Digitalization of Volvo Group's International Manufacturing supply chain

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ABSTRACT

Title: Digitalization of Volvo Group's International Manufacturing supply chain

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Background: The International Manufacturing division (IM) at Volvo Group Trucks Operations (Volvo) in Gothenburg handles the supply of Volvo's international manufacturing efforts. This is done using knock-down manufacturing where complete trucks are sent in pieces to be assembled at location. IM's supply chain is nonconforming in both processes and volumes, compared to the central Volvo organization, which has resulted in neglect of further digitalization efforts. Therefore, it is of interest for IM to investigate factors enabling and challenging further digital development within their supply chain.

Problem description: IM does not currently have full overview and understanding of to which extent their supply chain is digitalized. Therefore, IM has expressed an interest in a detailed case study of digitalization in their supply chain. This study should have the objective to map the current digitalization in IM's supply chain. The study should also aim to find and analyze enablers, challenges, and critical success factors for digitalization in the supply chain.

Purpose: The purpose of this master thesis is to identify enablers, challenges, and critical success factors and account for how these can be used in the current and further digitalization of Volvo Group Trucks Operations division IM's supply chain.

Research questions: RQ1: Which processes are sufficiently digitalized at IM, and which are neglected? RQ2: What enablers and challenges to digitalization are there?

Methodology: This master thesis was conducted as a single case study using a qualitative research approach. The data was collected through interviews, a survey and, excerpts from Volvo's internal documents. To verify the results, two verification workshops were held with the interviewees.

Results: RQ1 was answered by mapping the cyber-physical processes at IM and by evaluating IM's digitalization work using a digitalization maturity framework. The answer to RQ2 was found to be three critical success factors, namely, *digital change management*, *effective use of existing data*, and *clear digital organizational structure*.

Keywords: *Digitalization*, *knock-down manufacturing*, *Industry 4.0*, *supply chain transformation*, *automotive industry*.

SAMMANFATTNING

Titel: Digitalisering av Volvo Group's International Manufacturings försörjningskedja

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Bakgrund: Avdelningen International Manufacturing (IM) vid Volvo Group Trucks Operations (Volvo) i Göteborg är ansvarig för försörjning och leverans till Volvos internationella produktion. Detta genomförs genom en knock-downprocess, där färdigställda lastbilar skickas i kit för att sedan bli monterade på plats, vid den lokala fabriken. Denna försörjningskedja kräver annan anpassning och hanterar mindre volymer än Volvos centrala försörjningskedja. Detta har resulterat i att IMs processer blivit digitalt eftersatta. Denna eftersatthet i IM:s försörjningskedja har gjort att IM vill identifiera och utvärdera faktorer som kan möjliggöra och förhindra vidare digital utveckling för deras processer.

Problembeskrivning: IM har för tillfället varken översikt eller full insikt i hur väl deras försörjningskedja är digitaliserad. Avdelningen är därtill inte medveten om vilka faktorer som är viktiga för att understödja fortsatt digitalisering i hela försörjningskedjan. På grund av detta har IM visat intresse för en detaljerad fallstudie av digitalisering i deras försörjningskedja. Denna fallstudie skall kartlägga den nuvarande digitaliseringen av försörjningskedjan. Studien har också som mål att identifiera och analysera möjliggörare, utmaningar och kritiska framgångsfaktorer för digitalisering i försörjningskedjan.

Syfte: Syftet med detta examensarbete är att identifiera möjliggörare, utmaningar och kritiska framgångsfaktorer, samt redogöra för hur dessa kan användas i den nuvarande och framtida digitaliseringen av Volvo Group Trucks Operations avdelning IM:s försörjningskedja.

Forskningsfrågor: FF1: Vilka processer är tillräckligt digitaliserade på IM, och vilka är eftersatta? FF2: Vilka möjliggörare och utmaningar för digitalisering finns?

Metodologi: Detta examensarbete har utförts som en kvalitativ enskild fallstudie. Data har samlats in genom intervjuer, en enkät samt genom utdrag från Volvos interna dokument. Datan verifierades genom två verifikationsseminarium med intervjuobjekten.

Resultat: FF1 svarades på genom kartläggning av fysiska och digitala processer inom IM och genom att utvärdera IMs digitalisering med hjälp av ett ramverk för digital mognad. Svaret på FF2 är tre identifierade kritiska framgångsfaktorer, *digital förändringsledning*, *effektivt användande av befintlig data* och *tydlig digital organisatorisk struktur*.

Sökord: *Digitalisering*, *knock-downtillverkning*, *Industry 4.0*, *omvandling av försörjningskedjor*, *fordonstillverkning*.

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This thesis has allowed us to test our knowledge in our master's degree studies, supply chain management, and gain deeper knowledge about a subject both of us are interested in, digital transformation. We would like to thank the International Manufacturing division at Volvo Group for all the time and resources spent helping us, particularly the people who took their time to participate in the interviews, the survey, and the workshops. We would also like to direct a special thanks to our supervisor at Volvo Group, Karin Eriksson, for her immense help and support. Without her, this thesis would not have been possible. We would like to direct another special thanks to Viking Johansson, Vice President of Logistics at IM, for his valuable input.

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Fredrik Greftén & Anton Gunneberg
Lund, June 2021

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ABBREVIATIONS

AI Artificial intelligence

CBU Completely built-up

CKD Complete knock-down

CPS Cyber-physical systems

VGTO Volvo Group Trucks Operations

ERP Enterprise resource planning

IM International Manufacturing

IoS Internet of services

IoT Internet of things

IT Information technology

JV Joint venture

KD Knock-down

KPI Key performance indicator

MS Microsoft

RFID Radio frequency identification

RPA Robotic process automation

SKD Semi knock-down

SME Small and medium-sized enterprise

S&OP Sales and operations planning

UCR Unpacking control report

1 INTRODUCTION

This chapter provides an overview and background of this master thesis regarding the current and further digitalization of Volvo Group's International Manufacturing supply chain. The purpose of this master thesis is explained, as well as the problem this study aims to solve. Further, this chapter provides relevant context to understand the setting this master thesis is written in, a short presentation of the case company Volvo Group/IM and the focus and delimitations set for the research.

1.1 Background

When discussing technology in relation to manufacturing companies, it is important to acknowledge the constant development in this area. As Schwab (2016) explains, starting with the industrial revolution in Western Europe in the early 19th century, industrial technologies have gone through several paradigm shifts. During the last century, the use of computers and mass production became the norm. In a contemporary context, digitalization, automation, and Industry 4.0 are central concepts, regarded as the future in the area. Several features usually included in digitalization and Industry 4.0 can be recognized in many industries today. However, according to Yin et al. (2018), most of the technologies making up these concepts are still in the starting blocks. This is certainly true when it comes to the digitalization of supply chains, where many organizations do not have the digital infrastructure available to utilize these technologies. As this development continues, global manufacturing supply chains need to adapt to the reality of digitalization, including Industry 4.0, to stay relevant. To a high extent, this includes the digitalization of the supply chains in large manufacturing companies (Yin et al., 2018).

Lambert et al. (1998) declares the supply chain of a manufacturing company is the backbone of its operations, today. As the same authors also describe, during the last century, the very concept of a supply chain was defined. With that, extensive work and research have been done to understand how the design of a supply chain is optimally done to optimize performance. This has been done by applying theory developed by academia but also by closely examining company-specific supply chains. The optimization of supply chains has in recent years changed from a field where theory has been the main method of progress for individual companies, into a field dominated by extensive data analysis (Tiwari et al., 2018). However, according to (Kersten et al., 2017), digitalization is key to collect data. Lack of digitalization in modern manufacturing organizations' supply chains is often obstructing further development and optimization of said functions. Therefore, many organizations need to map and evaluate the current digitalization throughout their supply chain and identify enablers, challenges. and critical success factors for further development (Kersten et al., 2017).

As concluded by Schuh et al. (2020), by successfully evaluating its level of digitalization, an organization is able to decide what is the sensible next step in their digitalization effort. The technologies commonly related to Industry 4.0 can all be regarded as disruptive, and technologies as internet of things (IoT) sensors, additive manufacturing, and big data have the potential to fundamentally change how organizations operate. However, to implement these technologies efficiently, organizations need to be ready in many ways. Information technology (IT) infrastructure needs to be robust, with high connectivity and visibility. Data needs to be available and stored in efficient ways and employees need to have the right competencies. Most companies need to further digitalize their processes before they can become ready to adopt these disruptive technologies in an efficient manner (Schuh et al., 2020).

So why are Industry 4.0 and digitalization considered to be the future for manufacturing supply chains? According to McKinsey & Co (2015), the reason is traditional cost-saving strategies have been largely exhausted or ineffective. Outsourcing or offshoring is not as cost-effective as it used to be due to higher wages in low-cost countries, and decades of lean strategies have largely pushed costs as low as they practically can be, meaning that new sources of cost savings must be identified and utilized. McKinsey & Co (2015) identifies time to market and customer responsiveness as new factors of competitiveness and by using automation and data analysis it becomes possible to drive costs down while being responsive and have a short time to market. Another factor where Industry 4.0 is important is the increasing process visibility, resulting in more control of the supply chain. If done right, this can increase productivity and decrease machine downtime (McKinsey & Co, 2015).

The further digitalization and the subsequent implementation of Industry 4.0 technologies is the way forward for most companies in the manufacturing sector, as discussed by Schuh et al. (2020). However, to successfully do this, companies need to first assess at what technological level they currently are, and thereafter carefully construct a digitalization roadmap (Schuh et al., 2020).

1.2 The case company

According to AB Volvo (2021), Volvo Group is a Swedish aktiebolag (AB) consisting of different manufacturing subsidiaries producing commercial vehicles and powertrains. With around 100,000 employees worldwide it is one of Sweden's largest manufacturing companies. Volvo Trucks, one of the subsidiaries, is a world-leading manufacturer of long-haul trucks. Volvo Trucks headquarter is located in Gothenburg and is one of the city's main employers.

As noted by Eriksson (2021), Volvo Group Trucks Operations (VGTO) of Volvo Trucks (from here on, Volvo), handles all the operations of Volvo's manufacturing and supply chain efforts. VGTO has operations at several sites in Europe, the United States, and South America. All of these sites have their own operations and serve their own markets and while they share many suppliers, they source locally where beneficial. VGTO produces about 240,000 trucks per year all over the world.

Explained by Eriksson (2021), the International Manufacturing (IM) division within VGTO, handles all the strategic and tactical decisions of Volvo's knock-down (KD) manufacturing. Volvo's KD manufacturing is the manufacturing effort taking place outside of any of VGTO's main plants, also called completely built-up (CBU) plant. KD manufacturing is used when the postponement of truck assembly is strategically beneficial. Usually, due to import taxes or local customs or trade regulations. The KD assembly plants receive assembly kits containing parts possible to assemble into a truck. This makes IM's supply chain an interesting case, where most of its suppliers and its customers are Volvo themselves. However, some of the assembly sites are either joint ventures or not at all associated with Volvo. This results in IM having a wide variety of customers needing different treatments regarding supply chain processes and confidentiality. The main idea is that a KD assembly plant should be considered as a remote CBU assembly line and therefore produce the exact same product as the trucks produced by the CBU plants (Eriksson, 2021).

According to Eriksson (2021), Volvo, and IM, is by many measures organizations operating within the high-technology field, as today's vehicles become increasingly computerized and connected. Despite Volvo's eminent position within vehicle technology, the company is lacking in internal digitalization and usage of modern technology to facilitate operations. This certainly applies to the logistics unit at IM, which could benefit from the streamlining of processes more extensive digitalization provides. A more digitalized process also comes with the benefit of data getting more readily available for tactical and strategic functions, to support the strategic, tactical and operational decision making (Kersten et al., 2017).

1.3 Problem statement

Today, there is a perceived lack of digitalization at the International Manufacturing division at Volvo in their supply chain processes. IM does not currently have full overview and understanding of to which extent their supply chain is digitalized. Also, the division is not completely aware of which factors are important for facilitating further digitalization throughout the supply chain. This may be related to a previous lack of process evaluation, but also the extensive use of outdated information systems. In general, a clear strategy for further digitalization seems to be missing, especially before the current systems are replaced with more modern solutions. The varying age and integration levels of the systems Volvo uses for their supply chain processes result in different possibilities of data collection and integration of automated and digitalized solutions. Employees at IM specifically mentioned media breaks as a concern, meaning the situation where a digital process for some reason is interrupted by a physical process with manual output or input.

Therefore, IM has expressed interest in a detailed case study of the digitalization in their supply chain. This study should map the current digitalization in their supply chain. The study should also aim to find and analyze enablers, challenges, and critical success factors for digitalization in the supply chain. The results of the study should enable IM to obtain a more complete understanding of the digitalization in their supply chain and how to manage further digitalization.

1.4 Purpose

The purpose of this master thesis is to identify enablers, challenges, and critical success factors and account for how these can be used in the current and further digitalization of Volvo Group Trucks Operations division IM's supply chain.

1.5 Research questions

To support this master thesis to achieve its purpose, the following two research questions (RQs) were formulated:

- **RQ1**: Which processes are sufficiently digitalized at IM, and which are neglected?
- **RQ2**: What enablers and challenges to digitalization are there?

To facilitate answering RQ2, two sub-questions (SQs) were phrased:

- **SQ2.1**: Which are the main enablers and challenges to digitalization in the manufacturing industry?
- **SQ2.2**: How does the specific design of IM's supply chain affect its digitalization?

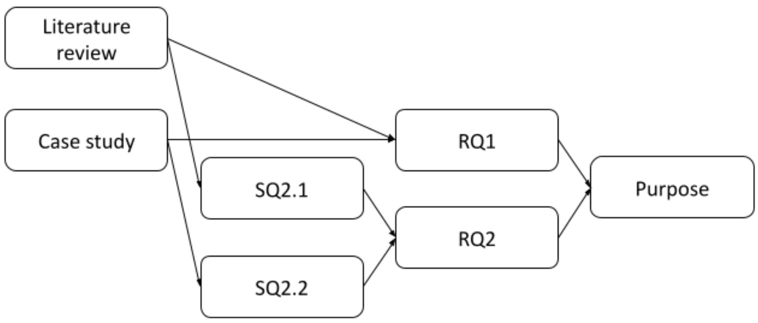

Figure 1.1: How the research questions were answered and how they supported achieving the purpose.

Figure 1.1 highlights how the process of achieving the purpose and answering the RQs were performed. RQ1 was answered partly by a literature review, and partly by the case study. RQ2 was divided into two SQs, where SQ2.1 was answered through the literature review and SQ2.2 was answered through the case study.

For studies using the research method case study, the RQs is usually based on the questions *how?* and *why?* (Yin, 2018). In this thesis however, the research questions relevant for achieving the purpose was rather *what?* and *which?* This is mainly a matter of wording, as to find the answers to the set RQs, the questions *how?* and *why?* had to be asked throughout the study, to collect the relevant data.

1.6 Focus and delimitations

The unit of analysis for this master thesis is Volvo Trucks KD supply chain which is handled by the International Manufacturing unit at VGTO. The focus was put on identifying to which degree the processes related to this supply chain are digitalized, as well as finding enablers, challenges, and critical success factors for further digitalization of specific processes and the organization surrounding the supply chain. Even though some synergies between Volvo's different logistics units were identified, focus was on mapping and investigating the IM supply chain. The focus was not on how to digitalize or implement specific solutions. The thesis instead focuses on key factors enabling or challenging the digitalization work of VGTO and IM. Further, it should be noted IM is not in the position to replace the outdated information systems present. Therefore, the focus was not on pointing out how these systems are lacking in automation and integration. Rather, the focus was put on how digitalized the processes specific for IM are, and what can be done in the current situation. The scope of the physical process researched in this master thesis is illustrated in Figure 1.2.

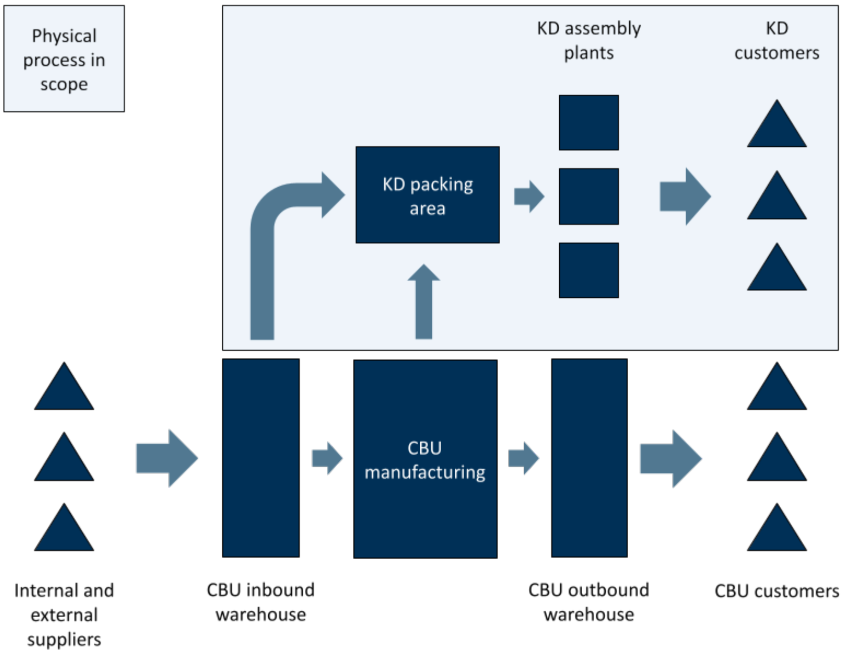

Figure 1.2: An overview of the physical processes of VGTO and processes included in this thesis' scope.

1.7 Definitions

In this section, definitions of central terms for this thesis which could cause ambiguity due to their broad or dual meaning are presented.

1.7.1 Digitalization

When discussing digitalization, the implementation of the technologies discussed in the literature review is meant. A digital process is a process taking place in the digital realm. This means a process solely is taking place in a computer is considered digitalized regardless of human interaction is needed in the process or not. However, the process can become further digitalized by eliminating manual inputs or manual information transfers. This, because process automation could be considered a form of digitalization, as stated by Schmitz et al. (2019) and Hofmann et al. (2020).

When the term *sufficiently digitalized* is used, it refers to a process or organization considered to be in the third stage of *Acatech Industrie 4.0 maturity index* developed by Schuh et al. (2020) and presented in Section 3.4. The third stage is by Schuh et al. (2020) termed *visibility*, and describes a situation where the organization's manufacturing parts and supply chain is connected, and where full digital insight in the process is achieved. This means the positive traits of the first two stages of the index also are achieved, where the organization is computerized and have connectivity between systems. This is further elaborated on in Table 3.9.

1.7.2 Automation

Groover (2001, p. 61) defines *automation* as *"the technology by which a process or procedure is accomplished without human assistance"*. When *automation* is discussed in this thesis, the kind of automation clearly related to digitalization is referred to. This means the *automation* discussed in this thesis is only process *automation*, meaning *automation* of calculations, analysis and information transfers. This differs from the *automation* achieved by implementing robotics in production by inherently increasing the digitalization level of an organization, whereas physical *automation* does not necessarily contribute to further digitalization of an organization. Schumacher et al. (2016) state digitalization and automation is two different concepts, with different impacts and consequences. However, they also conclude these concepts are merging, due to digital concepts becoming more all-encompassing. Therefore automation, in the context of this thesis, is considered to be a part of the digitalization effort.

1.7.3 Visibility

When discussing *visibility* in this thesis, the ability to monitor processes and activities the supply chain is concerned. As noted by Christopher and Peck (2004), an increased level of visibility means either when a process becomes easier to follow or when the information of the process becomes more detailed. According to them, when discussing *visibility*, the terms upstream and downstream *visibility* are often distinguished. Upstream *visibility* considers the inbound supply chain while downstream *visibility* considers the outbound supply chain. While both often are equally important, according to the same authors, considering this thesis' unit of analysis, only downstream *visibility* is discussed and analyzed.

1.7.4 Data visualization

Berinato (2016) defines *data visualization* as a layer of abstraction making data comprehensible, and this is the definition used in this study.

1.7.5 Effective use of data

Merriam-Webster (n.d.) defines the word *effective*, as "producing a decided, decisive or desired effect". This means, when using data effectively, the data is used for its purpose, to improve processes. In an environment where there is effective use of data, the existing data is used with purpose to improve processes and provide understanding, which includes facilitating a more data-driven decision making process. This definition of *effective use of data* is the one used in this master thesis.

1.7.6 Connectivity

Connectivity is described by Schuh et al. (2020) as the integration of an organization's information systems. *Connectivity* is the term used when describing an interconnected system's infrastructure, where data in one system is available to use in other systems. Not only systems have to be connected but also processes in the physical world, e.g. by the use of IoT-sensors. This is the definition of *connectivity* used throughout this study.

1.8 Report structure

In Table 1.1, every chapter of this master thesis is briefly summarized, providing an overview of the layout.

Table 1.1: Report structure.

1. Introduction	This chapter provides an overview and background of this master thesis regarding the current and further digitalization of Volvo Group's International Manufacturing supply chain. The purpose of this master thesis is explained, as well as the problem this study aims to solve. Further, this chapter provides relevant context to understand the setting this master thesis is written in, a short presentation of the case company Volvo Group/IM and the focus and delimitations set for the research.
2. Methodology	In this chapter, different approaches, strategies, methods, and philosophies for research in general and supply chain and operations research, in particular, are described, discussed, and evaluated. Further, the methods of choice for this research work are motivated. The research methods, approaches, and strategies selected all have the aim of supporting the process of writing this master thesis in being effective, objective, and balanced.
3. Literature review	In the literature review, relevant theories on digitalization, supply chain management, change management, and IT organization structure are presented and analyzed. The purpose of this chapter is to present relevant theory on the subjects of this master thesis and provide the necessary theoretical background for conducting the research work and achieving the purpose of the thesis.
4. Case study	In this chapter, the empirical findings from the case study on the digitalization of IM, including the interviews, the survey, and internal documents, are presented and discussed. The case study constitutes a synthesis of the empirical data collected during the research work. In total, data collected from nine interviews, 14 survey respondents, and two workshops are presented.
5. Analysis and results	In this chapter, the context of the case, the theory, and the empirical data is analyzed. By analyzing the theory and empirical data together and presenting the results, the case analysis aims to provide answers to the RQs of this master thesis. Further, the relevance and importance of these answers are analyzed with regard to achieving the purpose of this master thesis. The objective of this chapter is to provide clarity, structure, and understanding of the data collected, presented, and analyzed.
6. Conclusions	In this chapter, conclusions drawn from the analysis and results will be presented as answers to the research questions. Proposals and recommendations for the case company on how to proceed in this area are presented. Furthermore, this chapter aims to discuss the generalization of results and how the research results of the thesis contribute to research. The chapter also seeks to identify areas for future research and limitations of the research conducted.

2 METHODOLOGY

In this chapter, different approaches, strategies, methods, and philosophies for research in general and supply chain and operations research, in particular, are described, discussed, and evaluated. Further, the methods of choice for this research work are motivated. The research methods, approaches, and strategies selected all have the aim of supporting the process of writing this master thesis in being effective, objective, and balanced.

2.1 Summary of methodology

As noted by Höst et al. (2006), the methodology used when conducting any form of research will have a great impact on the results. Therefore, it is important to select the right approach for the research. In the preceding chapter, the background and purpose of this master thesis were clarified. Also, research questions were specified. This constitutes the main influences on how the methodology is designed in this master thesis. The methodology should be designed to give optimum requisites for the research to achieve its purpose and set objectives (Höst et al., 2006). In Figure 2.1, the research methods selected in this master thesis are summarized.

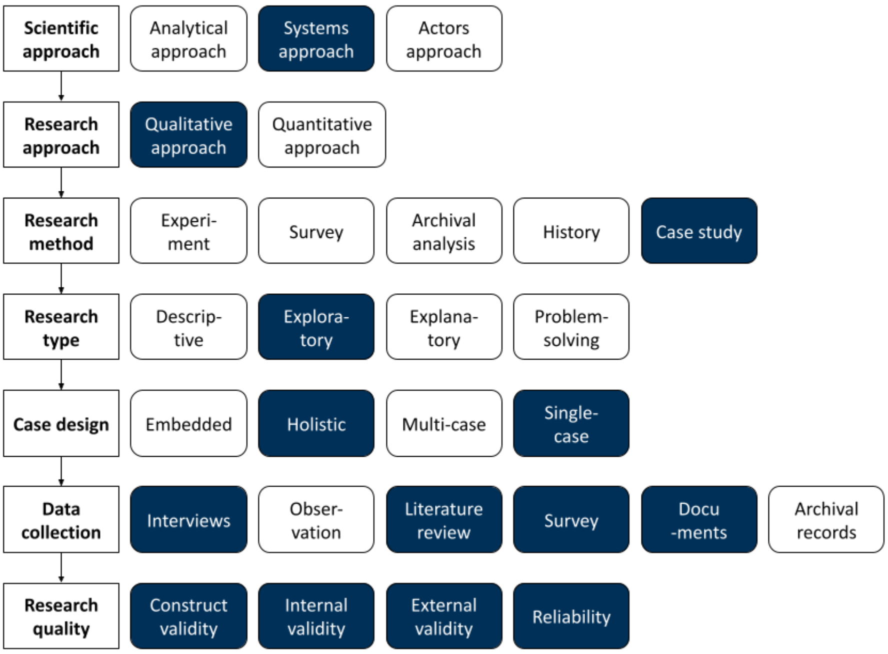

Figure 2.1: Summary of methods used in the master thesis.

2.2 Approach

The choice of approach greatly influences both theory and practice and therefore needs to be well-suited to the subject of the research (Nilsson & Gammelgaard, 2012). When deciding on a scientific approach and research approach, there will be trade-offs present, as they all have advantages and disadvantages (Golicic et al., 2005). As each approach generates different perspectives on the research subject, it is important to understand these different perspectives and how this will affect the process (Arbnor & Bjerke, 2009). In this section, different approaches are discussed and evaluated. Also, the selection of scientific approach and research approach is motivated.

2.2.1 Scientific approach

Gammelgaard (2004) presents three methodological approaches, originally developed by Arbnor and Bjerke (2009), of which two of the approaches are the ones almost exclusively used in logistics research. These approaches are the systems approach, the analytical approach, and the actor's approach, and their characteristics are presented in Table 2.1. According to Gammelgaard (2004), the third approach (actor's approach), is rarely used in logistics or operations management research. When studying a supply chain like IM's, a systems approach is viable, as it is essential to have this to retrieve a holistic perspective of the supply chain. The holistic perspective is, as Gammelgaard (2004) notes, needed to understand the interaction between actors in supply chains, ensuring the best optimal results for the entire supply chain, and not just its parts. When taking this approach, Gammelgaard (2004) highlights the focus should be on understanding the system studies contextually, and not in a universal environment. The objective should be to find a solution to the problem first and foremost working in practice. This made the systems approach the most viable option for this master thesis. The entire supply chain, and its internal and external interactions, needed to be understood to evaluate its ongoing digitalization and how it could be improved.

Table 2.1: Characteristics of three scientific approaches. Described by Arbnor and Bjerke (2009) and Gammelgaard (2004).

	Analytical approach	**Systems approach**	**Actors approach**
Theory type	Explanations, predictions, universal laws	Models, recommendations, knowledge about concrete systems	Interpretations, understanding, contextual knowledge.
Preferred method	Quantitative	Case studies (both qualitative and quantitative studies)	Qualitative
Unit of analysis	Concepts, relation between concepts	Systems, links, interaction in the system	People and how they interact
Data analysis	Description, hypothesis testing	Mapping and modelling	Interpretation
Position of the researcher	Outside	Preferably outside	Inside

2.2.2 Research approach

Näslund (2002) explains there is a discourse between the use of qualitative or quantitative approach in logistics research, which in earlier times has been strongly inclined towards the qualitative approach. At first sight, the high degree of measurability in supply chains makes them suitable for quantitative research The commonly measured dimensions in supply chains; lead times, order quality, service rate, warehouse utilization rate, etc., are all easy to measure or model quantitatively, as concluded by the same author. According to Näslund (2002), this might be a reason why a large portion of case studies on supply chains are have a quantitative research approach. Another reason mentioned is the tradition in the research field. Most published research on supply chains is quantitative, leading to the fact quantitative research might be favored, to avoid not getting published or cited. However, it is not to say qualitative case studies about supply chains do not exist and certainly not to say that qualitative case studies are not needed (Näslund, 2002).

