to the DMS maturity to enhance visualised KPI indicators and ensure that data processing systematically leads to concrete measures. The future research should address the reorganisation of individuals', teams' and the daily management system's meetings and ways of working around digital solutions. Empirical research could also be needed to analyse companies' capabilities to internalise and truly exploit the information development linked to the DMS. How can companies ensure that the information is truly evolving within the DMS meetings and what would be the target state of information development within DMS.

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Appendix: Interview questions

Basic information

1. What is your current role within the company?
2. How long have you worked within your current role?

Digitalisation

3. Do you feel that it is important to digitise operations?
4. What are the main reasons for digitising?
5. Can you think of any areas that would need digitisation measures at the company?
   5.1. What kind of digitisation measures would support your work?
6. What are the main barriers for digitising?
7. What effects do you feel digitalisation has on daily management/daily management decisions?
8. How does the accessibility/sharing of information change because of digitalisation?
9. According to your knowledge, what benefits and challenges has digitalisation brought, from the line operators' point of view?
10. How does the machine's everyday life differ from other machines where similar digitising has not been done?

Information development model

11. What kind of information do you need for management in your role?
12. At what frequency which information is needed (hourly, daily, weekly, monthly, quarterly?)
13. How is information processed and developed between different Daily Management meetings now?
14. What would be the target state for the development of the information between different Daily Management meetings?

Change management

15. What kind of challenges have been faced because of digitalisation? (Technical, cultural, educational, resources, etc.)
16. What kinds of things do you feel are important in terms of change management in the context of digitalisation?
17. According to your knowledge, how was the change received by the line operators?
18. What aspects of previous change's change management did you find effective?
19. Looking back, are there aspects of change management you wish had been managed differently?