The aim of the qualitative approach is to "create an understand a specific phenomenon, situation or action" (Björklund & Paulsson, 2003, p. 63), and doing this by describing or "telling a story" about the phenomenon or situation researched (Fawcett et al., 2014). Mainly, the formulation of the study's purpose is what is deciding which approach the study takes (Björklund & Paulsson, 2003). As Golicic et al. (2005) notes, this makes data collection the natural first step of qualitative studies. This is typically exercised through several field studies, which makes it possible to observe and understand the phenomenon in its natural setting. The data collection is, according to Golicic et al. (2005), typically done by observing, but also by interviewing people with proximity to the phenomenon researched. In qualitative studies, the literature review is not an independent step, but rather something performed throughout the data collection period. This is, per Golicic et al. (2005), to provide understanding of the behavior shown by the phenomenon. It is also common practice to have the developed framework emerge from the data observations, rather than previous knowledge in the literature. After collecting data, the typical second step is to describe the phenomenon from the view of the interviewees and other informants (Golicic et al., 2005). The phenomenon is best described by the people working with or being close to it. This way, a deep understanding of the phenomenon can be developed (Näslund, 2002). The next step is to build theory of the phenomenon. Further, Yin (2018) clarifies the criticism of research based on qualitative data often refers to the less robust measurements used in comparison to when collecting quantitative data. The non-numerical nature of qualitative data can be problematic because of a lack of understanding of how to manage it, according to the same author.

As both Björklund and Paulsson (2003) and Golicic et al. (2005) describe, quantitative studies are considered useful when there is a large quantity of highly measurable data present and one wants to draw conclusions from this large set of data. They are also considered useful when the objective is to generalize trends or larger events. Qualitative studies, on the other hand, are useful when realism is desired, as studying one small phenomenon or process in detail to know everything about it. From this knowledge, it is then possible to identify new relationships between variables and draw larger conclusions from the vast knowledge of one phenomenon (Björklund & Paulsson, 2003; Golicic et al., 2005).

For this master thesis, performing a qualitative study would probably be the preferred approach by most researchers. The phenomenon studied has no well-defined measurable variables. The research questions, seeking answers describing reality, are more suited for a qualitative study than for a quantitative study. This, since the objective was to study a specific phenomenon in detail and as the result of the study possibly can be applied to other parts of the case supply chain. However, since this case study also includes a framework for classification of the digitalization effort, some quantitative data was also used and compiled, as through the survey. This means the research questions were answered by qualitative studies, while parts of the research were conducted with quantitative elements present. The objective of this create conditions possible for achieving the purpose. All data collected was quantitative except from the survey performed, where answers were both qualitative and quantitative.

2.3 Research methods

In this section, different research strategies existing are discussed and evaluated. Also, the selection of research methods for this master thesis will be motivated. When deciding on research strategy and method, it is, according to Arbnor and Bjerke (2009), important they are aligned with the research approach and the characteristics of the subject studies. Therefore, the strategy and method chosen in the following section have to align with the research approach described in the preceding section, and with IM's supply chain characteristics.

2.3.1 Choice of method

When selecting a research method, Yin (2018) presents five different alternatives. These alternatives are *experiment*, *survey*, *archival analysis*, *history*, and *case study*. The methodologies differ in how they are carried out, but there are also many similarities present between them. To support the choice of the methodology best adapted to the research, (Yin, 2018) has developed a framework with three dimensions. This framework can be seen in Table 2.2.

Table 2.2: Relevant situations for different research methods. From Yin (2018).

Method	**Form of research question**	**Requires control of behavioral events?**	**Focuses on contemporary events?**
Experiment	how, why?	yes	yes
Survey	who, what, where, how many, how much?	no	yes
Archival analysis	who, what, where, how many, how much?	no	yes/no
History	how, why?	no	no
Case study	how, why?	no	yes

As mentioned in Section 1.5, this study's RQs poses the questions *what* and *which?* rather than what is advocated by Yin (2018) in Table 2.2, (*how?* and *why?*). The reason for this is that the fulfillment of the purpose was easier to describe by formulating the RQs in this way. However, to answer the RQs posed, the questions *how?* and *why?* was consistently asked in regard to IM's current digitalization situation and its improvement.

Further, as noted by Voss et al. (2002), case study research is often mentioned as one of the most relevant methods in operations management. Through this method, it is possible to understand changing technological environments and maintain high research quality. Even though case study research is a powerful way to conduct operations management research according to Voss et al. (2002), there are also several issues with this method. For instance, the researchers must be careful and accurate when drawing representative conclusions. If this caution is taken, case study research can provide relevant insights for the case subject, the researchers, and theory (Voss et al., 2002). Therefore, the expectation of this master thesis was to bring valuable insights to IM, the authors of this thesis, and theory.

For choosing the best possible research method, discussions with the company where the study is to be conducted are needed (Fisher, 2007). According to Fisher (2007), empirical research in operations management can be classified in two dimensions. The first one is the set goal of the research, whether the aim of the study is to be descriptive or prescriptive. The main question becomes: Is the focus of the study to describe an existing phenomenon as-is, or prescribe how a phenomenon correctly should be managed or studied? The second dimension is to which degree the research interacts with the world, ranging from less structured to highly structured. Interviews and observations are classified as less structured interactions, while data and algorithms are classified as highly structured. These dimensions are illustrated in Figure 2.2. As seen in the figure, the different dimensions make up different types of research, and how these research types evolve from *case studies* to *engineering*, by developing into having a more structured and prescriptive approach (Fisher, 2007).

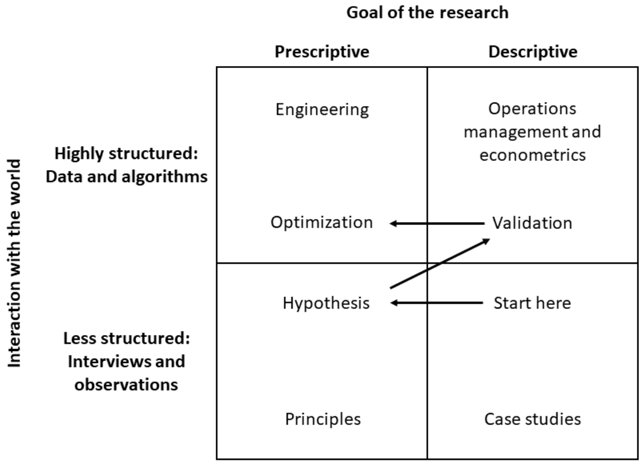

Figure 2.2: Types of empirical research in operations research. From Fisher (2007).

Fisher (2007) stresses the importance of case studies, especially when identifying areas for further research. Case studies are central in developing further research, leading to hypotheses and principles in the studied area. This master thesis is partly conducted through less structured interactions, as interviews. While the thesis aims to be both descriptive and prescriptive, the positioning of this research work is in the lower right quadrant of Figure 2.2, as a case study.

2.3.2 Research type

To ensure efficiency in research, it is beneficial to decide the approach from the characteristics of the study. According to the adoption from Höst et al. (2006) of Robson (2002), there are four categories of methodologies. These are presented in Table 2.3.

Table 2.3: Categories of studies. From Höst et al. (2006), and Robson (2002).

Category	**Characteristics**
Descriptive	Objective of understanding a specific phenomenon. Research is conducted through in-depth studies; the researcher can describe the phenomena in as much detail as possible. Often done in areas where much is already known.
Exploratory	Seeks to perform in-depth analyzes of areas where little is already known. The researcher works towards shedding light on a phenomenon rather than explaining or describing it.
Explanatory	A form of research where the objective is to explain why a phenomenon occurs.
Problem-solving	Used when the phenomenon studies is a problem needing to be solved.

This master thesis' objective is to shed light on the digitalization efforts of IM's supply chain, an area where the case company and division acknowledge they do not have extensive knowledge. The focus is to explore the phenomenon of digitalization in the case supply chain. The research questions which will be used to reach this objective can be categorized as exploratory studies (Höst et al., 2006). Some elements of the study could be considered descriptive, but the exploratory research type is the one mainly used to achieve the purpose, given the knowledge of digitalization in the case company. Therefore, exploratory studies are what will be used to study this phenomenon.

2.3.3 Research maturity cycle

Relating to the content of Figure 2.2, Malhotra and Grover (1998) discusses the maturity cycle for research. Over time, the knowledge of an area or phenomenon studied increases by further research. This affects the study type and research approach, like the views of Fisher (2007). When the initial research is conducted on a phenomenon, and there is uncertainty, the studies tend to be descriptive or exploratory, according to Malhotra and Grover (1998), and being either case studies or hypothesis generations and testing. In Figure 2.3, the maturity cycle of research is illustrated. It shows the development from hypothesis generation and exploratory or descriptive studies to explanatory and hypothesis-based research, with more focus on hypothesis testing and quantitative research methods (Malhotra & Grover, 1998).

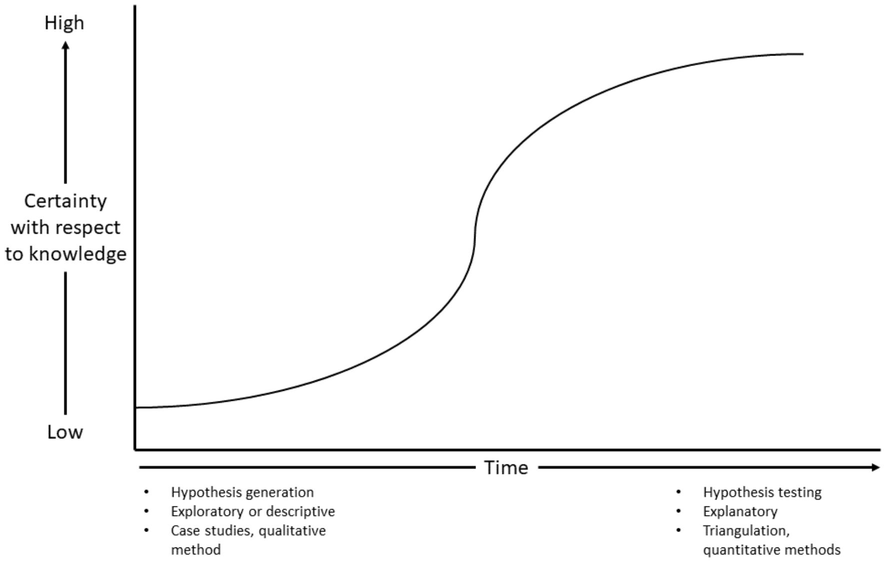

Figure 2.3: The maturity cycle of research. From Malhotra and Grover (1998).

One objective of the study is that the results can play a part in the prescription of further digitalization in large manufacturing supply chains. This corresponds to Fisher's (2007) perspective, where a case study approach will evolve into hypotheses and principles over time. The phenomenon of digitalization and Industry 4.0 is a modern research area, although the general knowledge is increasingly high (Yin et al., 2018). In the specific case of IM's supply chain, digitalization, and Industry 4.0 have high uncertainty and low knowledge, leading this master thesis to mainly correspond to an exploratory case study in the research maturity cycle, positioned to the left in Figure 2.3.

2.3.4 Case design

To properly conduct a case study, it is essential to have the optimal design of the case, according to (Yin, 2018). The same author clarifies there is a choice between a single-case design and a multi-case design, but also a choice between an embedded case design and a holistic case design. The case design should depend on what the study aims to investigate, and other choices in research strategy and approach. The characteristics of each case design category and when they are suitable to use are defined in the table below, developed from Yin (2018). Important to notice here is these categories do not exclude each other, as the selection of case design stands between an embedded and a holistic design and further between a multi-case and a single-case design. In Table 2.4, the situations for when to use each case design are described.

Table 2.4: Case design categories. From Yin (2018).

Case design	**When should it be used?**
Embedded	Several units of analysis (either multiple or single case study), the focus is on one or several sub-units. If the objective is to strengthen the external validity of the case study.
Holistic	If the global nature of an organization or program is the focus of the study, no sub-units are possible to identify.
Multi-case	If the objective is to evaluate and compare different studies, get an all-embracing view of the studied phenomena. If several organizations are subject for the study.
Single-case	When focus is only on one organization or program. Preferred if the study tests a theory, if the case is representative of a certain phenomenon or if the study is longitudinal. It may be more vulnerable due to difficulties in generalization, efforts to avoid misrepresentation should be taken.

When conducting a study where great depth is needed to answer the research questions, the single-case study is a viable option (Yin, 2018). Even though a single-case approach may limit to what degree the conclusions can be generalized, according to Voss et al. (2002), it will facilitate a greater understanding of IM's unique supply chain setup. To achieve the purpose of this thesis, great depth in the understanding of the research subject is needed. To answer the research questions, the unique aspects of IM's operations needed to be understood and examined with great depth. The different designs of case studies are illustrated in Figure 2.4.

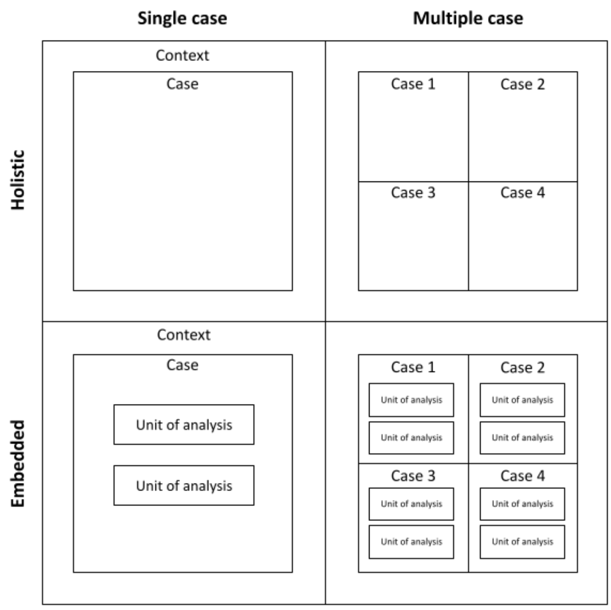

Figure 2.4: Design options for case studies. From Yin (2018).

This thesis aims to study the supply chain of IM, and no other reference supply chain will be studied. Therefore, this thesis was carried out as a single case study. Caution was taken in accordance with the vulnerabilities induced by the single case study method, to ensure the results of the research are valid (Yin, 2018). The thesis focused on the global nature of the unit of analysis, with no sub-units. This resulted in a holistic design of the case study. Altogether, this means a *holistic single-case* design of the case study was used in this master thesis.

2.3.5 Unit of analysis

As emphasized by Yin (2018), defining a strict unit of analysis is key to a well-delimited and structured case study. With a well-defined unit of analysis, reaching the purpose of the study becomes easier and more straightforward. Also, Yin (2018) notes the unit of analysis supports keeping the research to relevant areas and not becoming too wide in its scope. The chosen unit of analysis should have clearly defined boundaries and be possible to study as an independent unit.

When defining the unit of analysis, important to notice is it will greatly affect how the case study is conducted, as described by Yin (2018). If the unit of analysis is to be explored as an entirety, a holistic case study is the preferred method. If the unit of analysis instead can be divided into subunits and studied independently, an embedded case study is the right choice of study. According to Baxter and Jack (2010), the case studied must be taken into careful consideration when choosing the unit of analysis as well. In some ways, the unit of analysis is a representation of the case, or the system studied. This means, if the case studies a process, this process should be the unit of analysis. Arbnor and Bjerke (2009) notes that if the research is having a systems approach, the unit of analysis is the system. Here, the system being the unit of analysis is IM's supply chain and its ongoing digitalization.

The unit this master thesis explores and analyzes was the process of digitalization of the outbound supply chain of IM, meaning only the flows between VGTO and IM assembly sites are of interest. This, because the flow between VGTO suppliers and VGTO is shared with IM. The physical delimitation is only the supply chain within Volvo Group was studied, meaning no joint ventures or business partners were subject for study. Another delimitation is the fact only the supply chain of *Volvo* trucks was studied. Since Volvo also is the owner of brands Mack and Renault, this is important to notice. A chart mapping the physical flows studied can be found in Figure 1.2. The concept of digitalization was narrowed down through an extensive literature review. It was also narrowed by interviewing employees at IM. This, to understand which concepts of digitalization was most prominent in the literature and seen as most important for IM by the division's own employees. To understand how the unit of analysis was developed, Figure 2.5 can be of help. This unit of analysis follows the criteria specified by Yin (2018), by having clear boundaries, being able to study independently, and being relevant to answer the research questions stated. The figure is illustrating the unit of analysis in the thesis and is therefore also representing the system studied.

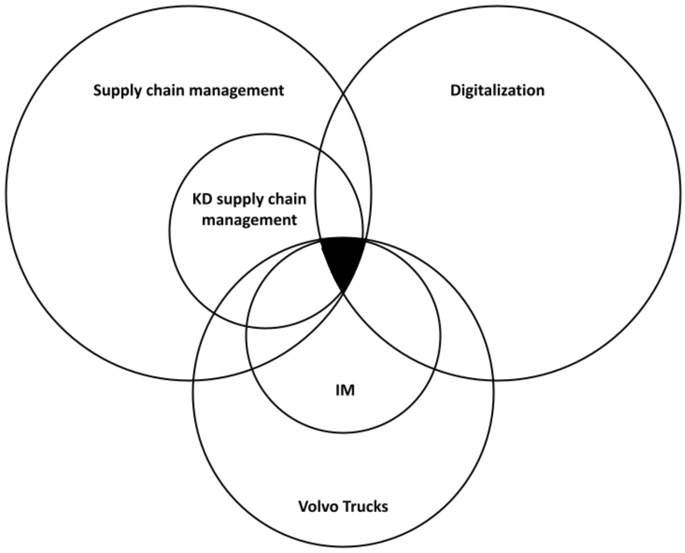

Figure 2.5: The unit of analysis for this master thesis. (The darkened area.)

2.4 Data collection

The thesis aims to shed light on the digitalization efforts of IM's supply chain. To do this while maintaining high research quality, both empirical and theoretical data were needed. When conducting the research of this master thesis, empirical data was collected in three different data collection methods, performing interviews, conducting a survey, and through excerpts of internal documents. Further, a workshop to verify the data from the interviews was held. Theoretical data were collected through an extensive literature review. The different data collection methods used in this thesis are described in more detail in the following sections.

2.4.1 Interviews

According to Dumay and Qu (2011), how the people interacting closely with a certain phenomenon perceive it is easiest found out by having a conversation with them. By conducting interviews with people within the case company in relevant positions it is possible to achieve a deep understanding of the phenomenon. Conducting interviews is a key method to understand experiences and opinions, as described by Dumay and Qu (2011). They are also a way of conducting qualitative data collection. By altering the way an interview is conducted different data can be collected. In Table 2.5 below, the three main ways to conduct an interview are described.

Table 2.5: Types of interviews, their characteristics, advantages, and disadvantages. Adapted from Dumay and Qu (2011).

Type of interview	Description	Advantages	Disadvantages
Structured interview	Predetermined questions, no deviations, and questions with predetermined answers	Quantifiable data, comparable results and questions will be answered	No further exploration of other areas of interest might miss important information
Semi-structured interview	Predetermined questions, deviations are allowed, mix between open and closed questions	Mix between quantifiable answers and elaborations	Quantifiable data might be less reliant if interviews are not conducted in the same manner
Unstructured interview	Few predetermined questions, open questions and exploratory	Flexible, can choose to ask interviewees to elaborate interesting points, chance to find new areas of interest	Not quantifiable, less in-depth knowledge and results are not comparable

As described by Dumay and Qu (2011), with a structured interview, the similarities in answers make it easy to generalize around the interviews and draw quantifiable conclusions. However, if the interviewee is not allowed to elaborate on their answers much information and nuance can be lost. According to the same authors, the advantage of semi-structured interviews is the flexibility in questions asked, using both predetermined questions with set answers but also open-ended questions. Also, the ability to follow up on answers with new questions is an advantage of this interview form. Unstructured interviews have the advantages of being exploratory and can lead to answers and new areas not expected. However, it can be hard to keep to the subject at hand with this kind of interview and also to compare answers from different interviewees, per Dumay and Qu (2011).

Conducting the interviews

According to Höst et al. (2006), an interview should be divided into four phases: *Context*, *initial questions*, *main questions*, and *summary*. The context is for the interviewee, so they know why the interview is conducted and why they are chosen to be interviewed. The initial questions should be general and be used for the interviewer to put the interviewee in the context of the interview and to get the conversation started. The main questions should be asked in a logical order which feels natural for the interviewee. The summary should be used to summarize the answers and give the opportunity for the interviewee to add anything they think is missing (Höst et al., 2006).

For this thesis, unstructured interviews were chosen as the type of interview. This, to gain a deeper understanding of the processes the interviewees handle and work in. This was followed up by a survey, resembling a structured interview with predefined questions. The interviews were conducted online through video calls at Microsoft (MS) Teams, due to the COVID-19 pandemic. Nine people were approached and asked if they wanted to participate in the interviews, and all of them accepted. Eight of those have positions at IM and the ninth at VGTO. Some of the interviewees had a more operative role, and others a more tactical or strategic role. The interviewees were chosen to get a holistic picture of the digitalization at IM. The interviewees with an operative role provided a picture of the current situation, and in which areas there are room for improvements. The persons on a strategic or tactical level, often within the IT department, provided a picture of the work of change within digitalization, and reasons for the current situation. All interviews conducted followed an unstructured approach. This, as the objective was to discuss the digitalization situation in general, and not specifics of it, as of now. All interviews were recorded and written down, to ensure nothing was disregarded and to provide opportunities for relistening of the interviews. A list of the interviewees, with their position, department, and date of interview, can be found in Table 2.6.

Table 2.6: List of interviewees by position, department, and date of interview.

Interviewee	Position	Department	Date
Interviewee A	Volume and capacity manager	S&OP	2021-02-15
Interviewee B	VP Digitalization and IT	Digitalization and IT	2021-02-16
Interviewee C	Logistics coordinator	Order and delivery	2021-02-16
Interviewee D	Senior project manager	Digitalization and IT	2021-02-19
Interviewee E	Logistics coordinator	Order and delivery	2021-02-22
Interviewee F	Business solution portfolio manager	Digitalization and IT	2021-02-23
Interviewee G	Logistics development and project manager	Logistics	2021-02-23
Interviewee H	Connected supply chain senior developer (VGTO)	Production logistics	2021-02-19/2021-02-25
Interviewee I	Logistics development and project manager	Logistics	2021-03-05

Verification workshop

To verify the conclusions from the case study and the literature review two verification workshops were held with the interviewees nine weeks after the initial interviews were held. This to give the authors of this thesis valuable feedback on the conclusions developed based on their interviews, but also to ensure the key concepts developed by the authors could be agreed upon by the interviewees. The idea with the workshops was that if the discussions held during the workshops resulted in consensus between the participants, the information used from the interviews could be seen as truths, at least from an employee perspective. Also, the expectation was input in the workshops could improve the ideas to solutions developed. All eight interviewees working at IM were approached and asked if they wanted to participate in the workshops, and seven interviewees chose to participate. The workshops were recorded, to ensure higher internal validity. In Table 2.7, date and participants in each workshop are listed.

Table 2.7: Date and participants for each workshop.

Workshop	Date	Participants
Workshop A	2021-05-06	Interviewee A, Interviewee B, Interviewee C, Interviewee G
Workshop B	2021-05-07	Interviewee D, Interviewee E, Interviewee F

2.4.2 Empirical observations

To study a phenomenon, observations is a viable method, according to (Höst et al., 2006). The same authors also emphasize the type of observational research performed mainly depends on two variables. The first variable discussed by them is the level of interaction with the observed process and the second one is how aware the observed party is of the study. When conducting observations, Höst et al. (2006) conclude it is important to notice a known observer might alter the work of the process observed but a hidden observer might pose ethical questions.

For this master thesis, it would have been beneficial to be able to have some empirical observations through field visits to IM plants and by being able to do much work at the office site where most of the processes examined take place. However, this was not possible to perform in a secure, practical way due to the COVID-19 pandemic. Instead, all the information planned to be collected in this manner instead had to be gathered by interviews and internal Volvo documents.

2.4.3 Literature review

According to Höst et al. (2006), a well-conducted literature review is key for successful research work. Apart from belonging to good scientific practice, a literature review gives the authors extensive knowledge about the field studied. As described by Rowley and Slack (2004), this knowledge will in its turn ensure the research conducted builds on existing knowledge and does not repeat what is already known. Further, they highlight the fact a literature review with well-documented references also increases the reliability of the research conducted, as the knowledge it is built on is made available for reviewing.

As Höst et al. (2006) notes, the literature review is an iterative process. In the start, it is used to get deep knowledge of the area. This knowledge will be used while starting the data collection to find suitable delimitations and questions to be answered. Höst et al. (2006) describes how this leads to a further literature review, this time with a smaller scope but with a deeper understanding. To conduct a literature review it must be decided what sources of information are suitable and reliable. Scientifically reviewed sources are peer-reviewed and can, most of the time, be trusted. However, when included in research, the author must always evaluate how suitable and reliable the source is (Höst et al., 2006). Rowley and Slack (2004) discusses other factors to consider when deciding on whether certain literature is suitable or not are the age of the article, which publisher, and how cited the work is. The relevant literature is often retrieved through university databases or search engines, as noted by Rowley and Slack (2004). Through keywords or topic search in databases or search engines, the relevant literature in the field can be found.

According to Rowley and Slack (2004), articles other than those from scientific journals might be of interest, especially coming fields regarding business and management where articles from the industry can be important. Even though these kinds of articles can be a compliment to the literature review, the core of articles cited should come from peer-review academic sources. This is, according to Rowley and Slack (2004), due to their rigorous fact-checking and scientific methodology. Further, they clarify there are a few different methods to use when searching for literature suggested. The two most relevant for this master thesis are listed in Table 2.8.

Table 2.8: Two methods for literature review. From Rowley and Slack (2004).

Method	**Description**
Citation pearl growing	In this method, the authors start from a small number of articles and use relevant keywords within these to search for new articles.
Successive fraction	Reducing a large set of articles by continuously introducing new sub-keywords. Exclude material by searching within them.

According to Rowley and Slack (2004), both methods can be used to find relevant literature in an effective way. The *citation pearl growing method* has more flexibility, as more literature can be added as desired. However, it does come with the drawback increasing keywords can lead the researcher into a “rabbit hole” of information. The *successive fraction method* is easier to navigate in since there is a set amount of literature, to begin with. Rowley and Slack (2004) do however note that this method require more prior knowledge on the subject in order, to begin with a relevant set of literature.

For structuring and understanding the literature collected, Rowley and Slack (2004) propose using a conceptual mind map. This mind map should show what concepts and topics are being studied and the relationships between these. The conceptual mind map can help with developing new keywords for literature search, as well as getting an overview of the literature being studied.

When writing the literature review, a relevant distillation of the key concepts of the literature collected should be stated in a concise way. This distillation should also be true to the literature's original meaning, according to Rowley and Slack (2004). When writing this thesis, citation *pearl growing method* was used to find relevant literature. The first search for literature was performed with the keywords *digitalization*, *supply chain*, *Industry 4.0* and, *automotive*. From the relevant articles found through this search, more relevant literature was found through these articles' keywords and the articles referenced.

2.4.4 Survey

A survey is described by Höst et al. (2006) as a structured interview, with predefined questions and often predetermined answers as yes or no, or on a numeric scale. The participants submit their answers themselves and then return the survey. How the sample of persons when surveying is selected is of great importance for the reliability of the survey. When surveying a small group, it is possible to ask everyone to participate, however, if the group is large some kind of sampling needs to be done. When sampling from a group, it is according to Höst et al. (2006) important to make sure the sampling does not affect the outcome of the survey. Therefore, it is important to either ask everyone in the group to participate or randomize the sampling of chosen participants.

The survey conducted in this master thesis contained questions about the topics deemed most important from the interviews. The idea was to validate and understand whether these topics were as important as described in the interviews. Also, in the survey, other IM employees than the interviewees had an opportunity to elaborate and submit their opinions on this topic. The survey was distributed to 25 IM employees and 14 of these answered. These 25 persons constitutes the group working with logistics or digitalization within IM. This means the survey conducted did not do any sampling within the group deemed relevant for the survey.

The survey consisted of 12 questions on overall *digitalization*, *resources*, *competencies*, *managerial commitment*, *data availability*, *visualization*, *visibility*, *system integration*, and *change management*. Of the 14 IM employees answering the survey, five considered their position being best described as *operational*, five as *manager*, two as *project leader*, and two considered themselves doing *administrative work*. The survey was distributed by email 2021-04-12, and answers were collected until 2021-04-23. The questions and full answers of the survey can be found in Appendix B.

2.4.5 Documents

Internal documents of the case organization studied can, according to Yin (2018), be of relevance when conducting studies. It should however be noted internal documents can be biased. Internal documentation often describes an ideal picture of the organization, as Yin (2018) notes. In this thesis, documentation was used to validate and back up statements from the interview, documents were also used to get an overview of systems used and how processes were supposed to function.

2.4.6 Archival records

Höst et al. (2006) describes archival records as data previously collected for another purpose than that of the current research. Archival data can be a great source of material, but caution has to be taken when using it since there are limited possibilities of validation of the data, according. Höst et al. (2006) also note the importance of knowing for what purpose the data was collected. This, to be able to evaluate if the data is relevant and whether the information is up to date with the latest version of collection methods. If all these factors are known, then archival records can be great sources of information. In this case study, no archival records were used due to limited relevancy for the thesis subject. Archival records are most suitable when conducting quantitative analysis to get historical data on the area studied (Höst et al., 2006). For this qualitative research data from archival records were deemed both irrelevant and unreliable.

2.5 Method of analysis

When Silverman (2013) describes conducting qualitative research, the analysis is often conducted as the data is collected. As the qualitative data often is more readily comprehensible than quantifiable data, the analysis of the data might overlap with theory and data collection. When starting to analyze qualitative data, it is, according to Silverman (2013), important to acknowledge its shortcomings in standardization and conformity, but also the strengths in data collected by many different means. Silverman (2013) discusses the fact that company documents, interviews, and surveys might all describe the same phenomenon but may all provide different perspectives. Each piece of the data collected then needs to be extracted to make it ready for analysis. This means the data need to be reduced of any cultural or personal context possibly present, thus making the data collected as objective as possible.

Further, Silverman (2013) describes most researchers on the subject propose coding as a viable method of sorting and analyzing qualitative data. Coding is by the same author described as the process of categorizing data in a way where it is easy to distinguish which subjects different data sources contain. This can be done with various computer aids or by color-coding if most of the material is physical. The coding helps with finding larger themes in the data collected and by doing coding, it will be easier to find which themes are most important and how different themes belong together. These themes often already begin to develop as the data is collected. When relationships between themes and patterns have been identified a model can be developed, as noted by Silverman (2013). This should be an iterative process where the model should be constantly tested against new data collected.

An example of this iterative process can be thematic analysis, which is one of the most common types of qualitative analysis. It uses identified themes in the data collected to build a theoretical model. Thematic analysis often follows a six-step process designed by Braun and Clarke (2006). In Table 2.9 below, these six steps are presented and explained.

Table 2.9: The six steps of thematic analysis. From Braun and Clarke (2006).

Step	Description
1. Familiarization with data	Get a deep and broad understanding of the data collected.
2. Coding	A form categorization of the data for future theme-building.
3. Theme searching	Identify and sort the different coding into larger themes. Here connections between different codes should be identified to start to understand how the data is related.
4. Theme validation	Reviewing the coding and themes to see if the themes identified correspond with the data.
5. Defining and naming themes	To define the themes, they need to be named and what is interesting about them needs to be defined.
6. Writing	Selection of the most meaningful themes, which contributes towards the purpose of the research conducted.

It should be noted, Braun and Clarke (2006) emphasize these steps should be seen as an iterative and recursive process and steps will be revisited as the research progresses. When writing this thesis, mainly qualitative data was collected and analyzed. The data from interviews, documents, and observations were all considered when themes were developed. When data had been collected and themes had been developed, a synthesis of the data was performed. In the synthesis, all the empirical data collected was assembled to illustrate how the unit of analysis functions. These themes, together with this synthesized picture, were then developed into the solutions presented in Chapter 5. The themes identified were verified multiple times by the quantitative survey and the workshops performed with the interviewees. The empirical data collected, as well as the theory presented in the literature review and what its implications for IM's digitalization are analyzed in Chapter 5 as well. This facilitates the identification the characteristics of IM's supply chain, and the characteristics of a digitalized supply chain. These concepts and characteristics were then analyzed in relation to each other, which is presented in Section 5.3. Further, the empirical data collected in the case study was analyzed and evaluated through the *Industrie 4.0 maturity index*, developed by Schuh et al. (2020). This index provided opportunities to quantitatively analyze and assess the digitalization of IM. Altogether, this analysis supported the identification and development of the critical success factors identified for IM's future digitalization.

2.6 Research quality

Yin (2018) presents four criteria for evaluating the quality of the research design are presented when performing case study research. To support the evaluation of the performance on these criteria, there is a detailed description of the criteria. The four criteria presented by Yin (2018) are *construct validity*, *internal validity*, *external validity*, and *reliability*. Using the criteria correctly and ensuring the research is "trustworthy, credible, confirmable and data dependable" will ensure high research quality throughout the process. The importance of research quality for having a high research process trustworthiness is further emphasized by Björklund and Paulsson (2003). A summary of criteria for the research quality and measures taken to ensure research quality can be found in Section 2.6.5.

2.6.1 Construct validity

Construct validity can be described as how well the research conducted measures what was intended to be measured (Björklund & Paulsson, 2003). According to Yin (2018), this area concerns what is measured and analyzed in the case study, and its relevance. To ensure high construct validity, researchers must be specific in their definition of what is the subject of the research, and how this and the specific method of data collection does reflect the reality of the subject researched. The validity of research can according to Yin (2018) be increased by ensuring the measurements and results of the research correspond to theory. Having multiple sources of theoretical evidence is also beneficial for the construct validity. Other methods to ensure construct validity presented by Yin (2018) include having multiple sources of evidence, establishing a chain of evidence, and letting persons involved in the data collection review the results. Another method for increasing construct validity is triangulation, according to Björklund and Paulsson (2003). Triangulation can be achieved by having multiple sources of data, multiple persons evaluating the results, or using multiple scientific theories supporting the analysis. Triangulation could also mean using multiple research methods on the same object of study. In the case of construct validity, triangulation should be used for retrieving different perspectives on the results, which can improve the overall research quality (Denzin & Lincoln, 2005). Triangulation by using different perspectives on the same research object is illustrated in Figure 2.6.

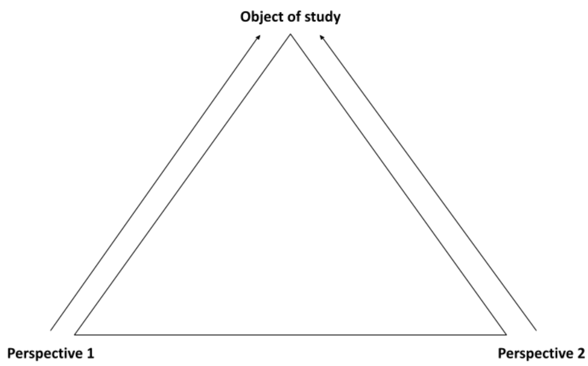

Figure 2.6: Triangulation. Adapted from Björklund and Paulsson (2012, p. 76).

Also, known insufficiencies in research quality should be accounted for, to strengthen construct validity (Yin, 2018). In this master thesis, interviews with people in various positions in the IM organization were interviewed. The results from the interview were supplemented with qualitative and quantitative data from the survey performed, as well as verification workshops for validating, verifying and securing the quality of results, analysis, and solutions.

2.6.2 Internal validity

To achieve internal validity in research, Björklund and Paulsson (2003) explains one's own opinions and perceptions must be disregarded, and the data collected should speak for itself. Internal validity can, according to them, be increased by the authors by being open about what motivations and influences are present in the context of the research. When describing a phenomenon, expressions with inherent value should be avoided and data should be collected without any presumptive ideas of the outcome. Yin (2018) describes that problems with internal validity could relate to the causality in the case studies, as some results being the results of unknown or disregarded factors. However, according to the same author, this is more relevant for explanatory studies rather than descriptive or exploratory. The other main issue related to internal validity described is the inference occurring when it is not possible to make direct observations, creating problems with interviews among other methods for data collection. To mitigate risks of compromising the internal validity, the researchers should do pattern matching, explanation building, and addressing alternative or confronting explanations, according to Yin (2018). To strengthen the internal validity in this thesis, the interviews performed have been recorded and verified by a survey and workshops with the interviewees. This to further validate the results from the interviews. The interviews were conducted by two persons, further increasing the validation of results. Furthermore, the interviews were conducted with persons in different positions and on different hierarchical levels throughout the division to ensure higher internal validity of the data collected.

2.6.3 External validity

Yin (2018) describes this criterion concerns to which extent the results and conclusions have external validity, i.e. to which extent they can be generalized and used outside the case study. The same author highlights this is a general issue in all case studies, and is an issue especially present in single-case studies, as this one. However, with other case studies on similar themes, it may be possible to retrieve more general conclusions on digitalization in manufacturing supply chains. Important measures to strengthen the external validity discussed by Yin (2018), are to use theory to support the case studies. With theory supporting the case study, the possibilities to get generalizable conclusions increases. Using support in theory is the single most important action taken in this thesis to ensure external validity. Another test for external validity is to be able to replicate the research and get similar results, although this is mainly relevant for multiple case studies, according to Yin (2018). Here, a cross-case analysis may be a viable solution for having high external validity (Eisenhardt, 1989). Also essential is to set a rigorous case context and have valid arguments for the selection of case study (Cook & Campbell, 1979). In this research study, external validity was strengthened by reinforcing the case study with theory to as high extent as possible. By doing so, the expectation is the research can provide some conclusions possible to generalize and use when discussing and evaluating other manufacturing supply chains, in a somewhat broader context.

2.6.4 Reliability

According to Björklund and Paulsson (2003), the reliability refers to how well-established the conducted research is. With an understanding of the theory surrounding the subject, large enough samples of data, and sources of information the research conducted can be said to be reliable. Another criterion for research to be considered reliable, described by Björklund and Paulsson (2003), is the ability to recreate the research with the same result. Also, triangulation can strengthen reliability by having several perspectives, as multiple persons evaluating the research results. Yin (2018) describes that it should be obvious other researchers could conduct the same case study and get the same results and conclusions. Yin (2018) and Björklund and Paulsson (2003) emphasize that with high reliability, there are fewer possibilities of how erroneous or biased the study is. Therefore, documentation of how the case study was conducted is important for having high reliability. Every procedure in the case study should be documented, how it was conducted, and the results retrieved (Yin, 2018). Other ways of increasing reliability are by being transparent on how the research has been conducted and asking peers to review the data collected (Björklund & Paulsson, 2003). In this master thesis, measures taken for increasing reliability include having a rigorous review of how the study was carried out (interviews, survey, workshop). The results from the case study are documented in the text, with more detailed results possible to find in the appendix of the thesis. Furthermore, through peer reviews and discussions with peers about the content and procedures of the research work, reliability was increased. For instance, the thesis work was peer reviewed before and during a half time seminar held 2021-03-30.

2.6.5 Summary of research quality

A summary of the criteria used for securing high research quality and which measures have been taken in this master thesis work are listed in Table 2.10 below. As Gibbert et al. (2008) emphasize, the criteria for research quality do not function independently. For instance, the same measures could strengthen all types of validity.

Table 2.10: Criteria for research quality, and measures taken for ensuring this. Adapted from Yin (2018).

Criterion	Measures taken
Construct validity	• Using multiple sources of evidence (interviews, documents, survey) for evaluating digitalization at IM • Results verified in workshop, where interviewees had opportunities to review results and conclusions • Interviews conducted with persons in various positions in the case company
Internal validity	• Interviews conducted with persons in various positions in the case company, on different hierarchical levels • Results verified in workshops • Interviews performed by two persons • Interviews recorded
External validity	• Basing the case study, results, and conclusions on theory to as high extent as possible • Reporting relevant theory in the report (literature review) • Setting a rigorous context for the case (purpose, research questions) and case company selected
Reliability	• Documenting the process • Documenting the results • Listing the interview guide, survey questions and answers in the appendix • Performing peer reviews, having discussions with peers

3 LITERATURE REVIEW

In the literature review, relevant theories on digitalization, supply chain management, change management, and IT organization structure are presented and analyzed. The purpose of this chapter is to present relevant theory on the subjects of this master thesis and provide the necessary theoretical background for conducting the research work and achieving the purpose of the thesis.

3.1 Background

To be able to answer the research questions and ultimately achieve the purpose of this thesis, an extensive literature review was conducted. Volvo is a global manufacturing company, and the purpose of the thesis is to find which strategies they should use to further digitalize their international manufacturing supply chain. Therefore, several different topics were researched and presented in this review. The literature review conducted was based on keywords such as *supply chain digitalization*, *Industry 4.0*, *KD manufacturing*, *digitalization*, *change management*, *supply chain integration*, etc. From these keywords, appropriate literature was found, and from these sources, a new list of keywords was developed, and more relevant literature was added to the list. This literature was then summarized and used for developing the literature review. The topics highlighted in this chapter were all deemed relevant for reaching the purpose of this thesis. The topics are ordered to first give the reader a brief introduction on supply chain management, KD manufacturing, and digitalization and thereafter provide a deeper insights in the topics relevant for this particular study.

3.2 Digitalization and Industry 4.0

The concept of digitalization is by Schuh et al. (2020) described as wide and can be related to most processes where analog processes are exchanged for computerized processes. Digitalization has been present in most companies for decades and most organizations are currently using computers and information systems exclusively for operations and administrative work. According to Schuh et al. (2020), digitalization can be seen as a prerequisite for an organization to be able to enter the realm of Industry 4.0. To be able to implement the advanced technologies of Industry 4.0 and reap the benefits coming with them such as increased visibility and automation, an organization needs to be sufficiently digitalized. A sufficiently digitalized organization is both computerized and has a high degree of connectivity, as explained by Schuh et al. (2020). Most companies are, as mentioned earlier, computerized today. However, they describe many companies struggle with connectivity, referring to how manufacturing equipment is connected to information systems and how well information systems are integrated and connected.

Industry 4.0 is a term describing a connected and digitally integrated industry, according to Galati and Bigliardi (2019). They explain the term implies the technologies and process changes manufacturing companies have started to implement is thought to be as groundbreaking as the three earlier industrial revolutions. Galati and Bigliardi (2019) describe how the first industrial revolution introduced mechanical production plants and made it possible to manufacture products using water and steam. The second industrial revolution introduced plants of mass production, using electrical energy for instance. The third industrial revolution brought automation and robotics to shop floors, using connectivity and computation. This development is illustrated below, in Figure 3.1.

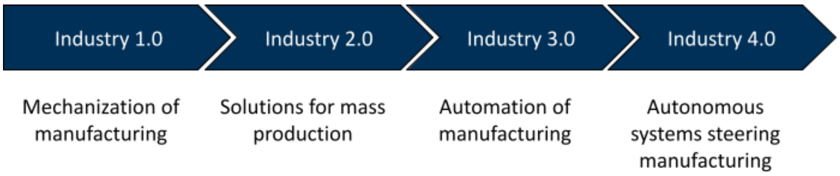

Figure 3.1: The evolution of the manufacturing industry. Adapted from Yin et al. (2018).

3.2.1 Technologies

According to McKinsey & Co (2015), technical advancements in the manufacturing industry are currently driven by the trend of relocating manufacturing from low-cost countries closer to the end consumer. This move is due to increasing wages for workers, and increasing shipping costs. It is also driven by the need for more responsive supply chains with a shorter time to market for new products. This change has, per McKinsey & Co (2015), kick-started a move towards new technologies. Due to the cost savings previously made by manufacturing in low-cost countries is decreasing. Using several identified disruptive technologies, McKinsey & Co (2015) expresses the belief Industry 4.0 will be the next primary cost saver. This, mainly through process optimization. Hofmann and Rüsch (2017) discuss four key concepts regarding the technologies of Industry 4.0. These technologies are listed in Table 3.1.

Table 3.1: Four key technologies of Industry 4.0. Adapted from Hofmann and Rüsch (2017).

Technology	**Description**
Cyber-physical system (CPS)	The concept of physical and computational processes becoming more intervening. Computational systems affecting shop floor actions and vice versa. Systems using this effectively and in a standardized way are called CPSs. These systems offer more visibility, control, and data collection.
Internet of things (IoT)	Smart, connected components or products offering the possibility of automatic communication between each other. The factor differentiating the IoT from the conventional internet is that in the IoT, products are communicating with each other. Also, the IoT consists of much physically smaller nodes and a higher number of nodes.
Internet of Services (IoS)	Similar to IoT. The main difference is instead IoS is the internet of services. Automatic analysis tools, cloud-based ERP (enterprise resource planning) systems, and other information systems are a few examples of what IoS are.
Smart factories	The idea of building factory floors around the three concepts above. In a smart factory, products find their own way through the production processes with the help of IoT, IoS, and CPS. Visibility is high throughout the whole process and computers or operators can influence their way through the processes independently, should the need arise.

3.2.2 Potential benefits

Hofmann and Rüsch (2017) also discuss some potential benefits of implementing these technologies.

- Optimization: Altogether, most literature reviewed suggests Industry 4.0 is a concept comprising a set of technologies that, while not necessarily being new, now is mature enough to be implemented by most manufacturing companies. These technologies often include additive manufacturing, IoT, big data, and artificial intelligence (AI) and

McKinsey & Co (2015) and Hofmann and Rüsch (2017) agree these technologies will support companies optimizing their processes.

- Shop-floor operators: Hofmann and Rüsch (2017) and Li et al. (2019) discuss the implications of Industry 4.0 on shop floor workers. The articles discuss the concept of shop floor operators becoming more skilled problem solvers, rather than actual operators. Li et al. (2019) describes how the term Operator 4.0 is used regarding a highly skilled problem-solver, aided by various digital solutions. These digital solutions could be control systems and wearables, increasing the operator's ability to control the workflow of a highly automated shop floor. The role of the "Operator 4.0" is not to partake in the manufacturing process, but rather be a decision-maker and a problem solver aided by these various systems and the IoT nodes in place.
- Responsiveness and time to market: McKinsey & Co (2015) and Galati and Bigliardi (2019) stress how important responsiveness is becoming for manufacturing companies. Being able to quickly adapt to changes in demand is regarded to be a key concept of how to succeed. McKinsey & Co (2015) also discusses the importance of decreasing the time to market for products in an environment where margins are ever decreasing. By McKinsey & Co (2015), time to market is considered as one of the most important value drivers for Industry 4.0. Big data analytics and additive manufacturing can both enable time to market reduction. Big data analytics can also be used to understand customer and demand patterns. This, to identify needs, or even predict future needs. By implementing solutions of additive manufacturing, the supply chains will be capable of having production closer to the end customer, and even access markets that were not lucrative before (Hofmann & Rüsch, 2017; McKinsey & Co, 2015).

In Table 3.2, potential benefits are linked to each technology concept.

Table 3.2: Technology concepts and their benefits for manufacturers. From Hofmann and Rüsch (2017).

Technology concept	**Benefits**
CPS	Optimization, Operator 4.0, responsiveness
IoT	Optimization, Operator 4.0
IoS	Optimization, responsiveness
Smart factories	Optimization, Operator 4.0, responsiveness

3.2.3 Challenges and gatekeepers

Thoben et al. (2017) presents issues with researching Industry 4.0. Much of the same concepts presented above are discussed, regarding what technologies and benefits Industry 4.0 bring. However, Thoben et al. (2017) point out there are some problems rarely accounted for following the entrance of Industry 4.0. One of the main problems is the lack of standards in the global economy for digitalization, which makes it hard to draw general conclusions from the shift. This may also become a problem for interoperability within and between companies, as modern manufacturing systems often have a complex nature. Data analytics is also an important issue discussed by Thoben et al. (2017), where the technology for visualization is not always up to date with the data collection technology, leading to information discrepancies. This is a problem related both to data collection and visualization. Another issue presented by the same authors is data security, as companies may be subject to hacking attacks. Data quality is another problem that needs to be attended, to maintain a smart manufacturing process. Other problems with the transition into Industry 4.0 mentioned by Thoben et al. (2017) are having sufficient engineering knowledge and data privacy issues.

Moeuf et al. (2020) identifies some risks for organizations trying to implement Industry 4.0 technology. These are the lack of the right knowledge, too much focus on short-term strategy, and the fear of the employee's views of Industry 4.0 technologies as surveillance. Gatekeepers for transitioning into Industry 4.0 were found by the same authors to be employee training, lack of communication, strategy problems, and communication issues between managers.

3.3 Supply chain management

Supply chain management is a term that includes the strategy and governance of a supply chain (Mentzer et al., 2001). A supply chain can be defined as *"a set of three or more entities (organizations or individuals) directly involved in the upstream and downstream flows of products, services, finances, and/or information from a source to a customer"* (Mentzer et al., 2001, p. 4). This means supply chain management is viewed by the same authors to be the cooperation of three or more interlinked companies, who share and coordinate information, objectives, and rewards, with the aim of reducing costs and adding value to customers, and gaining competitive advantages. To do this the companies must have the following towards the supply chain: "trust, commitment, interdependence, organizational compatibility, vision, key processes, leader, top management support" (Mentzer et al., 2001). This enables a functioning supply chain management process. Seven activities are listed below in Table 3.3 as making up supply chain management.

Table 3.3: SCM activities. From Mentzer et al. (2001, p. 8).

1. Integrated behaviour
2. Mutually sharing information
3. Mutually sharing risks and rewards
4. Cooperation
5. The same goal and the same focus on serving customers
6. Integration of processes
7. Partners to build and maintain long-term relationships

The scope of supply chain management is both functional and organizational, according to Mentzer et al. (2001). The functional scope of supply chain management considers the material flow, from point of purchase to point of sale, according to the same authors. This includes the entire operations part of the involved actors. The organizational scope is regarded as the holistic value-adding activities coming with the supply chain.

To understand supply chain management, one must be able to both see the entire chain, but also its parts, according to Mentzer et al. (2001). The relationship between the different actors in the supply chain is important for how to manage a supply chain, and this through activities illustrated in Table 3.3. Altogether, supply chain management means knowing the supply chain you manage. This includes the activities and flows to and from the actors in the supply chain, as the understanding and management of the interaction and coordination between them make up an important part of supply chain management, along the lines of Mentzer et al. (2001).

Further, they describe coordination and theoretical frameworks as crucial for the supply chain to maximize its full potential and support them reduce costs and add value.

3.3.1 Digitalization and Industry 4.0 in supply chains

For supply chains, the move towards Industry 4.0 means changing the entire organization, according to Sanders and Swink (2019). In this movement, data collection, analysis, and IoT are key concepts. However, the way forward differs a bit from the approach for e.g., manufacturing processes. By the same authors, the "digital supply chain" is described, and its main opportunities, challenges, and enablers. Also described, is how companies and supply chains should act going forward, to seize the digital improvement opportunities present. Three major trends supporting the overall digital supply chain transformation are also identified by Sanders and Swink (2019). These are presented in Table 3.4.

Table 3.4: Trends supporting digital transformation in supply chains. From Sanders and Swink (2019).

Technology trend	**Description**
Big data	Generated in the entire supply chain and makes it possible for real-time systems to exist. Supports RFID and ERP systems.
Advances in robotics	Facilitates the automation of processes, with recent improvements in both software and hardware. Through advances in robotics, automation gets cheaper and more adaptable to a supply chain's demands.
Advances in computing	More data can be analyzed and processed, and there are enormous opportunities for storage, retrieval, sharing. This is also less expensive and faster than it has been before.

Most supply chains acknowledge there is an ongoing digital revolution, with the industries transferring into the 4.0 versions of themselves, according to Sanders and Swink (2019). However, there is not widespread knowledge on how to utilize this industrial revolution, and there are several questions regarding digitalization strategy. The most important trait of a digitalized supply chain is its ability to "sense, analyze, predict and respond to changes", and to do this "quickly, accurately and specifically" from the entire supply chain (Sanders & Swink, 2019). In Table 3.5 below, the core attributes for a digital supply chain are described.

Table 3.5: Core attributes for a digital supply chain. From Sanders and Swink (2019).

Attribute	**Characteristics**
Digitized	The supply chain has access to reliable and complete data, quickly. All processes should be built on data, and the data should be the foundation of the digital strategy.
Connected	The entire supply chain should be connected, and the data should be distributed without *media breaks*. It should be possible to communicate with suppliers and customers, and access supply chain information centrally.
Intelligent	The supply chain should not only produce a large amount of data, but also provide key takeaways and prevent breakdowns, plan maintenance, etc.
Adaptive	From the insights, the supply chain should adapt and change to improve and maximize its performance. This should be done both short-term, but also in a longer time perspective.

In short, the data should be correct and received at the right time, it should be continuously communicated, provide insights, and adjust the operations according to these insights (Sanders & Swink, 2019).

3.3.2 Key digitalization concepts

In the light of what subjects are most prominent in the literature studied and in relation to what technologies are deemed most relevant for this master thesis' purpose, four key digitalization concepts have been identified.

Big data
There are many definitions of big data. In some research done, the concept has been defined by three Vs: "volume", "velocity", and "variety". Other Vs are sometimes added, as in Fosso Wamba et al. (2015) where it is argued "value" and "veracity" also should be part of the defining Vs. Other research defines big data by concepts as technology, analysis, and mythology (Boyd & Crawford, 2012). However, it is stated the five Vs is a viable way to define, understand and measure the process of using big data (Fosso Wamba et al., 2015).

The overall concept of big data is driven by more and more connected devices, IoT nodes, radio-frequency identification (RFID), and similar technologies being utilized. In Fosso Wamba et al. (2015), it is highlighted that utilization of big data can add business value and improve information sharing. This is useful in today's supply chains. Also, big data utilization can facilitate coordination, planning, and making smarter business decisions as well as provide many administrative benefits. This could be increased capabilities for measuring, supervising, and reporting. However, to achieve these benefits, a functioning digital infrastructure and strategy are needed, according to Fosso Wamba et al. (2015). This, as outdated systems may prevent the transition to the use of big data to proceed smoothly. Management support and buy-in from the staff are also important as in all corporate transitions. In the case discussed in Fosso Wamba et al. (2015), it is clear the use of big data can improve decision making and real-time planning. Overall, with the right use of these technologies, companies can benefit heavily from them.

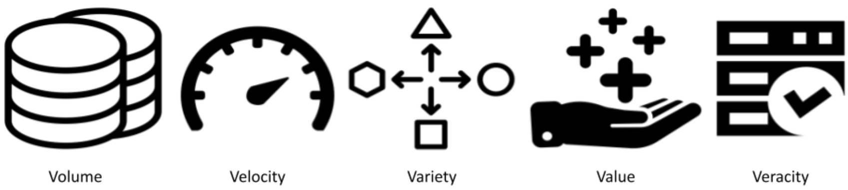

Figure 3.2: The five V:s of big data. Adapted from Fosso Wamba et al. (2015).

Automation
McKinsey & Co (2015) describes how the automation of manufacturing tasks has been an ongoing process during the last decades, mainly through the development of various precision manufacturing tools such as robotic arms and lately additive manufacturing technology. Automation is, according to McKinsey & Co (2015), something widely seen as a cost-saver since precision tools do not need as many operators and use far fewer resources than previous methods of manufacturing. This kind of automation is not necessarily part of further digitalization. However, with further digitalization and the introduction of Industry 4.0 into manufacturing companies, the desire and need to automate processes not belonging to the manufacturing process is growing, per the same author.

When discussing the automation of simple tasks performed by office workers or machine operators, the concept of Robotic Process Automation (RPA) is a common topic, as described by van der Aalst et al. (2018). RPA, or software robots, is the concept of taking a simple task and automating it by using applications interacting with the processes in place in the same ways as humans would (van der Aalst et al., 2018). In information systems, this is often used to replace manual data transfers between systems without connecting the two systems in the traditional manner, meaning connecting the back-end of the systems using data interfaces and connected databases (Hofmann et al., 2020). Instead, the RPA application transfers data the same way a human would, by submitting it in the front-end interface, which reduces tedious and unnecessary labor and reduces the risk for errors, as per Hofmann et al. (2020).

RPA is, according to Hofmann et al. (2020), a relatively inexpensive and efficient way to increase system integration, connectivity, and automation in an organization's information systems. However, RPA should not be seen as a solution to all sorts of system integration and connectivity. Here, the same authors emphasize the complex system communication with high volumes should be using robust back-end integration to avoid problems when systems are updated and to use the effectiveness of back-end data transfers fully.

Rather, RPA applications should be used to replace repetitive simple tasks humans perform, according to Willcocks et al. (2015). This could, according to them, be manual data transfers, repetitive reporting, data analysis, data collection and preprocessing for more complex analysis, or any other area where the task performed is repetitive. As further described by Willcocks et al. (2015), RPA applications can be implemented by anyone having the skill to do so. This, since RPA applications sit on top of the systems and do not disturb the logic or the processes the system performs. The kind of automation coming with RPA and other process automation is considered to be part of the digitalization effort, or at least an enabler for digitalization, as per Hofmann et al. (2020)

Visibility

At its core supply chain visibility is just the notion a supply chain will be more efficient if information about its processes is known, according to McIntire (2014). McIntire (2014) describes how supply chain information contains competitive advantages which, if identified and used correctly, together with other concepts and technologies, can be deployed to increase efficiency and profitability. The overall objective with visibility is end-to-end visibility, where all information of the processes and operations in a system is always available. This could be geographical positions of goods, inventory levels, process lead times, manufacturing speeds, etc. By having all this information, it should, according to McIntire (2014), be possible to perform analysis on the data to optimize or develop the processes further. Further, it is explained supply chain visibility requires a high degree of connectivity and integration in the systems supporting the supply chain. The relationship between IT, connectivity, and supply chain visibility are illustrated in Figure 3.3.

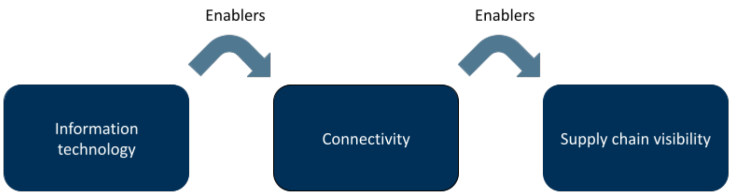

Figure 3.3: The relationship between IT, connectivity, and supply chain visibility. Adapted from McIntire (2014).

McIntire (2014) breaks down visibility into four steps: *capture data*, *integrate data*, *create intelligence* and *interrupt decisions*. Capture data is where physical process data enters an information system, such as when a delivery confirmation is reported. The delivery confirmation is then saved in a database with delivery confirmations from other customers and from other dates. This means the data is integrated with other data. When an analysis is done on delivery confirmations and it results in knowledge about how one customer always delivers late, intelligence is created. When deciding on penalizing or changing out the late customer, it is an example of the last step, deciding on the captured data. If these steps can be taken accurately on a majority of the data produced by a supply chain, it should be considered as having reached end-to-end visibility, per McIntire (2014).

Visualization

Without visualization, big data is described by Berinato (2016) as just values in a database. These values are something computers are good at handling, while humans are not. Big data makes it necessary for managers to know how to create useful visualizations. The sheer size and volume make it impossible to get an understanding of the data without visualization of it. Berinato (2016) discusses the role of good visualization. As an example, the author mentions every time aircraft manufacturer Boeing test flies their military aircraft Osprey, the sensors connected create a terabyte of data, which is a huge amount of data. Detecting anomalies in such a large amount of data, without visualization, would be tedious. Visualization is, according to Berinato (2016), also important even if the data is not purely quantitative. Complex processes such as workflows or how customers move through a store are also hard to grasp without having representation of it.

Berinato (2016) describes the recent technological advancements have resulted in affordable and easily accessible tools for visualizing data. This is beneficial for many companies, as large amounts of data are for the first time available to interpret for anyone. However, there are problems with this. One problem described by the same author is, as visualization of data is so easily accessible, visualizations are often done without contemplating what is meant to be shown. This may render the visualizations ineffective, or worse, counterproductive.

Discussed by Berinato (2016) are a set of rules for making functional visualizations, calling them visual grammar, which is useful in making visualizations easy to follow and correct. Concepts like how many colors can be used, what kind of chart should be used, or what dimensions should be used. Berinato (2016) acknowledges these rules are important while they are not representative of the whole picture. It is more important to know what kind of visualization is made and from this knowledge plan to find the best possible strategy for visualizing the data at hand.

There are two important questions to ask when starting a visualization project, according to Berinato (2016): *Is the information conceptual or data-driven?* and *am I declaring something or exploring something?* The first question is usually easy to answer, either qualitative data or quantitative is handled. This question answers what kind of data is at hand, but it is important this does not decide what method should be used. A line chart is not always the best choice for describing quantitative data. This is where the second question comes into place. It decides what is going to be done. Either communicate information (declarative) or try to figure something out (exploratory). The difference here is, as described by Berinato (2016), whether the visualization will be used to present the data or to understand the data. If financial numbers from the last quarter are going to be presented, the audience wants to see those numbers, not the data from last year. However, if the task is to explore why this quarter's sales are lower than last, then data from last year might be of value. Berinato (2016) uses a two-by-two diagram to visualize the decision of what kind of visualization should be used, which can be seen in Figure 3.4.

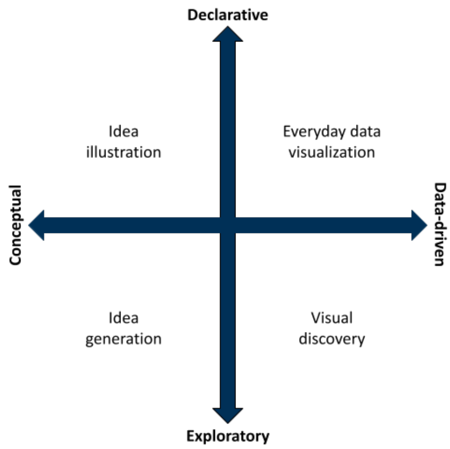

Figure 3.4: The different styles of visualization illustrated. From Berinato (2016).

Implications

Hofmann and Rüsch (2017) means the new technologies coming with Industry 4.0, in turn, will create two dimensions of the supply chain. The physical one and the digital one. The physical one will include autonomous transportation, connected manufacturing machines, etc. The digital one will be constituted by the decision systems controlling and analyzing the physical flows. According to Hofmann and Rüsch (2017), data will be collected by sensors at the physical nodes in the physical dimension and used for decision-making and analysis.

According to Sanders and Swink (2019), enabling technologies may include not only ERP systems but also advanced planning tools, which still are expensive in relation to the cost benefits. The most important takeaway is, however, the existing system should be linked to each other and business strategies, to utilize them fully. Sanders and Swink (2019) describe how companies differ a lot in which degree their supply chains are digitalized, but many of them feel as if they are lagging. A roadmap could facilitate digital development and should be based on the strategies and competencies of the supply chain's firms. Capabilities needed for enabling technology development are visibility, intelligence, efficiency and customer experience, agility, customization, and call-to-action. Challenges included are union contracts, finding skilled people, suppliers lacking technological capabilities, change fatigue, regulations, and siloed systems (Sanders & Swink, 2019).

3.3.3 Supply chain mapping

Supply chain mapping is according to Gardner and Cooper (2003) performed to visualize, track, and manage supply chains. There are many reasons for a company to map its supply chain. By Gardner and Cooper (2003), reasons why companies should map their supply chains are presented. Firstly, through mapping, it becomes easier to link the corporate strategy to the supply chain strategy. Secondly, a map is a way to collect and communicate essential information to key stakeholders in the supply chain. Thirdly, the map will constitute the base when redesigning and improving the supply chain. As further noted by the same authors, constructing the map will facilitate supply chain integration and give a more thorough understanding of it. Channel dynamics are put on display, the map is a tool for communication, and it becomes easier for new actors to orient themselves in the supply chain.

Further, Gardner and Cooper (2003), discusses how the mapping should be conducted. When mapping the supply chain, there is more focus on external orientation than internal (more process mapping), with a lower degree of details, and more strategic than tactical reasons for the mapping. When it comes to the orientation, the mapping focuses on information, goods, and money flows in the entire supply chain. The perspective of mapping should be high, with focus on volume, cost, or lead-time. Per the same authors, a sufficient map has standardized icons, includes a plan for dissemination, and can be tied to the strategy of the company/supply chain. The scope of the map could be product breadth, supply chain perspective, process view depth, or cycle view. Gardner and Cooper (2003) describe information density, live link to databases, and delivery mode may be implementation issues when starting to use the mapping. The same authors also note the design of supply chain maps can differ heavily from focusing on information and goods distribution, supply chain network, pictures of processes, projected on a geographical map, or a map where business processes are integrated into the geographical map, with the supply chain. The map can be designed from several dimensions: geometry (number of tiers, degree of aggregation, inclusion of explicit spatial relationships), perspective (scope, perspective, cyclic), and implementation issues (links, delivery modes). Included figures may be supply chain members, supply chain service providers, and different types of links.

The risks of mapping as described by Gardner and Cooper (2003) include giving away too much information, both to other supply chain members but also externally. A map could, according to them, also change the channel dynamics, and members could end up feeling like they are not as important as they believed they were. Also, there may be problems when deciding what to include when constructing the map, and which style the map should have.

3.3.4 Supply chain risk management

Norrman and Näslund (2016) explain that in today's business climate, every major supply chain must deal with risks. As the business climate has become more competitive over the years, many large companies have felt a need to have strategies for risk management. According to the same authors, supply chain risk management is regarded as very important by many companies, but most of these companies also feel their current risk management processes are not sufficient in the area. Further, Manuj and Mentzer (2008) discuss supply chain risk management on a global scale, and how companies should work for managing and mitigating these risks. They also compile relevant information and frameworks on supply chain risk management and provide a guide to this topic. In Table 3.6 different types of risks are listed.

Table 3.6: Types of supply chain risks. Based Manuj & Mentzer (2008).

Type of risk	Source
Supply risks	Disruptions or problems in the supplying part of the supply chain
Operational risks	Various breakdowns or malfunctions in the operation
Demand risks	Risks of problems stemming from the demand of one or several products, as variations in demand
Security risks	Risks regarding security as breaches, crime, IT security
Macro risks	Financial risks on a global scale
Policy risks	Global, regional, or local decision-makers changing policy, like sanctions or trade tariffs
Competitive risks	Unknown competitor behavior, new competitors
Resource risks	Lack of resources due to changing circumstances

Manuj and Mentzer (2008) stresses the importance to keep a holistic perspective on not focusing only on your firm, as the entire supply chain is exposed to risks which could affect every single supply chain actor. Risks with digitalization are, according to the same authors, most likely to be related to operational risks and security risks, even though policy risks could be a factor as well, with changing policies for data handling and storing. To mitigate the supply chain risks, Norrman and Jansson (2004) describe it as essential to identify the risks, structure them and assess them. Also, if the risks occur, a supply chain should have business continuity management in place to confront the problem and minimize the losses related to them. If losses related to unexpected events are identified, a company can mitigate the risks by creating mitigation plans (Norrman & Jansson, 2004).

There are several tools to assess the supply chain risks, as the risk assessment matrix developed by Norrman and Jansson (2004). The matrix developed illustrates the probability of the risk occurring on one axis, and the business impact if the risk occurs on the other axis. The matrix then can be used when creating risk mitigating plans and help supply chains focusing on minimizing the total losses relating to the supply chain risks. The matrix is illustrated in Table 3.7.

Table 3.7: Risk assessment matrix. Adapted from Norrman and Jansson (2004).

Probability	Very high				
	High				
	Medium				
	Low				
		Low	Medium	High	Very high
		Impact			

Digitalization risks

When discussing and understanding digitalization in supply chains, having a risk perspective is crucial, according to Deloitte (2018). 10 risk areas for digitalization are described, which are listed in Table 3.8. When it comes to mitigating these risks, they are no different from other supply chain risks. The risks need to be identified, structured, evaluated, and assessed on what threat they pose for the supply chain, according to Manuj and Mentzer (2008). Furthermore, the same authors emphasize mitigation plans to minimize the negative business impact from the risks need to be in place.

Table 3.8: Digitalization risk areas. From Deloitte (2018).

Risk area	Description
Technology	Risks of failure or other problems in the technology used, or risks of technology used being substandard
Cyber	Risks relating to confidentiality or integrity, due to unauthorized usage
Strategic	Risks of digital solutions not aligning with corporate strategy
Operations	Risks of operations breakdown relating to digital solutions
Data leakage	Risks of non-sufficient data protection, data leakage to unauthorized users
Third-party	Risks coming from inappropriate third-party actors getting access to data or technology
Privacy	Risks relating to insufficient management of personal and/or sensitive data
Forensics	Risks of not being able to support investigation through data in the case of crime, fraud, or security breach
Regulatory	Risks of changing laws and policies, affecting the digital work
Resilience	Risks of employees not being on board with change, possibly due to technology unavailability

While there are risks with digitalization, it can also facilitate the mitigation of other risks, as described by Ivanov et al. (2019). They discuss how a digital supply chain will be able to identify risks more efficiently than before, with supply chains being more proactive in their risk management. For instance, digitalization may have a positive impact on risk mitigation inventory, being able to be more flexible in capacity through technologies like additive manufacturing. This is echoed by Ivanov and Dolgui (2020), discussing how new technologies as digital supply chain twins can mitigate risks relating to disruptions in the operations by being more predictive and adaptable.

3.3.5 KD postponement strategy

Choi et al. (2012) describe how global manufacturing supply chains are heading towards a fragmentation, where parts of the supply chain are located in developed countries and other parts are located in developing countries. This has, according to the same author, led to intensified use of postponement, but also the use of knock-down strategies. This can be carried out by having a complete knock-down approach (CKD), a semi knock-down (SKD). The standard approach, without any postponement, is called complete build-up (CBU).

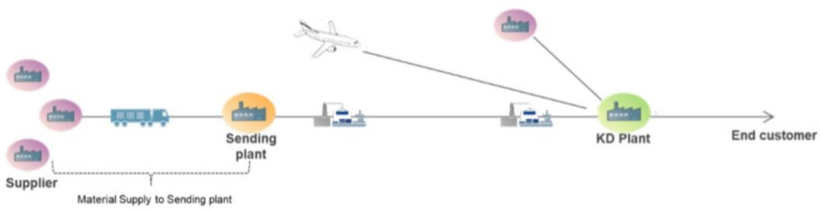

Figure 3.5: A generic KD supply chain setup. From internal IM documents.

According to Choi et al. (2012), a CBU product is produced and assembled in its original country, and then shipped to the country where it is supposed to be sold. The same authors also described CKD, where the finished product is assembled in the country, or in the proximity of, where it is to be sold. The plants for assembling units when using a CKD supply chain do not have the same advanced requirements as a CBU solution and are generally less expensive than CBU plants, which may make CKD or SKD plants the beneficiary option for developing countries, per Choi et al. (2012). They describe CKD is many times preferred when the solution has benefits when it comes to trade or customs tariffs. CKD is beneficial when there are small volumes of units sold in a certain country. SKD is also described by Choi et al. (2012). This, as the method in which the kits shipped to assembly plants are incomplete, or some parts are assembled prior to shipping. The use of the strategies differs a lot between countries, as tariffs and taxes vary heavily. Different tariffs may affect the choice of strategy, and also influential on the postponement strategy is demand fluctuations and demand uncertainty. In Figure 3.6, the KD mindset according to Volvo is illustrated.

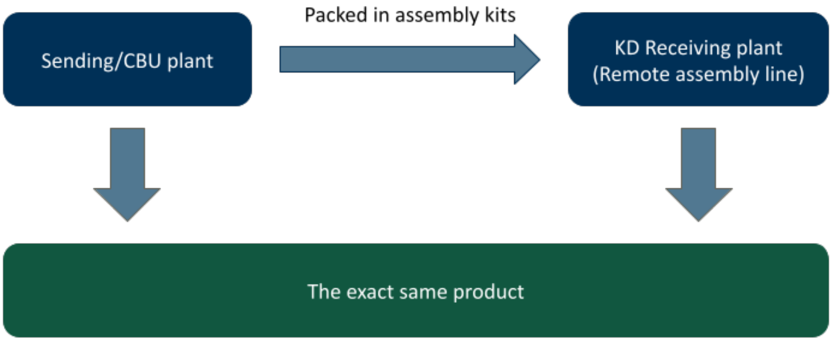

Figure 3.6: The KD mindset according to Volvo

Postponement strategies as CKD and SKD are recognized by Choi et al. (2012) as effective supply chain configurations and are sometimes seen as ways to increase supply chain integration. When deciding on a postponement strategy for a global supply chain, important factors listed by Choi et al. (2012) are: production location, international logistics, transportation costs, and customs tariffs. One main factor when designing the postponement strategy is also the production costs and capabilities across different countries, according to Choi et al. (2012). It is described that for international logistics, when choosing a postponement strategy, the main interest is changes in lead times. For instance, lead times may change as more or less goods are shipped across borders. Transportation costs simply relate to how the cost changes in the entire supply chain when changing the postponement strategy. As earlier mentioned, the last factor described by Choi et al. (2012) is custom tariffs and taxes. Although customs tax has been decreasing in the later years because of free trade agreements, it is still an important element when choosing postponement strategy.

Regarding the subject of this master thesis, the automotive industry was earlier most often located in developed countries, while it now has shifted towards manufacturing in developing countries (Choi et al., 2012). According to the same authors, as well as Lee and Tang (1997), postponement often reduces cost, while it may differ heavily depending on industry, company, and supply chain characteristics. However, in some cases an earlier decoupling point may lead to reduced costs, as it lowers the production cost and customs tax. Choi et al. (2012) shows the importance of carefully designing the strategy based on the characteristics of the supply chain and product. Often, it may be beneficial to postpone assembly, as it may lead to reductions in cost in both customs tax and production.

3.4 Industry 4.0 maturity

The *Industrie 4.0 maturity index* is a framework developed to assess an organization's digital maturity. The index is developed by Schuh et al. (2020) at the *German National Academy of Science and Engineering*. It is divided into six levels, where the two first levels are *computerization* and *connectivity*. The two first steps are prerequisites for Industry 4.0 and labeled as the digitalization of an organization. The consecutive four steps are *visibility*, *transparency*, *predictive capacity*, and *adaptability*. These four steps are considered to be part of an organization's process of adapting to Industry 4.0. This means digitalization is a prerequisite for Industry 4.0.

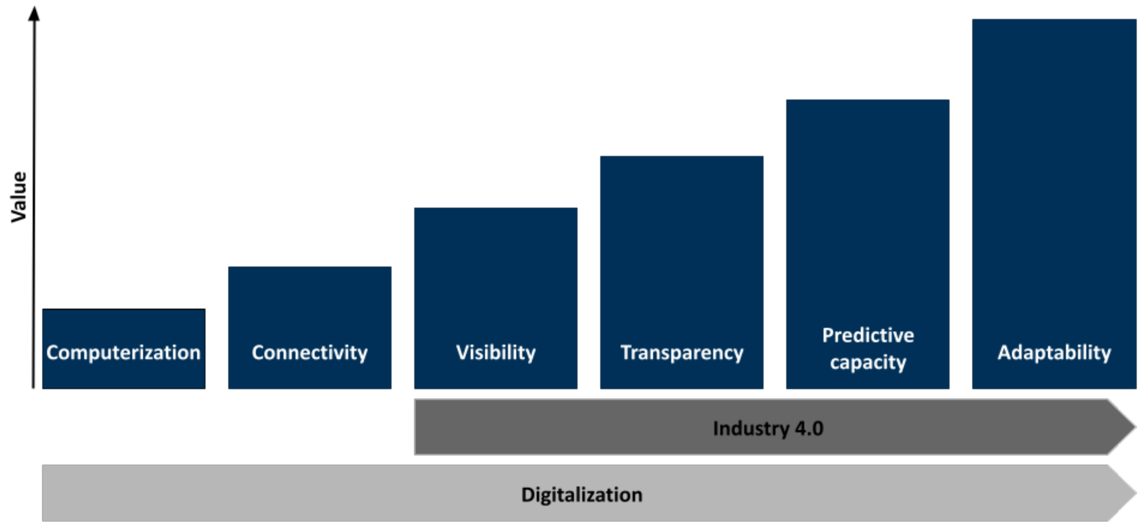

Figure 3.7: The six steps in the Industrie 4.0 maturity index. Adapted and modified from Schuh et al. (2020).

In the report by Schuh et al. (2020), the figure Figure 3.7 is adapted from looks differently. In their version, the digitalization arrow does not cover all the six steps, only the two first. This implies Schuh et al. (2020) see digitalization as an effort undertaken by an organization until it becomes digitally mature enough to enter the realm of Industry 4.0. The authors of this thesis disagree with this view and sees digitalization as an effort being continuously undertaken regardless of digital maturity and have therefore placed the digitalization arrow stretching over all the stages. Digitalization in this context is not seen as separate from Industry 4.0 by the authors of this thesis, rather as something ever present as a prerequisite when discussing Industry 4.0. Therefore, the *digitalization* arrow is stretched out to cover all six steps, including the entire *Indsutry 4.0* arrow.

3.4.1 Stages of maturity

In Table 3.9 below, the different stages of maturity in the Industrie 4.0 maturity index are described (Schuh et al., 2020).

Table 3.9: *Stages of maturity in the Industrie 4.0 maturity index. From Schuh et al. (2020).*

Stage	Description
1. Computerization	The basis for digitalization is computerization. Most companies today are already sufficiently computerized, meaning they use computers for communicating, performing computations, and performing repetitive tasks. Computerization is today something not possible to survive without and almost all production equipment used are in some way computerized. The traits of an organization at this stage are, for example, production machines producing efficient and complex products, but there is no way to automatically transfer computer-aided design drawings to them. Another example is a company using many different information systems which are not connected to each other automatically and therefore need manual data transfers. Organizations at this stage often have structures customized towards efficient, lean operations but usually only work in silos with little communication and collaboration between business units.
2. Connectivity	In this stage, the organization has started to connect the most used information systems to each other. This means the systems communicate automatically and data in one system is readily available for another system when needed. Some integration between operation technology and IT has been implemented, but not everywhere. Further, this means machines are connected to systems where they get production orders and drawings for products automatically and IoT sensors are used to communicate production pace, machine status, etc. At this step, the organizational culture is positive towards technological development, and change is seen as something positive. However, traditional project management methods are still used and the lack of agility coming with this approach makes change hard to achieve.
3. Visibility	In the visibility stage, the organization's manufacturing and supply chain efforts have connected sensors capturing data during the whole process. The sensors capture data in near real-time and this level of accuracy makes it possible for organizations to create a digital shadow of their operations. This digital shadow can illustrate what is happening anywhere in the processes at any time, making it possible to make decisions based on large amounts of data as well as the data captured in real-time. The digital shadow is important for later stages of Industry 4.0 maturity. To successfully create a digital shadow of an organization, traditional data collection to perform ad-hoc analysis must be changed into a well-measured operation where the data collection represents an up-to-date model of the whole organization. To achieve this, much organizational change needs to be undertaken. Silos need to be broken, agile teams capable of responding to changing customer requirements need to be created, and hierarchies are dismantled in favor of free discussions about innovation and change.
4. Transparency	The transparency stage refers to organizations having completed their digital shadow and started to use it together with technologies like big data analysis and AI. This, to find out where and why issues happen in the physical layer of the processes. The use of big data for analyzing the data produced by the digital shadow of a company should not only be used to find and resolve issues. The analysis of data should be used as a base for decision-making. This means the importance of having an agile organization and management style is even more important at this point.
5. Predictive capability	This stage builds on the capabilities developed in the transparency stage. However, the organization should now be able to simulate different scenarios and therefore be able to predict future development for the company. This predictive capability can help to find future machine failures, or support planning of what to do in case of unexpected events. For this to be possible to implement organizationally, further silo disassembly and greater individual decision-making agency. The organization also needs to have the ability to quickly change resources and employees towards the departments where it is needed.
6. Adaptability	The sixth stage is reached when an organization can use its information systems to not only automate data analysis but also to make certain decisions. These automated decisions should be used for the organization to be as efficient as possible in its operations. The earlier stage of prediction now uses the information systems to identify the best scenario and then execute operations in the way this scenario suggests. Obviously, not all decisions should be delegated to information systems, rather careful cost-benefit analysis should be conducted to find out what decisions need to be taken quickly enough to justify the increased risk of using AI to make decisions. To implement this, the organizational structure and culture must consider change as the norm and cross-functional teams are the standard way of working.

3.4.2 Dimensions for measuring maturity

Schuh et al. (2020) proposes four areas to evaluate when assessing the digital maturity of an organization. Each of the four areas has two principles that represent the X-axis and the Y-axis of the different areas measured. These principles are further divided into several capabilities which are used to assess how well an organization fulfills the principles of each dimension. For more detail, see Table 3.10.

Table 3.10: Industry 4.0 maturity index assessment table. From Schuh et al. (2020).

Dimension	Principle	Capability
Resources	Structured communication	Efficient communication
		Task-based interface design
	Digital capability	Provide digital competencies
		Automated data acquisition
		Decentralized processing of sensor data
Information systems	Information processing	Automated data analysis
		Contextualized data delivery
		Application-specific user interface
		Resilient IT infrastructure
	Integration	Horizontal and vertical integration
		Data governance
		Standard data interface
		IT security
Organizational structure	Dynamic collaboration in value networks	Focus on customer benefits
		Cooperation within the value network
	Organic internal organization	Flexible communities
		Decision rights management
		Motivational goal systems
		Agile management
Culture	Social collaboration	Democratic leadership style
		Open communication
		Confidence in processes and information systems
	Willingness to change	Recognise the value of mistakes
		Openness to innovation
		Data-based learning and decision-making
		Continuous professional development
		Shaping change

The Industry 4.0 maturity assessment diagram used in this master thesis is illustrated in Figure 3.8.

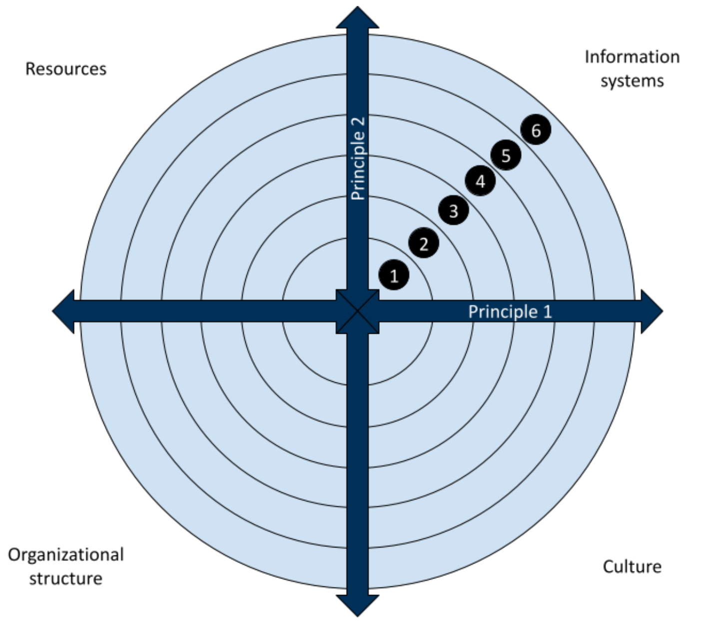

Figure 3.8: Assessment diagram for the Industrie 4.0 maturity index. Adapted from Schuh et al. (2020).

Resources

Along the lines of Schuh et al. (2020), resources refers to physical resources of the organization, i.e., human resources, tools, and machinery. The first principle for resources is *digital capability*, referring to the need for digital competencies in employees, machinery, and tools connected to information systems. The second principle is *structured communication*. This principle discusses the need for predetermined ways of communication and the record-taking of this communication. This does not only apply to communication between employees but also communication between systems or machinery. According to Schuh et al. (2020), it is important communication occurs in efficient ways where the information needed is easily available. The need for visualizations when systems communicate with humans is also discussed. This is deemed by Schuh et al. (2020) to be important due to how much easier it is to understand preprocessed data than just raw data. Described as important by the same authors is also that materials are taken into consideration when evaluating structured communication. The use of RFID tags easily communicates warehouse volumes and locations to the right people.

Information systems

As Schuh et al. (2020) note, data handling systems supporting the everyday work in an organization. The systems are used for preparing, storing, transferring, and visualizing data and the infrastructure of information systems are important for assessing how well digitalized an organization is. Well-designed information systems convey information to the right people at the right time, visualized in a way suited for the receiver. In the Industry 4.0 maturity index from Schuh et al. (2020), the digital maturity of a company's information systems is assessed based on two principles: *self-learning information processing* and *information system integration*. Schuh et al. (2020) describe the principle of information processing considers areas as automated data analysis, where the information systems are used to find relevant information in the data produced, how information is conveyed, and how the IT infrastructure is designed. The second principle, information systems integration considers how connected and automated the systems in an organization are, how easily available data is, data ownership, and IT security. The objective is, according to Schuh et al. (2020), to implement systems communicating unobstructed by having a standardized data interface, rigid IT security, and data availability across systems.

Organizational structure

Schuh et al. (2020) describe how the first principle considers internal organizational structure. The first capabilities discussed within this principle are flexible communities, meaning the formation of dynamic teams from many different functions with varying life spans. These communities work toward more agile organization and disassembling of silos. According to Schuh et al. (2020), decision rights management is the concept of delegating decision-making down in the organization towards where the decision is taken. With competent employees and well-functioning information systems as support, some decision-making should be decentralized to further promote agility in the organization. Further capabilities discussed by Schuh et al. (2020) are *motivational goal systems*, considering the need for incentive systems for employees when their roles become more autonomous, and *agile management*, meaning the need for a management style where flexibility and delegation are key.

The second principle concerns the external organization, which according to Schuh et al. (2020) concerns the value network in the vicinity of the organization. The capabilities mentioned by the same authors for this principle are customer benefits and cooperation within the value network. The first capability focuses on the need of analyzing what the end-customer needs and provides for that, rather than what direct customers want. The second capability refers to the need for information sharing and incentives being shared by the network actors. The need for mutual respect, confidentiality, and trust is also discussed by Schuh et al. (2020).

Culture

To achieve real digital change, it is, according to Schuh et al. (2020), not possible to only implement new digital technologies and to only change how the organizational structure is laid out. To be able to achieve digital transformation, the company culture also has to change. According to the same authors, there are two main principles coming to company culture, *willingness to change* and *social collaboration*.

The first principle of the culture is by Schuh et al. (2020) considered as the attitude towards change within the organization. The first capability discussed by them is the *value of mistakes*. This capability concerns how to learn from mistakes, and how to utilize them to shape an organization where employees are not reluctant to discuss their mistakes to avoid them in the future, but also to change processes that are prone to mistakes. The second capability mentioned by Schuh et al. (2020) is *openness to innovation*. A positive attitude towards new processes and technologies is crucial for achieving change. The use of data and data analysis to make decisions is another capability considered important for a culture embracing change, according to Schuh et al. (2020). They describe how manufacturing companies today have short innovation cycles and using data as support for decision-making is more important than ever. Further, it is explained there is a need for a management culture where data is more important and trusted than "gut feeling". The next capability discussed by Schuh et al. (2020) is the importance of continuous professional development. For employees to embrace change, they need to understand why innovation will benefit them and the company and how these innovations work. Without any professional development, employees may feel as if they do not understand innovation and resist it. The last capability is called *shaping change* and according Schuh et al. (2020) it stresses the importance of letting the right people in the right positions lead change. Giving decision-making rights to employees having extensive knowledge in the area being changed both helps employees feel more involved but also facilitates making change more agile.

The second principle discusses social collaboration and brings up the capabilities *of democratic leadership*, *open communication*, and *confidence in systems* as important for this principle, along the lines of Schuh et al. (2020). According to them, a democratic leadership style can be achieved by giving employees greater responsibilities to achieve a more agile organization. Open communication is the concept of employees always having access to the information needed for their work. This should be true for both data in information systems and knowledge only held by specifically experienced employees. This means relationships between different functions of the organization need to be functioning and without an “us and them” mentality. Further, Schuh et al. (2020) describes employees’ confidence in systems and processes is important when migrating towards a more data-driven decision-making process and more automation.

Outdated MS Excel sheets with information on the everyday work should be replaced with confidence in the systems. To achieve this, Schuh et al. (2020) stress the importance of involving the employees in the design of systems and processes to get their perspective and their buy-in.

3.5 Change management

It may be easy to discuss and plan technology implementations in an organization. The difficult and resource-demanding part of the implementation process is often to drive through the changes and make sure now procedures and processes are implemented and followed (Appelbaum et al., 2012). When discussing change management, Kotter's (1996) eight steps for change are often mentioned.

3.5.1 Kotter's views on change management

Kotter's (1996) eight steps for change is presented in Table 3.11 below.

Table 3.11: Eight steps for change. From Kotter (1996).

Step	Description
1. Establish a sense of urgency	This first step is necessary to draw attention and get the employees on board with the notion that change is needed. It must begin with an evaluation of the company's competitiveness, market situation, technological trends, or financial status. The proposal is to either present it in a dramatic way or draw attention to it by using consultants to imply a large change as this one cannot be handled internally. It is stated the first step is crucial since if the need for change is not understood by the employees it will not happen. Also, it is emphasized the start of an organizational change needs to be aggressive.
2. Create a guiding coalition	No one can single-handedly manage to drive through change. Therefore, it is important to put together the right team to guide the whole organization towards the change. This group should contain people with these characteristics: enough powerful key players should be on board with the project to gain momentum. Expertise in the area of change and on all other viewpoints should be represented to make well-informed decisions. The group members should be credible and act as people who can be trusted with important issues. The group should have enough leaders to be able to drive the project through.
3. Develop a vision of strategy	The guiding coalition's first task is to develop a vision and a strategy for the project. Without this measure, the change effort is at risk of becoming a confusing list of objectives that are incompatible. This would render the change efforts useless. Stated is a well-defined vision also is essential for breaking the current state and looking beyond the usual objectives of the organization. This means some of the organization's goals and strategies may need to be overridden during the time of change for the change to successfully take place. Also, a clear vision and strategy are easier for employees to follow than an abstract goal of change.
4. Communicate the vision for change	The communication of change is a critical element of conducting the change. It can reduce uncertainty, decrease ambiguity and even affect how the response to the change vision is. Kotter (1996) presses on the fact two-way communication is a more suitable way of communicating change than one-way communication. Meaning, it is more suitable for the managers to have a conversation with the employees about the change, asking for their input rather than just communicating the plan via an official memo.
5. Empower a broad-based action	By successfully communicating the strategy and vision of the change, employees can be encouraged to try new ideas or approaches. However, communication of the vision is not enough, and employees need encouragement from managers to keep up with this new-found approach to the change. The employees also need help in getting rid of obstacles of trying these new ideas. Common obstacles in the workplace are structures, skills, systems, and supervisors. It is important for managers to get rid of these obstacles for their employees to feel like they are helping with the change and to empower them to come with new ideas.
6. Generate short-term wins	It is essential to focus on smaller goals leading up to the main goal of change. Another key behavior is to appreciate steps taken by individual employees and celebrate them, to create the feeling of the work towards change is filled with small victories. These victories then create a sense of importance to the cause and build momentum towards more victories. Short-term wins both works to remove obstacles by cementing the change vision in people's minds but also provide a reason to celebrate the people who work extra hard towards the change.
7. Consolidate gains and produce more change	It might be easy for managers to declare the change as successful already after just a few small changes is implemented. However, according to Kotter (1996) these changes can regress, and therefore it is important for managers to use the change made and the victories gained to set the change made in stone and use it to pivot towards even more change.
8. Anchor new approaches in company culture	New habits and processes will be forgotten or even neglected over time if they are not rooted in the company culture. Also, there are two different factors to change the company culture. The first factor is to illustrate to the employees how the changes and new approaches have improved performance. The second factor is to ensure the new generation of managers personifies the changes.

By Appelbaum et al. (2012), Kotter's model for change are reviewed from a scientific viewpoint. Appelbaum et al. (2012) note in the beginning of the article, the classic model by Kotter is not built on any fundamental research. The original paper and book on the subject lack references, bibliography, and footnotes. The model seems to be built on Kotter's own business and experience. The purpose of the paper is therefore to try to find a scientific ground for this model. In the article, each step is reviewed, and its legitimacy is discussed from research. However, Appelbaum et al. (2012) acknowledges Kotter's research in this area is widely regarded as an effective roadmap for conducting change. While the steps in the model all can be said to be important to conduct a change effort, Kotter (1996) is claiming all steps always have to be taken in the right order and does not have support in the recent research done on the area. The idea that all steps must be done subsequently and not overlap is not supported either (Appelbaum et al., 2012).

3.5.2 Digital change management

The digitalization taking place in many companies is one of the major organizational changes in recent times, as described by Lee (2020). The process of integrating technology into every part of an organization is disruptive. It will change how everyone conducts their work tasks, how every process works, and how value is delivered to customers. According to Lee (2020), this change is as much a cultural change of organizations as a technological change, and to achieve digital transformation, strategic, technological, process, and structural change is needed while cultural change is the glue keeping it all together. The same author also lists three main barriers for the cultural change needed to facilitate digitalization. These are *functional and departmental silos*, *fear of taking risks*, and *difficulty to act on a single view of the customer*. Furthermore, Vogelsang et al. (2019) admit cultural change is important but regards it as only one of many major barriers for digital transformation. Instead, the same authors claim there are five major areas needed to work with when conducting digital change. The barriers are summarized in Table 3.12.

Table 3.12: Barriers for digital transformation. Adapted from Vogelsang et al. (2019).

Barrier	Description
Missing skills	Lack of IT and data skills, but also lack in knowledge about process optimization
Technical barriers	Barriers regarding existing technologies, existing infrastructure, data security
Individual barriers	Fear of loss of control, fear of loss of job, lack of individual skills
Organizational and cultural barriers	Traditional processes working, no strategy, lack of resources, risk aversion
Environmental barriers	Lack of standards and laws.

Moeuf et al. (2020) list a few critical success factors for small and medium-sized enterprises (SMEs) to succeed in their digitalization effort. These are: employee training, conducting pre-studies, communication, the use of already available data, having a "continuous improvement strategy", and having the manager communicate with other managers. Also emphasized by Moeuf et al. (2020) is the importance of exploiting data and having a functioning IT infrastructure. By following these critical success factors, it is believed Industry 4.0 can increase the overall performance and competitiveness of the involved companies.

The organization culture, communication, and employee training are all discussed by Kotter (1996). However, making use of already existing data is a concept unique for digital change, along the lines of Moeuf et al. (2020). According to them, already existing data can become more usable and available by increasing the connectivity in the organization's information system, by looking over the IT infrastructure, or by implementing modern ways of data storage. By using these methods data will become more available and new insights can be found using recently available technologies within big data analysis. As Moeuf et al. (2020) note, an SME might not have the resources to implement IoT technology or other expensive new technologies to generate more data. They can, however, make sure they use the data already produced in the most effective way to both optimize operations and drive further digital change.

3.6 IT centralization and decentralization

Pick (2015) describes IT decentralization as the concept of moving IT related decision-making and competencies from a central part of the organization towards smaller business units. The idea is, according to Pick (2015), a smaller organization with larger self-governance should be able to be agile and develop solutions that are tailor-made for the business unit they work for. Trends towards centralization and decentralization go back and forth and the current overall trend is according to Pick (2015), towards centralization due to the increasing risks of security breaches and larger overall digital transformations. However, research shows a universal way of organizing the IT effort of a company does not exist, but rather the organizational structure, size of the organization, and the industry should all be considered before choosing a strategy for centralization or decentralization (Ribbers et al., 2002). The structures of centralization and decentralization are illustrated in Figure 3.9.

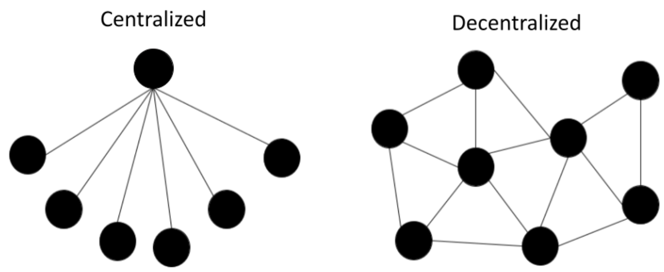

Figure 3.9: Centralized and decentralized structures. From Path Foundation (2018).

Weill (2004) proposes six different IT governance systems, which can be seen as all-including. These are listed and described in Table 3.13.

Table 3.13: IT governance system. From Weill (2004).

System	Description
Business monarchy	When all data and IT related decisions stem from a centralized organization with a business executive as the leader.
IT monarchy	Similar to business monarchy but with an IT executive as the leader.
Feudal system	The IT decisions are decentralized to the leaders of the different business units with a dedicated IT department.
IT duopoly	The organization's IT related decisions are made by a committee with both IT executives and another group such as C-level executives or business unit leaders.
Federal systems	IT decisions are centralized to a committee consisting of C-level executives and another group, such as IT executives or business unit leaders.
Anarchy	Every user can make their uncoordinated and decentralized decisions.

Pick (2015) notes that when an organization decides upon what kind of IT governance system they want, it is important to take the rest of the organization into consideration. According to the same author, each of the six different systems has its place and decisions about whether IT decisions should be made by business leaders, functional leaders, or dedicated IT leaders or where in the company structure certain competencies should be available must be taken before deciding upon one.

Along the lines of Pick (2015), if the degree of centralization is seen as a continuum, the feudal system would be most decentralized with all resources allocated to the different business units with their local knowledge of what to do with the resources. The most centralized option would be business monarchy, where all resources are allocated to one group governed by someone with overall knowledge of the business and strategy (Pick, 2015). Where centralization provides a more professional operation, efficient use of available resources, data standards, and overall data availability, decentralization instead provides greater user control, responsiveness, agility, simplicity, easier access of data as well as resources in the hands of the people who know what must be done (Cash et al., 1992).

4 CASE STUDY

In this chapter, the empirical findings from the case study on the digitalization of IM, including the interviews, the survey, and internal documents, are presented and discussed. The case study constitutes a synthesis of the empirical data collected during the research work. In total, data collected from nine interviews, 14 survey respondents, and two workshops are presented.

4.1 Background

The empirical study was conducted at IM, and the aim was primarily to identify the division's supply chain processes and the digitalization of these processes. The empirical study was performed as a case study and sought to provide clarity and understanding of this particular division of Volvo. In the case study, there are several concepts used which may be difficult to understand for people outside the Volvo organization. In Figure 4.1, important definitions used in the case study are listed. For further definition of important concepts, see Section 1.7.

Volvo Tuve plant: Volvo's main CBU plant in Gothenburg. All of Volvo's KD plants have the Tuve plant as their sole or main supplier.
IM processes: A work process taking place at the office side of IM's operation. E.g., order planning or shipment booking.
KD supply chain: The physical and digital processes related to the logistics of transporting trucks from the Tuve plant to KD plants and the assembly of these trucks.
Legacy systems: An outdated information system where a decision of replacement has been taken but not executed. Legacy systems are not further updated or built on.

Figure 4.1: Definitions used in the case study.

4.2 Interviews

In this section, data collected from the interviews are presented. The procedure of conducting the interviews is described in Section 2.4.1. The interviewees have varying backgrounds. Some of the interviewees have an operative position, and others have a tactical or strategic position. The interviewees were selected to get a holistic picture of the digitalization at IM. The interviewees with an operative role provided a picture of the current situation, and in which areas there are room for improvements. The persons acting on a strategic or tactical level, often within the IT department, provided a picture of the change work within digitalization, and reasons for the current situation. All interviews conducted followed an unstructured approach, as described earlier. In Figure 4.2, a diagram of the number of appearances for each relevant topic in the interviews can be seen.

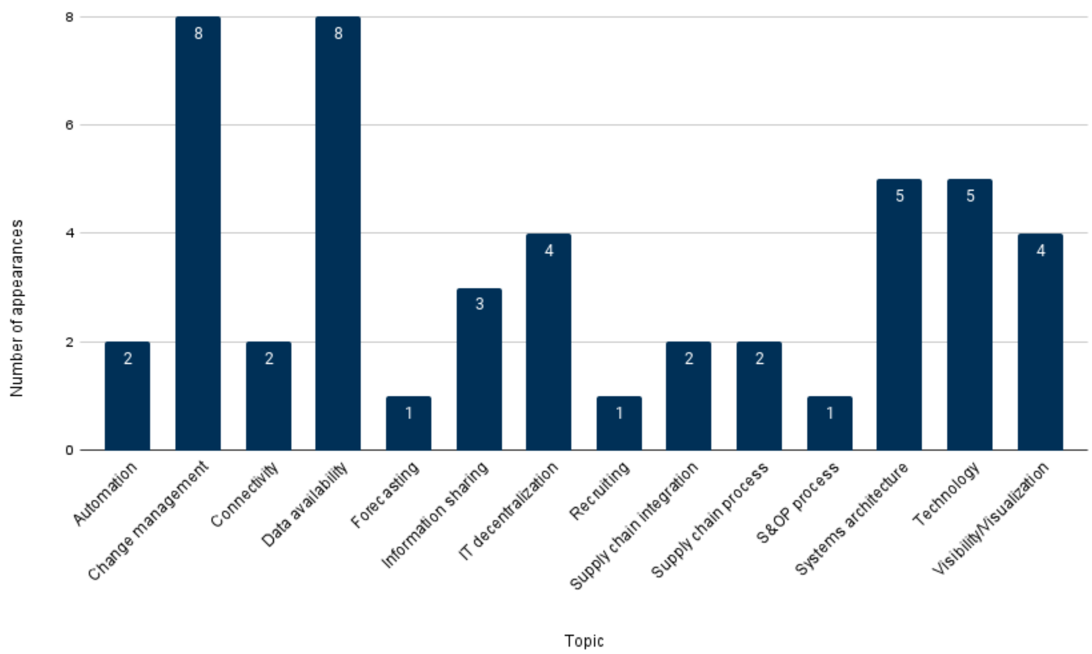

Figure 4.2: List of appearances of relevant topics in the interviews.

Figure 4.2 may not give a comprehensive illustration of the digitalization situation at IM, as the topics discussed in the interviews are not independent of the interviewers, who may steer the discussion in a certain direction. Also, the interviewees were not equally distributed among concerned departments, which may favor and disfavor the frequency of certain topics. Therefore, Figure 4.2 should not be regarded as a complete guide of which topics are most important for digitalization at IM. However, the same interview guide was used for every interview, and the interviewees had equal opportunities to direct the interview in any way. This makes the figure a useful, yet not comprehensive, support in assessing which topics people in relevant positions at IM and Volvo believe are most important when discussing further digitalization. In Figure 4.2, it is possible to see the most frequent topics discussed in the first round of interviews were change management and data availability, which both were discussed in all but one interview. Other topics frequently discussed were systems architecture and technology implementation, which occurred in five of nine interviews. Mentioned in four of the interviews were visibility/visualization and IT decentralization.

4.2.1 Summary of interviews

Below, short summaries of each interview conducted can be found, with a more in-depth perspective of which topics were discussed and in which context. For further information about the date of the interview and the interviewee's department, see Table 4.1.

Table 4.1: Repetition of list of interviewees by position, department, date of interview, supplemented with relevant topics discussed in the interview.

Interviewee	Position	Department	Date	Relevant topics discussed
Interviewee A	Volume and capacity manager	S&OP	2021-02-15	Data availability, forecasting, information sharing, systems, S&OP process
Interviewee B	VP Digitalization and IT	Digitalization and IT	2021-02-16	Change management, data availability, IT decentralization, supply chain integration, technology implementations
Interviewee C	Logistics coordinator	Order and delivery	2021-02-16	Change management, connectivity, data availability, systems, supply chain process, connectivity, visibility/visualization
Interviewee D	Senior project manager	Digitalization and IT	2021-02-19	Automation, change management, data availability, IT decentralization, systems, technology implementations
Interviewee E	Logistics coordinator	Order and delivery	2021-02-22	Change management, data availability, information sharing, IT decentralization, supply chain process, systems, visibility/visualization
Interviewee F	Business solution portfolio manager	Digitalization and IT	2021-02-23	Change management, data availability, IT decentralization, recruiting, technology implementations
Interviewee G	Logistics development and project manager	Logistics	2021-02-23	Change management, data availability, technology implementations, visibility/visualization
Interviewee H	Connected supply chain senior developer (VGTO)	Production logistics	2021-02-19 & 2021-02-25	Change management, information sharing, supply chain integration, technology implementation, visibility/visualization
Interviewee I	Logistics development and project manager	Logistics	2021-03-05	Change management, data availability, automation, systems, technology implementations

Interviewee A

As a manager within sales and operations planning (S&OP), the interviewee works closely to the KD assembly plants, the sales department, and the S&OP managers of other Volvo divisions. The interviewee described their working process in detail, which is further elaborated in Section 4.4.1. The process and systems used by the interviewee are generally the same for the entire Volvo organization.

The systems Interviewee A works with are mainly related to the inbound supply chain of IM and are therefore the same as is used by VGTO. According to the interviewee, the systems used are a mix between old, outdated systems and newer, recently replaced. The interviewee recognized the newer systems are easier, more user-friendly, and reduces the risk of errors. The interviewee has not experienced any media breaks in the systems and maintained the automation between systems is satisfactory. However, the interviewee acknowledges some of the systems used are outdated and can sometimes hinder the progress of the S&OP work.

In conclusion, Interviewee A was of the opinion Volvo and IM need a major system update. Through this update, the interviewee hoped more modern tools could be used. The expectation was new systems implemented in the future will be more user-friendly and provide more visualization of data.

Interviewee B

Interviewee B is the *Vice president (VP) and manager of the Digitalization and IT department* at IM. The interviewee's main responsibility is to improve the digital processes at KD plants and other departments within IM. This, through solutions within IT and digitalization. According to the interviewee, the processes and systems used at IM and in the KD supply chain are less developed and digitalized than in the larger divisions and supply chains at Volvo, as the main CBU supply chain.

According to the interviewee, change management is essential when driving digital change. In the interviewee's view, the company in general has some shortcomings when conducting it. It is often neglected and then, when digitalization projects fail, the usability of systems is blamed for the failure instead of the lack of change management. The interviewee mediated it is often easier to implement larger digitalization projects, as larger projects induce a feeling of importance and gravity. The perceived importance of these major projects is sometimes enough for people to understand the significance of using the new processes and systems coming with the project. However, projects of larger size are almost impossible to develop at IM. Most resources for digitalization and process development are reserved for the larger supply chains within the organization. Larger digitalization projects within IM are deemed to be too costly or resource-demanding for such a minor part of the organization.

When discussing improvements needing to be done, the interviewee mentioned the importance of integration projects. According to the interviewee, those projects are important as they are the most immediate places in processes where errors occur. However, the interviewee acknowledged this is something not possible to implement everywhere in the IM organization. This would be too resource-demanding, and some systems are not possible to update or replace.

Interviewee C
Interviewee C works operationally in the order and delivery process of the KD supply chain, as a *logistics coordinator*. The interviewee's main work tasks are to plan orders to the KD plants and book freight for these orders. Together with the order and delivery team, the interviewee is responsible for this process. The responsibilities in the team are divided into different geographical markets. Beyond operational responsibilities, the interviewee also works tactically in projects to improve and document work processes within the KD supply chain.

Further, Interviewee C explained the order and delivery process in detail, which is described in more detail in Section 4.4.2. The interviewee also explained which systems are used and where the interviewee believed the supporting systems are lacking digitally. The main problems with the systems supporting the order and delivery process are their age, and that the systems are built to fit the processes of the CBU supply chain. The KD supply chain uses the same systems with some functionality adaptations even though IM works with different flows than the CBU supply chain.

The interviewee discussed the importance of connectivity between systems, meaning the process where manual information transfers need to be eliminated. This, since these pose risks of both data loss and/or distortion. Visibility is also mentioned as lacking in the process, especially concerning the shipping process, where the total lack of visibility poses serious risks for IM not noticing deviations in the shipping process. Without visibility, IM does not have any insight into where their goods are located, and whether the shipping process is following the set timetable. The interviewee gave an example where a full shipment were not loaded in a transit harbor. The interviewee discovered this manually by chance in one of the systems.

Interviewee D

Interviewee D works at IM's digitalization and IT department as a *senior project manager*. The interviewee discussed Volvo's information systems strategy and mentioned Volvo mainly has developed their own information systems over the past 50 years. Today, there are over 3,000 systems used at Volvo Group, and around 1,000 of these are used by Volvo Trucks. Many of the systems are over 30 years old and are considered *legacy systems*.

The interviewee is mainly involved with the implementation of a project called TM1. TM1 is an SAP solution for automation of the receiving and assembly part of the KD supply chain. Currently, the interviewee works with implementing TM1 at the KD plant in Durban, South Africa. TM1 was earlier launched at the plant in Hosakote, India, with unsatisfactory results due to poor change management. In Durban, however, the interviewee believes the implementation will be satisfactory. Then, the system will be used as intended to support assembly and receiving processes. According to the interviewee, all the fully Volvo-owned KD plants will eventually switch to this SAP solution. Interviewee D also discussed change management and its importance. The interviewee estimated 80 percent of a successful change effort comes through change management and the rest is having the sufficient technologies in place.

In the IM supply chain, most of the monitoring and control is today conducted in MS Excel, which is not regarded as optimal. Currently, MS Excel documents are considered as the proper way to convey information in these processes. According to Interviewee D, information systems with higher visibility should instead be implemented. To eliminate the need for MS Excel documents, further integration of information systems is needed. The interviewee emphasized much manual work could be eliminated by automating data transfers. This, instead of updating MS Excel documents and manufacturing visibility in the systems by moving data between them.

Interviewee E

Interviewee E is *logistics coordinator* at IM, working operationally with the order and delivery process and tactically in projects improving processes within the KD supply chain. According to the interviewee, there is much potential for digital improvements in the order and delivery process. At this time, the working process is too dependent on MS Excel documents being updated in cloud solutions. Preferably, systems should have a higher degree of visibility and be more integrated instead.

Further, they described the information systems used. OPT, the main planning tool, is considered well-functioning and sufficient. OM, the tool for order management, was considered to not be especially well-adapted for the continuous work process. This due to OM being a system used by the CBU process and later adapted to the KD supply chain. Newer systems, as ATLAS and ShipIT, are working sufficiently according to the interviewee. Emphasized was the logistics coordinator's lack of understanding for why these systems, originally developed for the CBU supply chain, were not more adapted to the KD supply chain when developed.

The interviewee is part of a project working towards adapting these systems to IM's process. Through this project, the expectation is to improve the digital IM processes, increase end-to-end visibility and further integrate information systems in the entire process. It was stated now is a great time for the division to further digitalize their processes. This, since there are resources available, and management currently prioritizes digitalization. However, as Volvo is a large company, and many other parts of the organization demand the same thing, resources must be shared.

According to Interviewee E, Volvo and IM are on the right way and work with concepts from Industry 4.0 in a modern way. Volvo has employees with the right competencies within relevant technologies like big data, AI and IoT. The problem might instead be the availability of these competencies. This might be a problem with the overall IT decentralization trend within Volvo, the people with advanced competencies not being available to smaller departments within the organization.

Further, the importance of change management was accentuated. The interviewee believed there is more focus on change management now than five years ago. IM often uses the "train the trainer" approach to introduce new processes or information systems. This often works well if the right person for this approach is identified, although this is not always the case. IM is often having problems with changing the system, but not the procedure. In turn, this creates extra work when a new system is implemented, when the process is optimized towards a new procedure while the old procedure still is the one used.

Interviewee F

Interviewee F has two positions. Firstly, *business solution portfolio manager*, meaning the interviewee has the responsibility for several applications supporting IM's processes. The other position the interviewee has is *business process developer*. This means the interviewee has responsibilities to ensure IM's processes are in line with Volvo's long-term objectives. Interviewee F expressed the Digitalization and IT department at IM does not have enough resources. The lack of resources is the main reason why the department has almost no time to carry out important digitalization projects.

The usage of already existing data was regarded by the interviewee as one of the key concepts to solving many problems related to digitalization. Today, the accessibility and usage of this data is a problem for IM. Also discussed was how data availability is related to data visibility, and the improvements of IM in this area during the last years.

Further, the interviewee mentioned the importance of change management to drive any project. Change management is somewhat disregarded at IM, although the interviewee recognized change management is resource-demanding and complex to exercise. In general, people want to follow the same processes they always have. The human resources department was mentioned as an important factor in this area, as recruiting to IM needs to be done in a way to promote change and digitalization.

While discussing whether IM is disregarded regarding larger projects of digitalization, the interviewee verifies this but also notes IM's processes are sometimes used to test new solutions. This, since failure would lead to fewer problems in IM's smaller organization rather than the CBU supply chain. Further, Interviewee F said IM is neglected when it comes to digitalization. The interviewee believed this is related to the unit's smaller size within Volvo, as well as with the decentralization of IT departments. The interviewee considered the decentralization of IT departments as a positive trend. However, this must be done right for it to work successfully, which the interviewee considered it has not. IM's digitalization and IT department is too small and does not have enough resources or competencies to be a successfully decentralized function with high adaptability and agility.

Interviewee G

Interviewee G is *logistics development and project manager* at IM and is currently working on an end-to-end visibility project in the KD supply chain. The objective of this project is a Qlikview dashboard for management. This will help management understand, observe, and control the ongoing processes in the supply chain. This tool will be used to connect the systems Order Planning Tool (OPT) and COPILOT to a dashboard, to have the data from these tools accessible for less initiated employees, such as management. This is currently done using MS Excel, which is something the interviewee wanted to eliminate. This, because the manual input in MS Excel increases the risk of deviations. If there are deviations present, decisions might be based on erroneous data, which in turn may cause problems and interruptions throughout the entire supply chain.

According to Interviewee G, this tool will be the first time management can retrieve a collected view of a majority of the process. By monitoring the dashboard, planning, packing, delivery dates, unpacking, and assembly can be tracked in the same system. The implementation of this system is an ongoing process and is currently being implemented in Durban, South Africa, and Hosakote, India. The objective is to have every important process visible in this tool. As of now, it is mostly used for monitoring the progress of trucks through the supply chain and assembly. The interviewee maintained visibility is key to any digitalization project. For employees to understand processes and set key performance indicators (KPIs), end-to-end visibility is crucial. Also briefly mentioned was change management as an important factor for any project.

Interviewee H

Interviewee H is responsible for the implementation of the One Information Chain project (OIC) as a *connected supply chain developer* at VGTO. OIC is a project improving visibility and connectivity, primarily for the inbound supply chain for VGTO. The long-term goal of this project and the interviewee's work is to eliminate organizational silos and pursue an organization where all parts work together. This, by having information visible and accessible for the right people and to have automatic information flows.

Currently, the interviewee implements dashboards for material controllers and suppliers. In the dashboards, it is possible to observe inventory levels, lead times, and transportation progress. OIC is a large project involving many systems, both new and old. There was no business case prior to developing this project, rather Volvo decided this update was necessary to stay competitive. Further, Interviewee H continued with explaining the digitalization processes at Volvo. The interviewee maintains this process is currently well-functioning, and that management has realized digitalization is key to stay competitive and eliminating silos.

The neglect of IM's digitalization should not be an issue according to the interviewee, since any organization of Volvo regardless of size should be able to get help with automation and further digitalization. However, the interviewee emphasized their lack of knowledge of IM's specific processes.

Interviewee I

Interviewee I works with process development as *logistics development and project manager*, primarily within the KD supply chain. According to the interviewee, Volvo is facing a great shift in technology. In some ways, Volvo is prepared for this and in other ways not. The interviewee claims Volvo has come far when it comes to the technological development on the shop floors. In this area, Volvo often excels at technological development, according to the interviewee. This, because it is easy to connect shop floor innovations to saved financial resources. However, Volvo is for the first time facing rapid technological change on the administrative side and, according to the interviewee, Volvo has some problems managing this change. One reason for this could be the digitalization efforts on the office side, as they are not as easy to relate to saved financial resources. Another reason could be the uncertainty about how many employees will be affected by a forthcoming change. Interviewee I claimed many office positions at Volvo have repetitive and easy tasks, and that these positions should be possible to be automated and replaced when transferring into Industry 4.0.

The interviewee continued discussing many technology implementations IM should look into and also clarified the importance of recruitment for further digitalization. The human resources department should change the way they recruit new employees. The interviewee believes IM's digitalization readiness could benefit from recruiting people outside of the current accepted education and background and be more open to new competencies.

4.2.2 Key concepts discussed in the interviews

Although nine interviews following an unstructured approach provide a somewhat broad picture of Volvo's and IM's current and future work for digitalization of their supply chain, some key concepts were conveyed in the process. In addition to Figure 4.2, the topics and areas with the most relevance for answering the research questions of this master thesis were identified. Below, the main concepts of relevance conveyed during the interview and how they relate to the ideas of the interviewees are specified. The idea conveyed by the interviewees is these concepts are important in creating a successful environment for digitalization at IM. The key concepts mentioned also induce challenges for further digitalization. For achieving a successful digitalization process at IM, the importance of succeeding within these key concepts cannot be understated.

Table 4.2: Key concepts discussed in the interviews.

Key concept	Takeaways from interviews
Change management	• Need of specific digital change management • Importance of change management is consistently recognized • Uncertainty of how to use change management in some processes
Data availability	• Use the existing data by making it more available • Need to be careful to not add too much information • With high data availability, successful digital change is easier to accomplish
Visibility/visualization	• Seen by several interviewees as the next big step in IM's digitalization • Needed for the transfer from execution and troubleshooting to monitoring and control in the operational work • Closely connected and dependent on data availability
IT decentralization	• Can create more agile and adaptable IT departments, higher digital readiness • May reduce resources and possibilities to create change in IM • The decentralization must be done correctly to constitute an enabler for digitalization

Other important concepts frequently discussed according to Figure 4.2 are technology implementation and systems architecture, among others. These concepts are discussed in the description of IM's processes but are considered either out of scope, of less importance for this master thesis, or as a sub-concept to the key concepts discussed. For instance, technology implementation is a concept supported by the other key concepts. Implementation of new technology needs specific attention for each separate solution and is considered to be of less relevance in the overall digitalization process at IM.

Change management

The concept of change management was emphasized by almost every interviewee, and is regarded as one of the main enablers for successful digitalization. The concepts is seen as crucial for successful implementations of digital solutions, and the importance of using change management correctly was stressed during several of the interviews. When discussing failed implementations of digital solutions, insufficient change management is often viewed as the main reason. Although there seems to be consensus regarding the importance of change management, there are often uncertainties of how to apply it. There may be several reasons for this according to the interviewees, including lack of understanding of the specific process, lack of management focus, and unwillingness to change.

The process of implementing digital solutions should in many ways be managed as a regular change process when it comes to change management, according to the interviews. However, there also needs to be a specific focus on digitalization when creating a sustainable climate for change. From IM's side, these specific measures for supporting digital change management are not always clearly formulated. The importance of this is fully recognized by the interviewees, although there is some uncertainty of how the division should use it for digitalization purposes.

Data availability

Discussed in a majority of the interviews was the importance of using the already existing data when transferring into a new digital environment. According to the interviewees, the data needed for further digitalization often already exists in the current systems. The problem is usually not the lack of existing data, rather the low availability and potential to understand and interpret the already existing data.

One problem with new technologies is the lack of knowledge and understanding of how to use data generated from these solutions. There may be a lack of both resources and knowledge to use this data, regardless of its importance and usefulness. Therefore, when implementing a digital solution, it is important to incorporate and use the already existing data, which often is sufficient according to several interviewees. This makes new processes easier to understand and coordinate with existing processes and reduces the risk of data overflow. By using the existing data, digitalization will be easier to embrace for the individuals at the concerned division or department. By a majority of the interviewees, to use and make the existing data more available is identified as one of the key enablers for successfully digitalizing the supply chain. The general opinion by the interviewees is the organization, and primarily management, must realize this going forward.

Visibility and visualization

A key concept when transferring into Industry 4.0 and the new digital age is the visibility and visualization of data. The aim of IM is to create processes where information is transferred and used correctly, where focus is put on monitoring and controlling rather than troubleshooting and executing. To create this process, visibility and visualization are central concepts. Visibility and visualization are needed to generate understanding of the entire process and to make informed decisions. Decisions at operational, tactical, and strategic levels are supported by having information visible and visualized, and these concepts will enable more informed decisions and smoother processes. This, according to several interviewees, who acknowledges the importance of these concepts in a digitalized manufacturing supply chain. This concept is closely related to data availability.

IT decentralization

Often discussed during the interviews is the concept of IT decentralization. According to several interviewees, this is considered a trend in the entire Volvo organization. Larger, centralized functions are compartmentalized and decentralized in different functions. If done correctly, the decentralization may create more agile and adaptable IT functions, which can provide customized and quick solutions to specific problems at the concerned division. As a part of Industry 4.0, decentralized IT departments are viewed by several of the interviewees as being an enabler for successful digitalization.

According to the interviewees, there are also downsides to decentralized IT departments. In the case of Volvo, they have both decentralized IT departments, but also central IT functions. This may create issues in the allocation of resources. This, as the central IT function still may receive the main resources, while the decentralized departments are responsible for new digital solutions in the smaller divisions. Then, expectations on the smaller, decentralized IT departments are high, while they do not have sufficient resources for fulfilling these expectations. The main challenge in this aspect is to decentralize IT departments without reducing their resources too much. Done correctly, having decentralized IT departments may create a more competitive, agile, and adaptable organization with high maturity for digital change.

4.2.3 Results from verification workshops

To verify and validate the results from the interviews and the survey, the interviewees were invited to participate in a workshop where the results of the case study were presented and discussed among the interviewees. This was seen as an opportunity for the interviewees to give feedback to the solutions developed from the interviews. The interviewees also had the opportunity to say whether they disagreed with the analysis made and solutions developed.

In the workshop, discussions around the solutions presented were held. The discussions involved change management and the importance of getting managers to actually deploy techniques for driving change. Another topic discussed was the recruitment of new technologies and whether new recruits or consultants are the answer to the lack of specific competencies present. This generated ideas of more clearly separating the concepts competencies and resources. The fact IM can be used as an organization where Volvo pilots projects were discussed, and the participants agreed IM should try to market itself as an organization where new projects can be tested before being launched in a larger context. Also, the importance of not changing well-functioning solutions even if they are old was discussed. Here, there were some disagreements, but a majority of the participants claimed it is wiser not to develop or change processes working well. Also, an additional digitalization risk at IM was highlighted by the workshop participants; workers not being open to digital change. Summarizing the workshops, they provided deeper insights about how to use change management at IM and how the concepts of competencies and resources should be discussed.

4.3 Survey on IM's digitalization

To support and validate insights gained from the interviews, a survey was constructed and distributed to persons with relevant positions for digitalization at IM, as described in Section 2.4.4. In Appendix B, the full survey answers are provided.

4.3.1 Survey results

Below the results from the quantifiable questions asked are presented. The answers were submitted on a scale, 1-7. In Figure 4.3, the average and median answer on each question are presented. For clarification, the minimum possible value in all these categories is *1.0*, and the maximum possible value is *7.0*, making the medium score on the scale *4.0*.

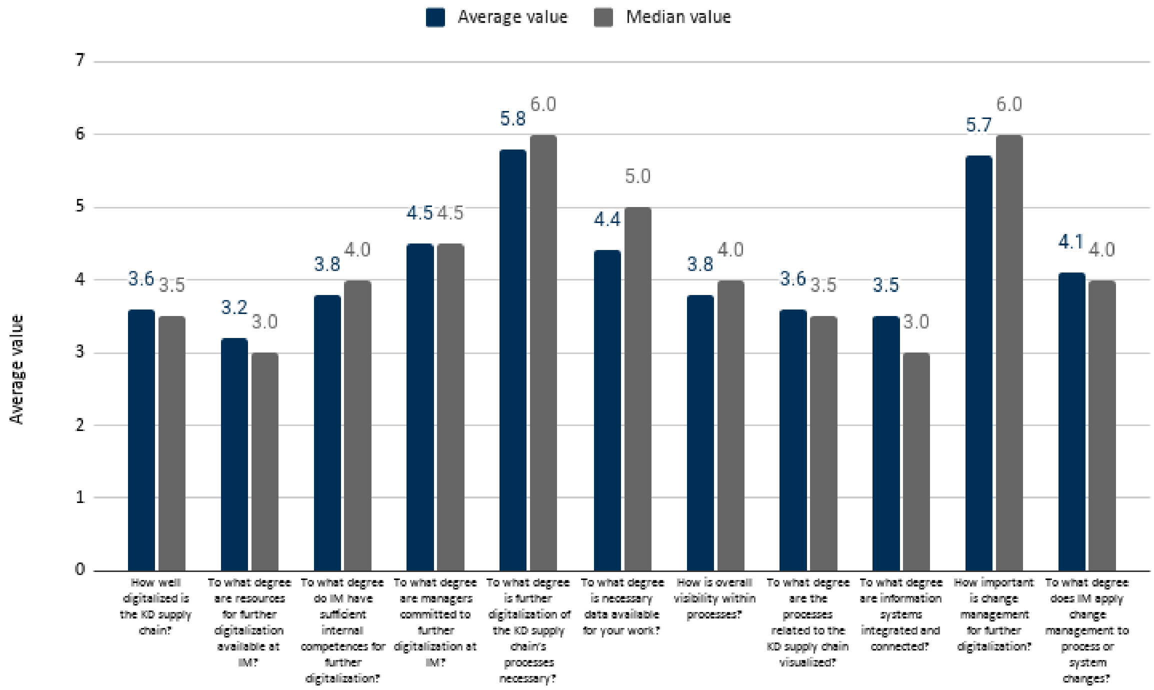

Figure 4.3: Diagram of average and median results of the quantifiable survey questions.

From these results, there are some takeaways to be made. On the topic of overall digitalization, it is obvious the respondents do not consider IM as sufficiently digitalized. This, as the mean answer to the question *"how well digitalized is the KD supply chain"* was just below medium (*3.6*). When asked to elaborate, one respondent answered there are many manual steps in processes and data often is inaccurate. The respondents also believed not enough resources are available for further digitalization with an average answer below medium (*3.2*). One comment on this question expressed the IM organization is characterized by lean manufacturing, with a high workload, which makes time and resources inaccessible for digitalization. The perceived competencies for further digitalization were on average marginally lower than medium (*3.7*), and comments on this question imply there are limited specialist competencies at IM for digitalization. The managerial commitment for digitalization was seen as above medium on average (*4.5*). However, out of seven comments on this topic, five made it clear even though management is committed towards digitalization, little action is taken. These comments were made by both managers and other respondents. On the question whether IM needs further digitalization, the average answer was *5.8*, and comments imply it is important to stay competitive and to reach the 2030 goals set out for the company by corporate management.

On the data availability topic, the average answer was above medium (*4.4*) on the question of whether necessary data is available for the work they do. Comments did however stress although data is available, manual work is often needed to compile it and data inaccuracy is sometimes a problem.

On the topic of visualization and visibility, the answers imply processes are not satisfactorily visualized with an average score of *3.6*. The connection and integration of systems are regarded at about the same level by the respondents (*3.5*). Overall visibility in the process got a somewhat higher score, at *3.8*. Comments here emphasized visualizations are sometimes available to people with insight, but not fully available to persons at a higher corporate level, such as managers. One comment stated much work is being conducted on making processes more visualized on a high level. Comments regarding systems integration mentioned media breaks and manual inputs as a problem, and integrations not being used as intended. Regarding visibility, respondents stated some systems are more functional than others, and while visibility is limited there are ongoing projects with the objective of improving IM's performance in this area.

The last section of the survey discusses change management. In the first question of this section, regarding the importance of change management for digitalization, the respondents agreed over the importance of change management. The average answer was *5.7*. On the question of whether change management is applied at IM, the respondents gave an above medium score of *4.1*. The comments suggest there are resources for change management on requests, but that this is not currently sufficient.

4.3.2 Summary of survey results

The answers in the survey echoed the results from the interviews to a high degree. Clearly, the respondents consider digitalization at IM an important part of the future and acknowledge the current lack of sufficient digitalization and digital solutions. As there is some overlap between the interviewees and the respondents, similarities in the answers are not surprising. Some discrepancies was identified, although. The perception from the interviews where: managers are non-committed towards digitalization and change management is not used sufficiently. This was not the case in the survey results. However, by comments in the survey, some clarity was provided. Although the perception is managers are committed to digitalization theoretically, the employees felt there has been too little action taken in this area. The same situation seems to be present for change management, where there was consensus of its importance. However, it is not used correspondingly to this perceived importance in ongoing projects and implementations. Even though there were new insights provided by the survey results, the main idea stays the same as for the interview results. IM needs further digitalization, visualization, and visibility to stay competitive. This can be done with the support of change management and managerial commitment. The commitment is present, but more actions are needed.

4.4 The supply chain

In this section, the aim is to provide a detailed illustration of the supply chain of the unit of analysis. This to give the reader a more thorough understanding of the current conditions for developing and using digital solutions.

4.4.1 S&OP

The process starts with the S&OP. The S&OP team starts with planning on up to a ten-year horizon, even though their most common planning horizon is monthly. The S&OP is primarily based on forecasts from the sales department. From this information, through meetings, they set up the planning of operations and shipment of goods. For the KD market, the time from order to a finished truck is often around two months. This process is described in more detail in Table 4.3.

Table 4.3: Activities in each step of the S&OP process.

Step	Activities
Step 1	At the end of the first week, the sales department reports their forecast for the following period. Here, the same systems are used in every place of the supply chain, to minimize the risk for errors.
Step 2	At the beginning of the second planning week, the sales department leaves their unconstrained demand report to the S&OP department.
Step 3	When the reports are submitted, all Volvo-affiliated brands have an S&OP meeting where unconstrained demand is discussed.
Step 4	On the Wednesday in the second week, S&OP files their proposed supply plan. Optimally, this is identical to the unconstrained demand report. However, if there is some shortage of material, it will not be. From this, a file is distributed to everyone involved in the process, suppliers included, where sales planning reports for trucks are presented.
Step 5	At the end of the second week, S&OP checks in with the factories, to understand how high volumes they are capable of managing. In most cases, the plants receive the material they need. Sometimes, when there is a shortage of supply material, it has to be allocated between concerned plants.
Step 6	Supply response meeting, IM submits their response to the S&OP plan. All responses from all factories are then put together to form the total demand.
Step 7	Meeting with executives about how to allocate resources between plants. If there are any shortages the executives will decide how to allocate.
Step 8	At the end of week four, a firm supply plan is released to the whole chain and from this, all further planning is made.

The S&OP is one of the main activities of the overall IM process, with the planning as the base for many of IM's operations. This makes it an essential activity, where it is important there are functional digital solutions. S&OP uses several systems, but primarily a system named DSPT, where the planning is done. The planning should preferably be done automatically in this system, based on the number of trucks which are planned to be built. It is then sent to the system CPO, a system receiving all volume plans and orders in DSPT. This is then transferred to CBR, breaking down the truck demand on article level. The process of sending information between these systems is automated but slow. This, as the information is transferred overnight, in periodical data transfers.

As mentioned earlier, forecasting is often used in the S&OP process, and this is based on historical data from the last three months. Here, no advanced planning or forecasting system is used. The forecasting is therefore somewhat primitive. The systems are working slowly but correctly, and they are perceived as somewhat impractical as they in many cases are old and robust. As the S&OP process consists of many systems, the functionality and digitalization level is varying, and individually characterized for the systems. IM's S&OP process and the systems supporting it are the same as for the CBU flow.

4.4.2 Order and delivery

One other main process at IM is handled by the order and delivery department. This department is responsible for ordering, and delivery of material to the plants and is currently made up of seven persons. This constitutes an important process in the entire KD supply chain, essential for execution and problem-solving throughout the supply chain. This, of course, puts pressure on the functionality of the systems used. Digitalization in this process is important for IM to maintain its position as a competitive and profitable department for Volvo.

Ordering is done by the logistics coordinators, who are responsible for ordering the correct articles to the right plants. This is done using several systems, where the order planning mainly is carried out in a system called order planning tool (OPT), and in several other systems. This planning is currently done mainly through manual input of data. The order and delivery process starts when the logistics coordinators receive the S&OP preliminary information about orders for the upcoming period. The S&OP department calls this a "proposed supply plan". The logistics coordinator starts to plan the ordering of material from the Tuve plant and prepares this mainly in OPT. Synchronization between the information received from S&OP and the program process is conducted in OPT. Forecast data is also available in OPT. The logistics coordinators also use the system OM (Order Manager), where the planning of orders is performed. Important to note is this still is a process based on forecast and planning.

The next step in the order and delivery process is to receive the firm/definitive plan from the S&OP department. The firm/definitive plan is completed three weeks before the material is available for packing, which is the same time horizon as for the CBU supply chain. Then, the logistics coordinators plan and execute the ordering of material. All material ordered in the supply chain, with a few exceptions of local sourcing, passes through the Tuve plant, regardless of where it is supplied from or where it is to be delivered. Now, a three-week time span starts, before the packing of material starts. Here, the main planning and execution of orders are conducted. If everything proceeds as planned during these three weeks, the logistics coordinators do not adjust anything. If they receive information regarding errors or quality issues in the input data, they adjust accordingly.

The packing usually takes one week from start to finish. Usually, the logistics coordinators are not active between the start and the finish of the packing. When the packing is done, there is a closing of the order. This, as the order departs with ocean freight after the packing is complete, eliminating the possibilities to modify the order. Several systems now start to be involved, used for invoicing, tracking, customs declarations, etc. To build a truck through a KD strategy, there could be large variance in how many articles are needed. Figure 4.4 shows a timeline over the order and delivery process, and also the receiving and unpacking process.

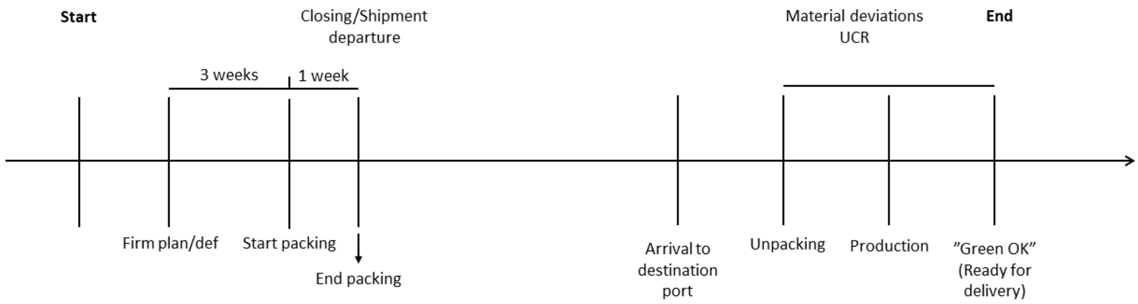

Figure 4.4: Timeline of the order and delivery process.

The systems used for the order and delivery process are often old and complicated to use. Many of the systems have been exchanged for modern solutions in the main supply chain but are still used at IM. There has been some updates but automation between systems and visibility of processes is still lacking.

4.4.3 Receiving and unpacking

Receiving and unpacking is the process undertaken when the KD material has arrived at the receiving plant and awaits further assembly. The receiving is the physical process of getting the material into the plant but also the function of import and customs declaration. The unpacking takes place after this and is done manually using checklists. A project called TruckMaster 1 (TM1) is currently under development where this process is going to be updated. When implemented, barcode scanning will be used instead of pen and paper. It is at this point unpacking control report (UCR) deviations should be detected and claims conducted. The packing sequence requested by the receiving plant is important, making it easier for the receiving plant to unpack and stow the material received in an efficient manner.

UCR

The unpacking control report is an important part of the order and delivery process, where digitalization efforts have been put in recent times. This activity considers the situation when goods are delivered to a KD plant, and there are damaged or missing goods. If these damaged or missing goods need to be replaced, this is done through a UCR. Consequently, it is essential this process is possible to realize smoothly, without time-consuming and demanding activities. Today, the situation is almost the opposite, and when errors occur in this process, resources are needed. When errors in the incoming orders are identified in the receiving plant, workers must manually report what is missing or damaged. This information is sent by email to the order and delivery department in Gothenburg, who then requests extra material from the material controllers at the Tuve plant. If this request is accepted the material is packed and sent by air freight to the concerned plant. No steps in the UCR process are done automatically. The essential nature of this process for the plants' processes running smoothly makes improvements in this area severely demanded.

Currently, IM is implementing a new solution in the UCR process. This solution is an application, which could simplify and fasten this resource-demanding process. The solution is being implemented in the plant in Hosakote, India. If the result of this digital solution is financially and technically positive, further implementation on other plants will be carried out. Instead of handling all UCRs manually, this app will enable the workers responsible for UCRs at the receiving plant to take a picture with their cellphone camera. The app will then use this picture to analyze what is missing or damaged in the received goods and file an automatic UCR. As this yet only is a pilot project, the implications of the implementation are still unclear. However, the employees have a positive outlook on this project, with high expectations of it increasing speed and quality of processes.

4.4.4 Systems used in the supply chain

In total, Volvo uses over 1000 systems, most of them built by the company itself. Many of these systems could be classified as outdated, and many of them are classified as legacy systems. A map of the systems used in this thesis' unit of analysis can be seen in Figure 4.5.

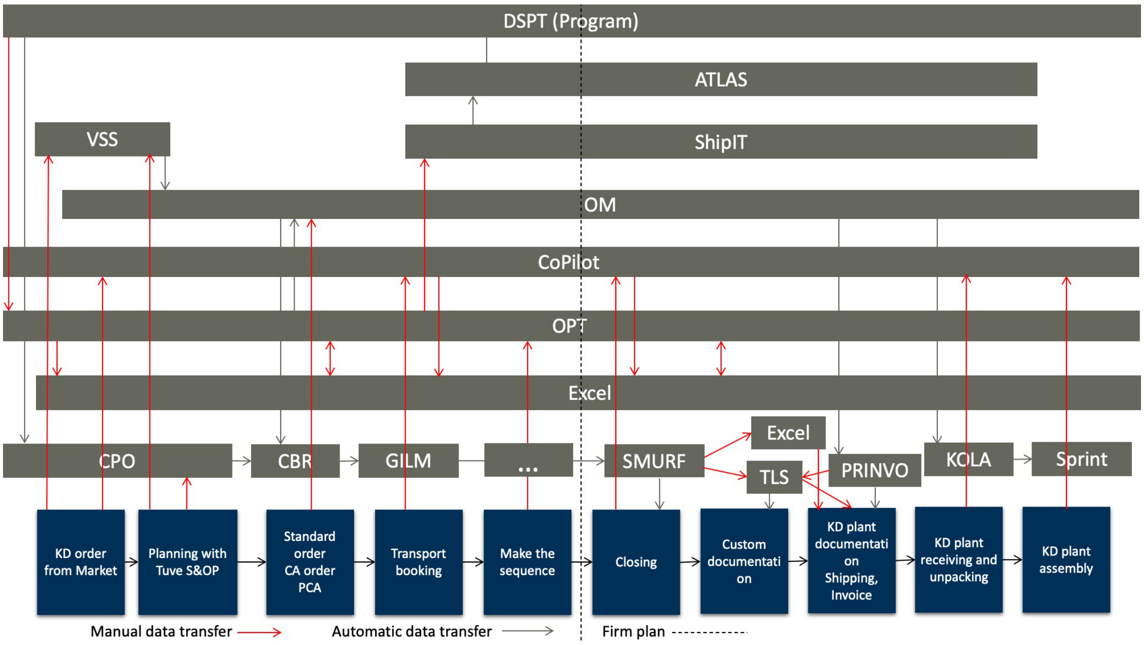

Figure 4.5: Map of the systems used in the IM supply chain and their connections.

The systems mapped in Figure 4.5 are listed and described in Table 4.4.

Table 4.4: List and description of systems used in the IM supply chain.

System	Description
ATLAS	Advanced Transport Logistics for Automotive Supply (ATLAS) is Volvo's system for freight booking. The system is connected to a number of freight suppliers' booking systems and is used by IM to book ordinary shipments to all markets. UCR shipments are booked in a separate process, and to monitor shipping progress. ATLAS is currently not connected to any of the other systems IM uses to visualize and monitor the supply chain processes, as OPT and OM. Thus, changes in shipping time or delays are not automatically transferred to the internal supply chain planning tools used.
OPT	Order Planning Tool (OPT) is the system used for visualizing and planning the KD manufacturing process. In this system, planning, packing, closing, shipping, unpacking, and assembly are planned and visualized in a comprehensive way. The system is mostly updated manually, especially when handling shipping or assembly delays occur. It is however updated automatically with new shipments from forecasts.
OM	Order Manager (OM) is the main customer order placement tool at Volvo. Related to the KD supply chain it is used by S&OP and the KD assembly plants together to place orders. It communicates with OPT and it is not possible to place an order in OM if this order is not planned in OPT.
COPILOT	COPILOT is a supporting system used mainly for monitoring the actual supply chain progress. COPILOT is updated manually, and the accuracy of the system heavily relies on correct data being manually input by many different functions. COPILOT is used from order placement to truck delivery and is mainly a tool for visualizing the progress of operations.
DSPT	A high-level planning tool much like an ERP system. Both OPT and CPO get their forecasted truck deliveries from DSPT.
CPO	CPO is used when the volume and capacity planning have gone through the S&OP progress. If sales forecasts are accurate the volumes are sent from DSPT to CPO. Otherwise, the volume plans are corrected in CPO.
CBR	CBR takes the volume plans from CPO and breaks the trucks down to article level. The system receives input from OM on exactly what kind of trucks are ordered.
GILM	Global Inbound Logistics Management (GILM) is the system used to put supply orders in Volvo. When putting an order towards GILM it first checks if the supply is in stock, if not, the system places a call-off from the supplier.
MH	In the systems map above, MH represents a number of systems working automatically together from the supply call off to the assembly line or in this case the packing area where the material is ordered to. These systems are automatically connected to both GILM and SMURF.
SMURF	SMURF is used to associate articles in an order to a specific package, carrier, and shipment. It is also used for dispatching orders and to calculate invoices. SMURF is semi-automatically connected with TLS and PRINVO.
TLS	TLS is an invoice and customs declaration formatting tool with the possibility to either print documents or send them via EDI to customs or customers. It is connected to SMURF and can make invoices based on information from SMURF semi-automatically with a manual trigger.
PRINVO	PRINVO is used for making invoices for complete trucks. PRINVO gets information about the cost of trucks from OM and sends this information to TLS where an invoice is formatted and can be managed from there.
KOLA	Konstruktion Lastvagnar (KOLA) is used by the assembly lines to know what material is supposed to be used for each truck built. The system receives the specific orders from OM.
SPRINT	A development of KOLA where every step of assembly is illustrated, and in which sequence it is supposed to be done.
ShipIT	An interface used for freight booking, recently implemented. Connected to ATLAS and mainly adapted for the CBU flow. Part of the OIC. Used by IM as an interface to book via ATLAS.

4.5 Setup and product of IM

The final product of IM and the entire KD supply chain is the same final product of the CBU supply chain. However, the main difference of the supply chain is constituted in the production method. The supply chain structure also differs a lot within the KD supply chain, as the setup differs for the different plants in the supply chain. However, the main idea is the same for all KD plants. IM ships material in kits, which the plants then put together into complete trucks. Depending on the chosen postponement strategy, the kits shipped to the plants to build truck shifts.

4.5.1 Levels of KD cooperation

The different level of cooperation is classified in four levels: Fully owned by Volvo, owned partly by Volvo in a joint venture (JV), contracted assembly and private partners. In Table 4.5, it is illustrated which of the IM plant belongs to which level. In Figure 4.6, it is illustrated where these different plants are located.

Table 4.5: List of location and level of KD cooperation for IM's plants

Fully owned by Volvo	Partly owned in JV	Contracted assembly	Private partners
Durban, South Africa Wacol, Australia Hosakote, India	Meftah, Algeria Jeddah, Saudi Arabia	Kuala Lumpur, Malaysia Taipei, Taiwan	Baghdad, Iraq Nairobi, Kenya

In Figure 4.6 below, a geographical map illustrating the information in Table 4.5 can be seen.

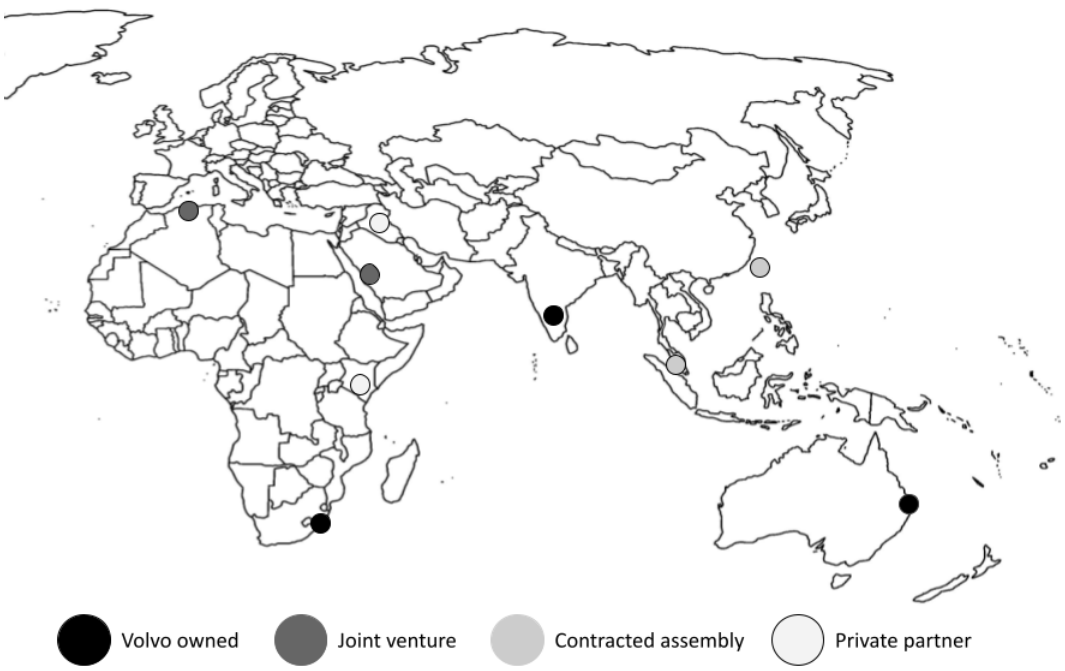

Figure 4.6: Map of location for each plant and their level of KD cooperation.

Further, the different KD setups used by Volvo are presented and described in Table 4.6

Table 4.6: The different levels of KD cooperation.

Level of KD cooperation	Description
Fully owned by Volvo	Volvo owns the entire process, including the plant. On this level, Volvo considered a KD solution beneficial, but still has full ownership of the entire supply chain. Often, the case where Volvo has had a strong, far-reaching presence.
Partly owned by Volvo in JV	The KD plant is here owned by Volvo together with an external company. The responsibility is shared with the venture partner. This is more common where Volvo wants to build a stronger presence but does not have desired knowledge or understanding of the market yet.
Contracted assembly	Volvo owns the process until the assembly of the trucks. At this point, another company which Volvo has a contract with, takes over the assembly and ownership.
Private partner	The entire receiving part is externally owned. In this case, the best solution for Volvo was to assign the entire assembly to the external contract, often because of local regulations. This leads to less process responsibility, but also less insight and control.

In Figure 4.7, some of the existing KD configurations are illustrated.

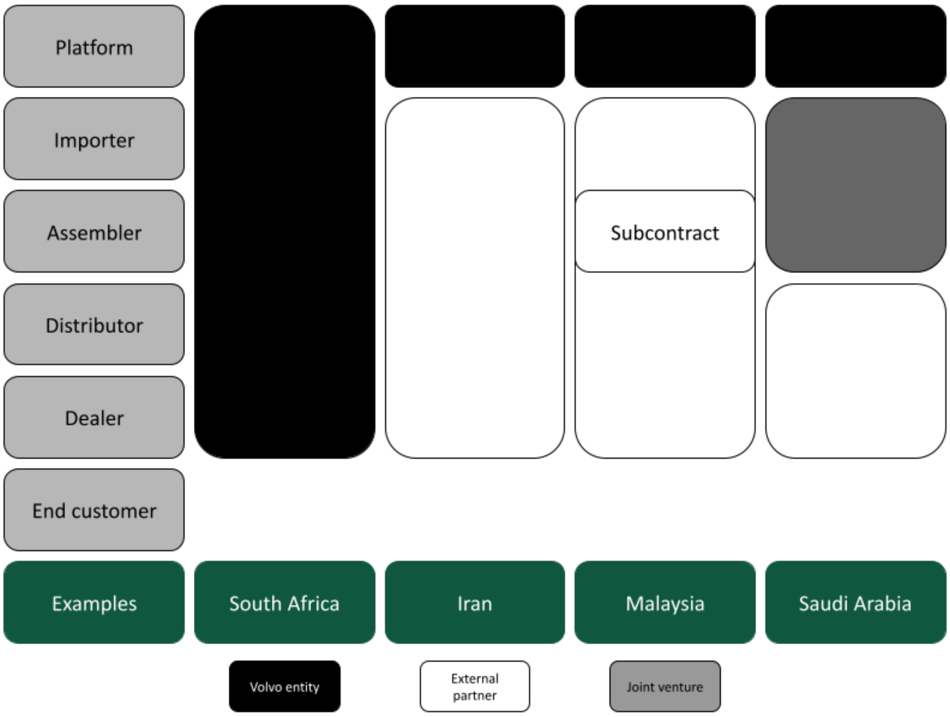

Figure 4.7: Existing KD configurations.

4.5.2 Synergies with CBU flow

Both Volvo's and IM's objective is the KD supply chain should not be separated and independent from the CBU supply chain. Rather, corporate management seeks synergies between the KD function and the CBU function. The importance of cooperation between the supply chains was emphasized by interviewees at IM. In some cases, this works well, and KD can utilize technologies or systems developed and used by the CBU flow. The CBU flow has a more prominent appearance, and more financial resources. This may give the CBU supply chain opportunities to develop systems and solutions the KD supply chain does not have resources available for. Synergies can also be present in manufacturing technologies and shipping. The benefits can also proceed in the opposite direction, where the CBU supply chain is able to use the KD supply chain's solutions. For instance, prototypes could be tested in the KD supply chain, as the financial stakes are not as high as for the CBU supply chain. If these prototypes lead to improved results, they can later be implemented in the CBU supply chain. Also, the sending plant should use the same system as the CBU supply chain. Furthermore, the receiving plant's system should be possible to integrate with the sending plant's system, if needed.

Even though these synergies are sought by corporate management, many employees within IM and the KD supply chain often feel KD is left behind the rest of the Volvo organization. This, as all the resources available, are allocated to the supply chain with the most importance, leaving KD lagging. This is a feeling shared by several IM employees interviewed and could lead to a digitalization gap between the different divisions. Eventually, this may lead to problems in the cooperation between the supply chains, as they may have too different technological requisitions.

It is also important to emphasize the inbound supply chain of IM is the same supply chain as for the CBU process of the Tuve plant, which is Volvo's main manufacturing site in the world. This effectively makes the Tuve plant, Volvo's largest manufacturing site, the main supplier of IM's operations. This part of the supply chain is considered out of scope and is regarded as sufficiently digitalized. However, the part of the supply chain mentioned as the outbound supply chain, from the Tuve site to the KD plants, is perceived as neglected in many aspects by the interviewees.

4.5.3 Logistics principles

For the KD supply chain, Volvo has some important logistics principles other than the integration with CBU. The system information by the sending plant should be easy to interpret by the receiving plant, and possible to use without modification. The sequence to build trucks is firmly planned, and the production is done using batches from the sending plant. KD only uses local sourcing when necessary, because of local regulations or specific requirements. If local sourcing is needed, cross-functional validation is conducted. The sending plant is responsible to provide all UCR replacement parts if local sourcing is not used. The shipping plant is also responsible for logistics preparation activities (customs declaration, taxes, etc.) and kit breakdown.

4.5.4 Processes

At IM, the main objective is to provide the factories in the KD supply chain with the right material, at the right time. As this supply chain sustains 11 plants on three continents, it must be considered a complex supply chain with high demands. Due to this complexity, it is important the digital and automated processes present are supporting the physical supply chain and are easily understood.

To understand IM's process holistically, it is important to understand its parts. Therefore, the unit of analysis in this thesis is divided into sub-parts, to convey the current digitalization situation of IM more distinctly. First, the S&OP process is described, and the digital solutions used to facilitate those activities. Secondly, the order and delivery process and its digital infrastructure are displayed. Also, empirical data have been collected from persons within IM's Digitalization and IT department, which functions on a strategic or tactical level, rather than operational. As the unit of analysis is the outbound supply chain of IM, only activities inside the unit are included in the scope of the case study. However, data about other parts in the same supply chain was collected as well. This, to be able to make comparisons and draw conclusions of the digitalization progress in the concerned supply chain.

4.6 Digitalization activities

Like most divisions in a large manufacturing company, there are ongoing activities supporting digitalization. IM has a department for digitalization and IT, with responsibilities both when it comes to continuous IT service as well as long-term digitalization.

4.6.1 Digitalization and IT department

The Digitalization and IT department functions both as an IT service for the entire IM division, as well as one of the main drivers of digitalization efforts. The department is small, consisting only of three people. Mostly, the department drives minor projects in the plants. They also have some larger projects spanning over a longer time. The employees working with digitalization and IT at IM have backgrounds either at Volvo IT, an internal IT consultancy firm or within logistics at Volvo Group. Due to the minor size of the departments, it is often hard to develop and implement larger projects. According to the interviews, the decentralization of IT at Volvo may at have led to larger projects being postponed at IM.

Currently, the department develops systems meant to increase visibility and connectivity within IM, among other projects. However, there are problems with developing new solutions when the underlying systems used are outdated. For several years, a discussion about exchanging these systems has been ongoing. However, this has not yet been done. This means many of the updates currently done are only functioning as temporary fixes.

4.6.2 Applications

As a part of the continuous digitalization effort at IM, some applications supporting the IM processes have been developed. Some of these applications have been developed for increased visibility and/or connectivity and are at this time Windows Office 365 applications. These apps are, according to the interviewees, easy to develop and possible to integrate with existing systems. Whether these applications are a part of the future of information systems within IM is currently unclear. The agility and adaptability as well as the simple and user-friendly interfaces of Windows Office 365 applications are beneficial for a smaller organization as IM. However, these systems are not rigid information systems built for a larger, highly connected organization. IM risks becoming isolated from the larger Volvo organization if relying too much on these applications. Further, the question about the technical support of these applications is not currently resolved. Since the Digitalization and IT department at IM is the current product owner, the responsibility for IT support is theirs. This might be a viable solution as of now, but when the applications built reach wider use, this will become unsustainable for a minor department.

4.7 Summary of case study

The case study conducted mainly consisted of unstructured interviews, a survey, and two verification workshops. The only other means of data collection used were excerpts from Volvo's and IM's internal documents. The purpose of the case study was to map IM's processes but also to identify which concepts the employees view as important for further digitalization and what is currently hindering this process. A brief summary of the activities performed in the case study can be found in Table 4.7 below.

Table 4.7: Summary of activities performed in the case study.

Activity	**Summary**
Interviews	The interviews were the main source of information in the case study. The unstructured form allowed for maximum information transfer. The interviews contributed with information on the digitalization level of IM and information of IM's structure and how the processes work. Through the interviews two key concepts, almost every interviewee mentioned or discussed were identified. These were *change management* and *data availability*. Other than this, the interviewees were asked to describe their work process to enable the mapping of IM's processes. The interviews were followed by two verification workshops, where the interviewees had the opportunity to discuss and propose improvements to the developed solutions.
Survey	The survey was used to quantify the part of the interviews which were focused on digitalization concepts. From the survey, it was found that the concepts deemed important by the interviewees also were concepts important to the survey participants.
Supply chain mapping	Through the interviews and excerpts from Volvo's internal documents a holistic mapping of the processes undertaken in the daily operations of IM was conducted. This mapping was made to get an overview of how IM operates but is also a part of the deliverables for IM. This, since a similar mapping over systems and processes has not been done before. This mapping also provides an overview of how sufficient the current digitalization is, and which areas where there is the largest potential for improvement.

5 ANALYSIS AND RESULTS

In this chapter, the context of the case, the theory, and the empirical data is analyzed. By analyzing the theory and empirical data together and presenting the results, the case analysis aims to provide answers to the RQs of this master thesis. Further, the relevance and importance of these answers are analyzed with regard to achieving the purpose of this master thesis. The objective of this chapter is to provide clarity, structure, and understanding of the data collected, presented, and analyzed.

5.1 Characteristics of the IM supply chain

IM's supply chain is characterized by the KD postponement strategy used. This postponement strategy is mainly what makes IM's processes special and is why an agile and adaptable supply chain is needed. According to Interviewee C, this particular supply chain has existed since the early 2000s. The supply chain is the result of a long-term build-up, as Volvo has used KD postponement strategy since 1956. Plants, systems, and activities have been added over time, resulting in this complex and intricate supply chain. Although of high complexity, the IM supply chain is internally viewed as a highly functioning and profitable part of the entire Volvo organization (Eriksson, 2021). Regardless of the historical and current success of this division, the case study highlighted there are several areas where IM as an organization lacks understanding of how to benefit from Industry 4.0 and digitalization. In Section 5.1.1 below, an analysis of the digitalization in the operational activities performed at IM can be found. In the following section, analyses of tactical and strategical activities divided into relevant subsections are performed. The reason for not dividing the analysis on strategical and tactical activities is that these are strongly connected to each other and therefore hard to distinguish. Rather, they concern the organizational traits of IM, and is consequently divided into subsections relating to IM's organizational characteristics.

5.1.1 Operational activities

Today, a large part of the focus of the employees working operationally in IM's systems is to execute in these systems, according to Interviewee C and Interviewee E. By this, they are ensuring supply chain activities throughout the flow are performed according to plan. These executions are often to order and prepare goods (customs and tax declaration, etc.), making sure the order and delivery process follows the plan and the goods are ready for shipping. Another main task of the employees working operationally is troubleshooting, meaning they must identify occurred problems or errors in the processes, and resolve these problems. This is a time-consuming process, especially given the complex infrastructure of the systems used. The objective is the ongoing and future digitalization activities will create a shift in focus from the current operational activities, where execution and troubleshooting are central, to focusing more on monitoring and control. The importance of this shift was especially emphasized by the interviewees working operationally, Interviewee C and Interviewee E. Even so, this was reiterated by most of the interviewees, regardless of their level of management. One of the main objectives of implementing new, digital solutions in the administrative part of the supply chain is to create a shift from a reactive to a proactive approach. This change in the digital approach, from reactive to proactive, was a concept often discussed by the interviewees. It was emphasized this was one of the most important areas for IM to achieve, for successful digitalization. This change in approach, and what it means practically for IM, is clarified in Table 5.1.

Table 5.1: Example of IM activities before and after a change in digital approach from reactive to proactive.

Reactive approach	**Proactive approach**
Manually receiving UCRs, and sending replacement goods based on lists	Automatically sending replacement goods based on automated UCRs in the application
Identifying problems in shipments by analyzing the data manually	Problems are identified automatically or at least more easily, through high degrees of visibility and visualization and a change in behavior
Digitalization projects only on request or as temporary solutions	Following an ambitious digital strategy with continuous digital improvement

With digital tools reducing the need for manual inputs, as the automation of an information flow between two systems (e.g. RPA), the time spent on the reactive tasks is expected to decrease, according to Interviewee C and Interviewee E. The consistent need for manual input represents one of the most pressing issues in IM's operations. The manual input is one of the activities where most errors appear, according to the interviewees. An example of this is the UCR process, where manual input is needed to order replacement parts. This process requires several manual inputs meaning many resources are spent on this. Manual input means a higher risk of mistakes that will have to be corrected, meaning even more resources are spent on this process because of the frequent errors. If this instead is to be done automatically, based on the receiving plant's report of which articles are missing or damaged, fewer resources would be considered. The UCR process and the UCR application under implementation described in Section 4.4.3 is an example of digitalization efforts taken to simplify and improve this part of the process, where manual input will be reduced.

To reduce time and resources spent on troubleshooting, increased visualization is essential. If the information used in the supply chain processes is visualized correctly, it becomes possible to understand at what point in the flow problems or errors have occurred. This means, less time will be spent on finding what is wrong, and more time could be spent on solving the occurred issues proactively. In an ideal scenario, the problems or contingencies would not occur at all. However, given the setup of the supply chain, this is not a likely scenario. Therefore, a more useful and viable solution for the operational tasks in this supply chain is focusing on making problems easier to identify and solve. Altogether, the objective of the automation of the operational tasks is to move the focus towards monitoring and control. This will extricate more time and resources, which could be spent on improving the processes. The automation is not supported by a general business case but is seen as an unavoidable step to maintain IM profitable and competitive. The desire expressed by the interviewees, to move from primarily executing and troubleshooting towards primarily monitoring and controlling, characterizes the ongoing digitalization process of the entire supply chain. This is also seen as a key digitalization factor in the literature, by Moeuf et al. (2020).

By focusing more on monitoring and controlling, the interviewees accentuate the possibility to improve process performance. If less time were spent on finding and solving problems, the interviewees mean more of their time can be spent on preventing the occurrence of these problems in the first place. This coincides with the shift of IM from being digitally reactive to digitally proactive. It is currently unclear whether reduced manual input and time spent on troubleshooting can be converted into improved processes and fewer issues in the supply chain. Still, this shift is closely related to the overall digitalization discussions at IM, both strategically and tactically, as well as the views of automation in the research literature. The shift of automating operational activities is illustrated in Figure 5.1.

Figure 5.1: Current and future state of the operational activities performed.

5.1.2 Complex system infrastructure

Given the high complexity in the systems infrastructure discussed in Section 4.4.4, updates and maintenance become more advanced activities with higher technical requirements, as each system often has to be managed on its own. This is resource-demanding, and obstructs the digitalization work in general, as large updates and replacements of systems are not possible for IM employees to perform. As described, the expectation is the number of manual inputs in the systems can be minimized with digitalization, which will lead to more opportunities of proper management and understanding of the complex systems infrastructure. It is not in the scope of this master thesis to propose a replacement of the outdated systems to create a more adapted systems environment. This would require a complete transformation of how the entire division works, something not reasonable to expect in the foreseeable future. The situation instead must be managed from these conditions, and by reducing manual inputs and transitioning from troubleshooting and execution, the negative effects of the complex infrastructure present can be decreased.

There is another apparent problem with many of the systems used today, around 50 percent of the systems used at IM are legacy systems. (A definition of legacy systems can be found in Figure 4.1.) As the interviewees acknowledge, this is hard to avoid when systems have been added on for 50 years. Some systems will after time become outdated and keeping them up to date would be practically impossible due to the time and/or financial resources this would require. This creates a situation where many of the systems used are not adapted to the new environment of Industry 4.0. As many of these older systems have been classified as legacy systems for a longer time, the willingness of Volvo management to replace these does not seem to be strong. By having many legacy systems, consequential problems are created. For instance, at IM, several persons have been working in the same position for decades. These persons may often know how to use some of the older and outdated systems and are through this knowledge the unofficial internal expert on these systems. This means when this certain employee retires, this knowledge will be lost if measures to communicate this knowledge are not taken. Then, knowledge gaps will emerge, and the organization is forced to either make substantial system updates or spend even more resources on maintaining and understanding the outdated systems.

There are several methods to increasing digital maturity within an organization. Updating and replacing old systems is not the only step needed to be taken, but it would certainly facilitate the digitalization process. This is not the chosen way forward, interchanging the older systems and creating a new environment more adapted to Industry 4.0 technologies. This means the legacy systems will be part of the change, and the digitalization must be made accordingly. Yet, there is an obvious need for a line of action regarding the future knowledge of how to use these systems.

5.1.3 Lack of resources and competences

Another main characteristic of IM is the lack of resources allocated for digitalization, which was discussed by all eight interviewees working at IM. Starting with the Digitalization and IT department, it consists of three persons. This department supports the IT activities of a division with around 200 office workers and 650 plant workers, and in addition, also facilitates and supports the implementation of various digital solutions at the plants. Knowing this, it is obvious the Digitalization and IT department and the rest of IM do not have the workforce present to also sustain successful digital development at IM. This was particularly emphasized by the three interviewees from this department, Interviewee B, Interviewee D, and Interviewee F, and was also echoed by the survey answers. This, in combination with the perceived lack of management focus on digitalization discussed in Section 4.3 illustrates one of the main problems when understanding how IM's characteristics affect the digitalization process.

More resources are needed for the department focusing on this, the Digitalization and IT department. Now, most of the focus from this department is spent on troubleshooting and short-term problem solving, much like the situation of the order and delivery department described in Section 4.4.2. This could primarily be classified as a workforce problem, where there is a need for more people handling the current activities for digitalization. This would create more time and opportunities for digital change management and provide possibilities for the Digitalization and IT department to focus on long-term, large-scale and strategical digitalization projects.

Table 5.2: Tasks performed by the Digitalization and IT department.

Tasks performed by Digitalization and IT today	Proposals of future tasks performed by Digitalization and IT
• Supporting IT processes at IM and in the plants • Implementation of systems throughout the KD supply chain • Short-term problem solving	• Large-scale digitalization projects • Performing and supporting digital change management • Long-term problem solving

Another important issue, accentuated by interviewees both within and outside the Digitalization and IT department is the absence of the right competencies for Industry 4.0. Here, several interviewees discussed recruitment as the primary tool for increasing competence and securing long-term competitiveness within digitalization for IM. Interviewee F stressed the importance of a recruiting function with full insights in IM's digitalization issues, to be able to recruit accordingly. Currently, there does not seem to be sufficient communication between departments within IM to ensure future digital competencies. Possibly, IM would benefit from creating a framework for which competencies are believed to be most important for an organization working in Industry 4.0, and use those for recruiting measures. Currently, there seem to be organizational silos, where information of which abilities and competencies are most needed are not communicated between departments. The change of focus coming from more efficient use of resources is illustrated in Figure 5.2.

Figure 5.2: Current and future state of digitalization resources.

5.1.4 Dependence of CBU flow

Another crucial factor to keep in mind when discussing this supply chain is its relation to the CBU supply chain. Given the size of the physical and financial flow of the CBU supply chain, IM shrinks in comparison. While IM makes up around 7 percent of the volume compared to the CBU flow, it still must be considered a large supply chain (Eriksson, 2021). By all interviewees with positions within IM, the flows and plants are described as minor or small even though it would probably be considered as a medium-sized to large company if seen as an entity.

A factor mentioned by almost every interviewee when discussing IM's characteristics is its relationship to the CBU supply chain. As described above, the yearly volume of the KD flow is just 7 percent of the CBU flow. Therefore, there may be a absence of desire to spend resources on the improvements of IM's digital process. This, as a major improvement or change of IM's processes, will not affect the main flow of Volvo, where more resources could be saved if the implementation is carried out there instead. Considering a solution where the savings are on a certain share of the turnover, the total savings will be higher for a supply chain with higher turnover. This dilemma was discussed by the interviewees, how appropriate focus of resources should be allocated by corporate management to the improvement of IM. This was described by the interviewees as one of the main factors characterizing IM's current supply chain. Adaptations and adjustments according to the CBU supply chain characteristics must be done constantly, for example when using systems not at all optimized for IM's processes. An example of this is the order management system, OM, which Interviewee E described as not adapted to IM's processes and difficult to manage. Since this system is customized for the CBU flow, Interviewee E describes this system as forced onto the IM's processes.

On the contrary, the dynamic between the flows may also function in the opposite direction, where IM in some respects benefits from being the smaller, financially less important actor in the relationship. Interviewee F described situations where projects have been rolled out as pilot projects at IM, as the financial stakes are not as high for the KD supply chain as for the CBU supply chain. This could be exemplified by certain systems used by the receiving plants, firstly being implemented at the KD plants. If the implementations of these systems were deemed successful, they later was implemented in the CBU flow in some cases. This dynamic between the major CBU flow and the minor IM flow has to be remembered when implementing new digital solutions and can be viewed both as an enabler and as a challenge for further digitalization. When transforming IM into Industry 4.0, this must be done in close cooperation with the rest of the Volvo organization to have access to needed resources and knowledge. However, since IM has its unique flow with specialized needs, IM also must develop its digitalization, to not be too dependent on the CBU supply chain.

5.1.5 Neglect of supportive functions

Interviewee I suggested technological upgrades and investments in process improvement are more common on the shop floor and in the physical supply chain flows than in the supporting, administrative functions. According to the interviewee, this might be due to the higher degree of measurability in process improvement coming to physical flows. Reductions in material, direct salary, or lead times are easier to measure and relate to actual costs than the benefits of an updated and integrated system.

Further, Interviewee I expressed their concern neither Volvo or IM is ready for the ongoing technological shift, where office workers for the first time might be replaced by system automation and other cyber-physical processes. As discussed in Section 5.1.1, automation leads to a shift in focus from execution and troubleshooting to controlling and monitoring which frees up time. From this, Volvo can either decide to decrease the workforce or change the roles from strictly operational to a more tactical role with a part-time focus on process development and other improvements.

5.1.6 Activities facilitated by information systems

In the case study conducted, a map of operational activities carried out by the order and delivery department and the information systems facilitating these activities was developed. This map was developed to understand if the activities were sufficiently digitalized or digitally neglected. The map can be found in Figure 5.3 below.

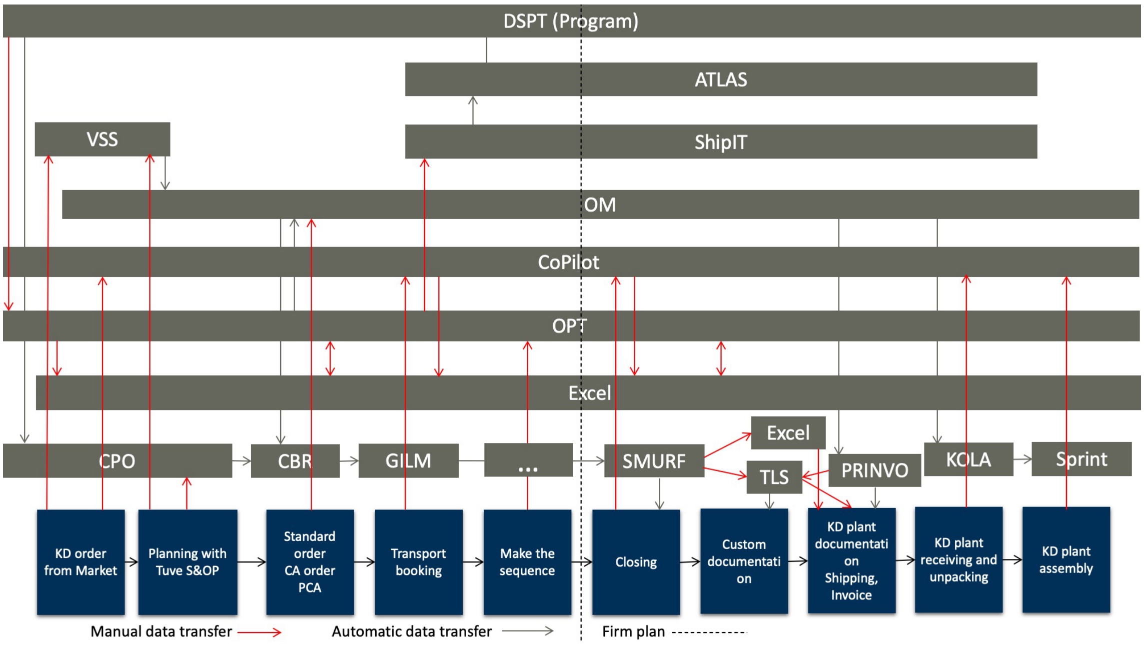

Figure 5.3: Repetition of map of the systems used in the IM supply chain and their connections, highlighting neglected digital processes at IM.

By analyzing this map it is possible to see the operational process of IM's order and delivery department is digitally neglected for almost every activity performed. In this process there are at least 21 occasions where an operator needs to transfer information between systems manually.

5.1.7 Summary of IM's characteristics

In Table 5.3, the current and future, aspiring characteristics of IM's supply chain are listed.

Table 5.3: Characteristics of IM's current and future supply chain.

Characteristics of IM's current processes	Aspiring characteristics of IM's future processes
Traits: • Complex system infrastructure • Frequent manual inputs • Focus on execution and troubleshooting • Low degree of visualization and visibility	Traits: • Minimized manual input • Focus on monitoring and controlling • High degree of visualization and visibility • Adaptable and agile processes • Change management is performed
Challenges: • Adapting and adjusting from CBU flow • Lack of resources and competencies for digitalization • Proper use of change management	Challenges: • Adapting and adjusting from CBU flow • Maintaining digitally updated • Use existing and available data • Maintaining the right competences

5.2 Characteristics of a digitalized supply chain

In the literature, a few key concepts characterizing a digitalized supply chain were found. These concepts were linked to connectivity, data availability, automation, and adaptability. These concepts are supported by some technologies often associated with Industry 4.0, like IoT, AI, and big data analysis (Hofmann & Rüsch, 2017). Through the empirical data collected, it can be seen that the digitalization work already undertaken at IM and the work required is closely related to several of these concepts. By comparing the theory and the empirical data collected, three major concepts important for the digitalization effort at IM were identified: *Automation and connectivity*, *visibility and visualization*, and *effective use of existing data*. There are of course many other concepts related to supply chain digitalization which would be beneficial for IM. However, due to the limited time frame for this thesis only concepts with prominence in literature or high frequency of occurrence in the interviews were chosen for further study.

5.2.1 Automation and connectivity

As described by Hofmann et al. (2020) and van der Aalst et al. (2018), simple, repetitive tasks can be automated by connecting and integrating information systems, either through RPA or conventional back-end integration. This kind of automation is important because it does not only free up time to work with more important and demanding tasks, but also eliminates the risk of human error when transferring or modifying data. By working towards integrating systems to work together, many simple tasks can hopefully be eliminated.

Automation is important for companies transitioning their digital approach from reactive to proactive, as it enables employees to put greater focus on monitoring and controlling. If a company seeks to reduce manual tasks and input, automation should be highly prioritized. In the research literature, automation is regarded as one of the most important aspects of Industry 4.0 (McKinsey & Co, 2015). Manufacturing companies cannot disregard this aspect of digitalization if they want to stay competitive, and management must ensure the right competencies for further automation is available (McKinsey & Co, 2015). Important is also employees' understanding of the importance of automation, to create a sense of urgency in this particular change process.

5.2.2 Visibility and visualization

Increasing system visibility ca lead to increased control of the supply chain and is important in a digitalized supply chain. Sufficient visibility means it is always possible to track articles in the supply chain. As noted by Berinato (2016), systems with high visibility lacking sufficient visualization tend to get complicated to understand, and this often results in visibility only for people with extensive knowledge of systems and processes. The same author acknowledges utilization of visualization tools makes this information available to a larger group of people. BI software is an example of visualization a tool further increasing system visibility through visualization by making data available for less informed employees. As discussed in Section 3.3.2, BI can be used for management to make more informed decisions, as greater process insight is received.

In more sufficiently digitalized supply chains, both visibility and visualization are key features, according to McIntire (2014). Without process insight, it will not be possible to take the most optimal decisions. If there are many factors to consider, such as several flows, plants, and markets, KPIs for these factors need to be available and easy to understand, as McIntire (2014) notes. One of the most important objectives with digitalization is to make data earlier only available to experts possible to use and understand for a wider group of employees, including employees on higher management levels. It is also essential to minimize both the number of errors occurring and the time spent on troubleshooting, according to the same author. This, as high visibility and visualization enable users to see where in the flow problems have occurred, why it becomes easier to take measures for avoiding these problems. In general, a digitalized supply chain must have high visibility and visualization for it to utilize existing data and automation (McIntire, 2014).

5.2.3 Effective use of existing data

Supply chains seeking to utilize technologies of Industry 4.0 need to acquire full control of their data. Fosso Wamba et al. (2015) suggest the most necessary data already exists within the organizations, and the main issue relates to not knowing how to make it available and use it correctly. Often, the availability of the data is the problem, according to them. Effective handling of data can be reached by finding the right way of storing it, making sure the data saved is relevant and of sufficient quality. As Fosso Wamba et al. (2015) note, a plan of how to utilize the data saved is needed for large digitalization projects to succeed. A large database with unstructured data of varying quality is not effectively available data. However, structured databases with a plan of how to utilize the stored data is an example of this, and then the organization also can utilize it.

As described by McIntire (2014), in most modern supply chains, data is constantly collected throughout the flow, from several data collection points. This often generates huge amounts of data which, if used correctly, could create more understanding of the process, and provide tools for optimization, according to the same author. As BI or other similar tools could facilitate making the data more available, it is also essential for employees involved to create an understanding of the importance of using the data. It is not enough to have high data availability according to McIntire (2014), there also must be a demand for the data. Also noted is an understanding of why the data, and how it will improve overall processes is important. When discussing successful digitalization, the effective use of already existing data is often regarded as an enabler (Moeuf et al., 2020). Therefore, making use of the already existing data represents one of the main challenges for companies and divisions in similar positions to IM. If succeeding in this aspect, it is possible to gain a competitive advantage.

5.2.4 Summary of digitalized supply chain characteristics

In Table 5.4, a summary of a digitalized supply chain characteristics can be found.

Table 5.4: Key concepts identified for further digitalization.

Key concept	Traits	Issues solved
Automation and connectivity	• Automation of simple tasks • Eliminate manual data transfers • Further integrate information systems	• Data availability • Data quality issues • End-to-end visibility
Visibility and visualization	• Increasing process control • Making data easily understandable • Relying on a high degree of system integration	• MS Excel documents as information conveyors • Operational uncertainty • Higher degree of fact-based decision-making
Effective use of existing data	• Structured database • A clear data handling strategy • Data availability	• All above • Data ready for analysis

5.3 Comparative analysis

Comparing IM's digitalization process with researchers' views on the digitalization of manufacturing supply chains, there are similarities in identified enablers and challenges. This section aims to discuss IM's ongoing digitalization from a theoretical perspective. It also seeks to clarify how the division can use enablers and challenges for digitalization in supply chains to its benefit, and how management should act going forward. IM has identified the need for digitalization and is organizationally aware of its necessity. Employees at all decision-making levels acknowledge the importance of this transformation. Most of the approached employees have well-defined insights of what is important when achieving successful digitalization, although this is not fully translated to reality in the actions of IM. The issues identified often relate to implementation issues, where there is a lack of knowledge and resources to perform the implementation correctly. Today, there is no clear organizational structure for overall digitalization at the division, and management often acts uncertain of how to successfully achieve it . Even though management commitment is shown to some degree, according to the survey, there is a perceived lack of actions supporting digitalization.

5.3.1 Automation and connectivity

The interviews conducted provided a picture of how IM is working with these key concepts for a digital supply chain. In most of the areas discussed by the interviewees, automation and further system connectivity/integration would be needed. As Figure 4.5 suggests, many of the systems used in the supply chain process are relying on manual input to function and stay updated. These media breaks should be eliminated to reduce unnecessary labor and decrease the risk of inaccurate data, due to incorrect inputs. According to Interviewee H, competence to solve this issue is available from a department within VGTO called Robotic Process Automation. However, whether resources from this department are available to IM or not is unknown. This could be one way forward for automation of processes at IM, but then an implementation strategy is needed.

Automation and connectivity are areas where IM acknowledges large improvement potentials, although earlier work has been done in these areas. This is exemplified by the ongoing implementation of the UCR app, which will reduce manual input and increase automation. The employees are aware of the benefits of automating manual tasks but believe there is a lack of resources for making adjustments. There needs to be a sense of urgency around the automation situation if a larger transformation is to take place, where management realizes the further need for automation and has a clear automation strategy for the outdated parts of the processes. Management should identify paths for digitalization and put resources on understanding for which systems updates and automation is most critically needed. Then, a roadmap for digitalization is easier to develop and follow.

5.3.2 Visibility and visualization

The existing issues with automation and connectivity at IM are among other factors related to the concept of visibility and visualization. With sufficient automation, it would be easier to make data visible, as updated systems would support visibility. Currently, the visibility in the supply chain is acceptable at its best. The current process and its visibility is mainly based on making data visible by transferring it from one system to another, which is a problem. This, as the visibility of the data is largely based on manual work when data is transferred from one system to another by using MS Excel. These activities make information more available and increase the visibility in the processes but at the cost of unnecessary labor and the risk of human errors. These activities should be automated to eliminate these costs and risks.

Important to notice is some of IM's systems show a high degree of visibility and use visualization solutions to communicate this. As an example, OPT is highly appreciated by employees using it. In OPT, visibility and visualization make it possible to easily follow the whole process of packing, shipping, and assembly of trucks from a synoptical order planning perspective. As OPT is not fully connected to every other relevant system, this visibility is not transferred between the systems. I.e., it is not possible to follow other processes than the ones relevant for order planning in OPT. As mentioned, there are many systems not sufficiently connected to other systems, and visibility is therefore reduced in the entire supply chain.

One example of the disconnection present can be seen in shipping process. Here, it is complicated to follow the containers with KD kits being shipped on their way to the assembly plant as this process has low visibility, where the logistics coordinators have no insight into where the containers are located. The low visibility in this part of the process makes delays or lost containers hard to notice, and therefore these issues are also hard to, both automatically and manually, communicate further down the chain. As discussed in Section 4.2, Interviewee C explained there have been multiple examples where entire shipments were not loaded because of errors by the shipping company. These issues have been detected manually, luckily. Deviations as this one would be detected earlier in the process if the shipment systems were integrated into other planning and control systems. It would also be possible to put out alerts for large deviations or other quality issues.

5.3.3 Effective use of existing data

The last key concept identified as being important for IM's digitalization effort is the effective use of existing data. Currently, data is collected in various parts of IM's supply chain, but this data is not regarded as effectively available. Even though this data is collected, it is often scattered and not easily compiled. The issue with unformatted and complicated data can be seen as one of the primary reasons for IM's visibility problems, as this illustrates the lack of effective use of data for improving processes. However, it can also be viewed as a solution for the same problems. By structuring the data created in the supply chain processes, connecting and integrating systems, implementing a reliable data storage solution, and ensuring the quality of the data, the problem with low visibility can be resolved. In the process, automation and data management are achieved. This is one of the main areas where IM can improve its digitalization level and would transfer IM a further into an Industry 4.0 environment. To successfully utilize data already existing within the organization is by theory considered as one of the main enablers for successful digitalization and indicates high digital readiness (McIntire, 2014). Would IM improve their processes' visibility by using existing data, this would be a great advancement in their digital transformation. The problem here is having the right competence for making the right data available. This means understanding of both data technology and IM's internal processes is needed. Overall, this will require many resources and a cultural shift among the employees.

5.3.4 Summary of comparative analysis

In Table 5.5, a summary of the comparative analysis can be found, with a comparison between a digitalized supply chain and IM's supply chain.

Table 5.5: Traits and challenges of a digitalized supply chain and IM's supply chain.

Digitalized supply chain	**IM's supply chain**
Enablers: • Visibility and visualization • Automation and connectivity • Data availability • Resource availability	Attributes: • Low visibility and visualization • Frequent manual inputs • Automation and connectivity opportunities • Data exists and is collected • Lack of resources
Challenges: • Tools and knowledge for data analysis • Efficiently utilize digital capabilities • Agile and adaptable organizational structure	Challenges: • Effective use of existing data • Resources for increasing automation, connectivity, visibility, and visualization

5.4 IM in the Industry 4.0 maturity index

The Industry 4.0 maturity index is developed by Schuh et al. (2020), and is further described in Section 3.4. The index can be used to assess an organization's maturity regarding digitalization and Industry 4.0. The scale used is divided into six steps, where the first two steps are a part of an organization's digitalization effort and the following four are used to assess the organization's efforts in adapting technologies of Industry 4.0. The framework assesses four different areas of an organization and for each area, there are two principles evaluated. In total there are eight different dimensions used to assess the digital maturity of an organization (Schuh et al., 2020).

5.4.1 Digital maturity in company resources

Along the lines of Schuh et al. (2020), the term *resource* refer to the physical resources of an organization. In this case: human resources, machinery, tools, and the final product. The principles used for assessing the level of maturity in the resource area are *digital capabilities* and *structured communication* (Schuh et al., 2020). Due to the limitations of the unit of analysis, resources will in this case only refer to the IM personnel.

From insights acquired in the case study and the criteria presented in the Industrie 4.0 maturity model, it is possible to position IM's digital capabilities at level 2, and their structured communication at level 1. In this case, digital capabilities translate to the employees' competencies within digitalization and Industry 4.0. At IM, the overall capabilities are low in this area, even though the division has programs for further development in place. Also, there are possibilities for an employee to become a superuser for a system. The Digitalization and IT department have competencies in the connectivity area and also some competencies relating to visibility. However, the overall digital capabilities are evaluated to be within the second stage in the model: connectivity.

The structured communication at IM is not developed. Structured communication is related to the way information is communicated in the organization. Communication between employees at IM is not supported by systems. Data is not always stored at a central point, and even though there is a structured way of providing access to files and systems it is not always used as intended. Communication between employees at different sites is either performed by updating cloud-based MS Excel documents or by sending a copy via email. There is little to no automatic connection between the physical and the digital realm using sensors, and most physical data must be manually inputted into systems. In some areas, it is possible to argue IM is at the connected stage of communication. Overall, it is not considered being positioned at a higher level than level 1: computerized. The position of IM's resources in Industrie 4.0 maturity index is illustrated in Figure 5.4.

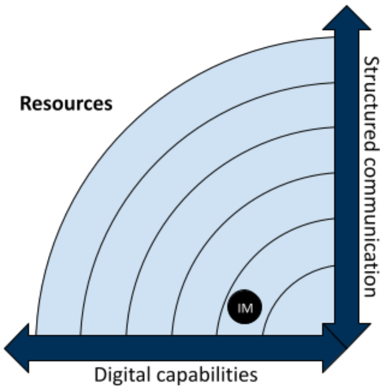

Figure 5.4: IM's resources mapped in the Industrie 4.0 maturity index. Adapted from Schuh et al. (2020).

5.4.2 Digital maturity in information systems

The digital maturity of information systems is evaluated on the principles of *information processing* and *integration*, as described by Schuh et al. (2020). As explained by them, information processing relates to how data is prepared by the systems before transferred to the user, and how well machine learning and AI are used to predict situations in the manufacturing and supply chain process. Integration relates to how satisfactory systems are connected and in what way data is available to the systems and the users.

The information systems used at IM perform almost no data processing or self-learning from data. Forecasts are primarily based on previous demand, systems can forward data to other systems and make easy calculations based on pre-input data on currency exchange, weight, and price of products. No advanced manipulation of data is done by the systems, and most of the systems used have low visibility. Due to no data effectively available, no automatic data analysis is performed. Neither, any real data preparation for the user or visualizations exists. Therefore, the level of information processing at IM is positioned at level 1.

The level of information systems integration is higher, while still flawed. Systems are integrated, connected, and communicate data. However, not all systems are connected. As earlier discussed, manual input is needed where a connection between systems instead could have been implemented. Schuh et al. (2020) discuss a single source of truth when discussing systems integration, meaning all systems should get their data from the same source. This is not the case, since IM does not have a dedicated database for all the information used by systems. Even though some systems offer visibility, it is not true for all systems, and the level of connectivity could be improved. The integration of the information systems of IM is positioned at level 2. The position of IM's information systems in Industrie 4.0 maturity index is illustrated in Figure 5.5.

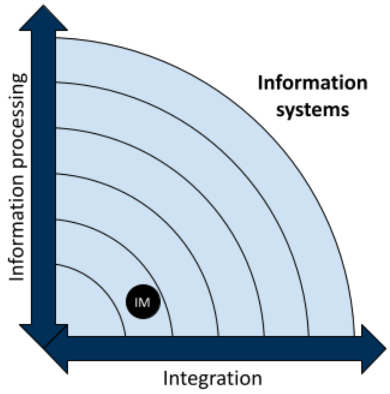

Figure 5.5: IM's information systems mapped in the Industrie 4.0 maturity index. Adapted from Schuh et al. (2020).

5.4.3 Digital maturity in organizational structure

The principles the organizational structure is assessed by are *organic internal organization* and *dynamic collaboration in the value network*, as described by Schuh et al. (2020). The first principle is based on the organization's internal capabilities and focuses on how employees collaborate and work in agile teams, how decision-making is conducted, and how the organization is managed. The second principle is based on the external perspective with a focus on information sharing in the value network.

IM's organizational structure does not currently promote digital maturity. Instead of working in agile teams in short projects, employees instead have the same tasks every day and new projects are often hindered by day-to-day work, troubleshooting, and recurring meetings. IM is oriented towards silo thinking, and collaborations between departments are not common even if they do occur. IM is currently oriented towards the lean philosophy, preserving cost-effective old systems and work processes instead of acting agile. While there are no real contradistinctions between the lean philosophy and digitalization in general, IM has lean processes which have been optimized for decades. These processes are not adapted to work in favor of further digitalization. The organizational structure leaves much to be desired, and IM is positioned at level 1 on the digital maturity index on this principle.

The external environment IM belongs to is an open environment, where information sharing is not considered to be the problem. This, as the customers of IM either are Volvo-owned plants, joint ventures, or private partners. Therefore, there is a clear incentive to share information and collaboration takes place within the borders of IM or with a close partner. Since the collaboration between partners in the value network is well established, visibility in the chain is considered developed. However, electronic data interface and other automatic systems are neglected, even though imminent projects are aiming to change this. This entails IM's external organizational structure is positioned at level 3. The position of IM's organizational structure in Industrie 4.0 maturity index is illustrated in Figure 5.6.

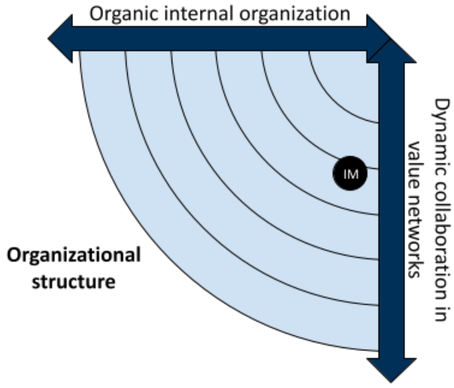

Figure 5.6: IM's organizational structure mapped in the Industrie 4.0 maturity index. Adapted from Schuh et al. (2020).

5.4.4 Digital maturity in organizational culture

The two principles assessed related to the cultural maturity of an organization are *willingness to change* and *social collaboration*, as developed by Schuh et al. (2020). Willingness to change considers how well an organization deals with mistakes made, the attitude towards innovation, how data is used for learning and decision-making, how professional development is handled, and how change is shaped. Social collaboration considers leadership style, how communication is conducted, and how much confidence there is in processes and systems.

The overall culture at IM towards change is positive. Innovations and ideas are welcomed, mistakes are accepted as a part of the process and further professional development is encouraged and sanctioned. However, in practice there are often too few resources, both financially and competence-wise, to successfully carry out the change. There is also little use of data or computer aids in decision-making. This has to do with both the availability of data and the lean ideology used for decision-making. IM's willingness to change is therefore considered to be positioned at level 2, because of the high awareness of the need for change.

The first capability evaluated in the social collaboration principle is management style. A digitally mature organization has flexible leadership without rigid hierarchies. This, to be able to make many small decisions at all times and be more agile. This is not the case at IM, as many of the interviewees claimed the decision-making process is slow and rigid. While IM does not have an authoritarian hierarchy and individual decision-making is encouraged to some extent, the hierarchies in place result in a non-agile organization. The second capability discussed is communication and relates to how siloed the organization is. At IM, there are silos present between departments, especially between the office workers and the workers at the packing and shipping platform. There is little information sharing between these areas and almost no knowledge exchange. The last capability is confidence in processes and information systems. Most of the operating systems used for planning, order, and delivery are old and outdated. They do, however, run smoothly and do exactly what they were built for. The processes built around these systems are sometimes complicated due to the limitations of the systems. There is almost no aid or analysis built into the systems, and systems are mostly used to transfer information rather than processing information. IM's social collaboration level is positioned at level 2. The position of IM's information systems in Industrie 4.0 maturity index is illustrated in Figure 5.7.

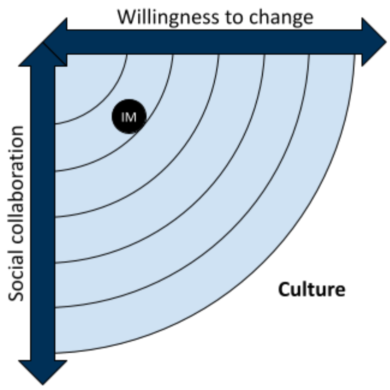

Figure 5.7: IM's culture mapped in the Industrie 4.0 maturity index. Adapted from Schuh et al. (2020).

5.4.5 Overview of capabilities

Below, in Table 5.6, the capabilities discussed in the Industry 4.0 maturity index and how well IM works with these capabilities are displayed. The grades are based on empirical data from the case study.

Table 5.6: *Overview of capabilities discussed in Industry 4.0 maturity index. Adapted from Schuh et al. (2020).*

Dimension	Principle	Capability	IM fulfillment (1-6)
Resources	Structured communication	Efficient communication	1
		Task-based interface design	2
	Digital capability	Provide digital competencies	2
		Automated data acquisition	2
		Decentralized processing of sensor data	1
Information systems	Information processing	Automated data analysis	1
		Contextualized data delivery	1
		Application-specific user interface	1
		Resilient IT infrastructure	2
	Integration	Horizontal and vertical integration	2
		Data governance	1
		Standard data interface	2
		IT security	3
Organizational structure	Dynamic collaboration in value networks	Focus on customer benefits	2
		Cooperation within the value network	3
	Organic internal organization	Flexible communities	2
		Decision rights management	1
		Motivational goal systems	1
		Agile management	1
Culture	Social collaboration	Democratic leadership style	2
		Open communication	2
		Confidence in processes and information systems	2
	Willingness to change	Recognise the value of mistakes	2
		Openness to innovation	2
		Data-based learning and decision-making	2
		Continuous professional development	2
		Shaping change	1

5.4.6 Framework results

In Figure 5.8, the summarized result of the assessment of IM's digital maturity can be seen. IM is positioned between the level of 1 and 2, in the stage where a computerized organization transforms into a connected one. For IM, the work with connectivity has progressed far but is not yet implemented in all aspects of the organization. Coincidentally, IM has some degree of visibility in certain processes, but further work is required with both connectivity and visibility to reach the higher levels of the maturity index. The results further illustrate IM's digitalization conveyed by the interviewees and survey participants.

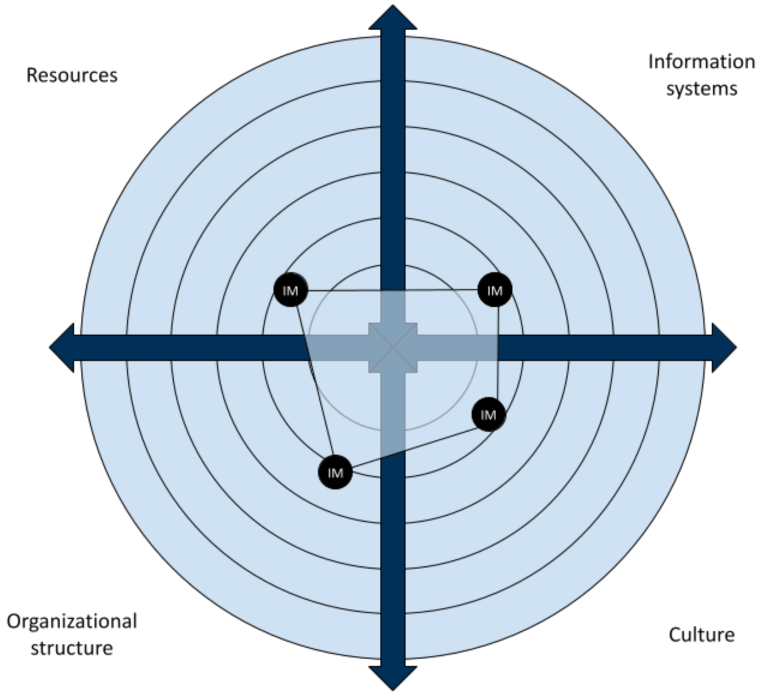

Figure 5.8: IM's digital maturity mapped in the Industrie 4.0 maturity index. Adapted from Schuh et al. (2020).

By using the framework, it is apparent the division has made progress in the digitalization area and has prerequisites for further development. The framework classification also illustrates IM has improvement potential in most capabilities supporting digitalization and facilitates understanding of which areas where most resources and change management are needed.

5.5 Critical success factors

There is a long road ahead for IM to become sufficiently digitalized. Inevitably, IM will encounter more problems relating to digital change and Industry 4.0, as digitalization is an unwieldy and resource-demanding process. The purpose of this master thesis is to find critical success factors for digitalization within the IM supply chain, to help decision-makers at IM know what to focus on going forward. Through the interviews and this analysis, three critical success factors have been identified. When identifying the critical success factors, focus was put on understanding the challenges and enablers currently existing at IM for further digitalization. In this process, these factors were mapped with the starting-point in key digitalization concepts and technologies found in the literature. By combining these insights, and applying them to an IM context, the factors most critical for further digitalization at IM were identified. If focus and resources are put on enabling these critical success factors, a full transition into a new digital environment hopefully can be achieved. Presented in this section are enablers for achieving these critical success factors, and challenges for each success factor.

5.5.1 Digital change management

Digital change management is essential for the digitalization of IM's processes, to get the organization and its employees on-board with the imminent digital change. This will ensure digitalization is anchored throughout the organization and will facilitate the change process. The importance of change management, and in this specific case digital change management, has been emphasized throughout the research work. Both by the approached Volvo employees, and the research literature. Conventional change management, with efforts put on cultural change and anchoring change, is essential for digitalization. In addition to this, specific digital change management will be required. Management needs to locate people with the right competencies in digitalization and Industry 4.0, to help the organization understand the urgent need for new digital solutions. They also need to identify which cultural and organizational requirements are needed to transfer into a digital environment where automation, connectivity, visibility, and visualization are central concepts.

Enablers

To utilize digital change management, a central enabler is to create an organizational understanding of the need for change, a process which must start at the higher management level. Strategic and tactical management must grasp and acknowledge the need for change, in this case, the need for systematic digitalization. Then, the rest of the organization can apprehend the importance of digitalization, and the readiness for change is increased. Management commitment enables the organization to understand the need for digital change, which in turn enables further digital change management. To realize sufficient digital change management, another enabler is to get long-term buy-in from all stakeholders. If management on different levels, employees, the central Volvo organization, associated plants, and partners, all have long-term buy-in, digital change will be inevitable.

Challenges

Even though digital change management is a critical success factor, there are several challenges associated. Currently, the interviews and the survey illustrated management is committed to digital change. However, there is little action coming from management. Without this commitment translating into actions, digital change management is not an easy activity to carry out. However, there seems to be an imminent attitude change towards digital transformation, where most stakeholders realize the urgency and inevitability. Hopefully, this will support further digital change management activities. Other challenges with this factor relate to lack of specific employee competencies and knowledge, where there are uncertainties regarding how well employees know digitalization, and how to implement it. For supporting change in the best way possible, an organization could create a group specialized for carrying out the change. This group can then in turn increase employee competencies by either education or recruiting new competencies.

Digital change management is a resource-demanding activity, where employees dedicated to enforcing the change need to be appointed. These employees also need resources to execute the change and change the culture. This, through meetings, information dispatches, or education. The digitalization process will not be made by a few persons with small resources, and there is no way around both financial and labor resources will be demanded. Another problem present is the siloed characteristics of IM logistics, with departments working somewhat independently and individually. Digital change management could mitigate this problem, but the digitalization process must be seen as a collective effort, which benefits all departments. For this, management must work towards eliminating the silo thinking.

In Table 5.7, enablers and challenges for digital change management are listed.

Table 5.7: Enablers and challenges for the critical success factor "digital change management".

Critical success factor	**Enablers**	**Challenges**
Digital change management	• Management commitment • Organizational understanding of the need for change • Long-term buy-in from all stakeholders	• Low current management commitment • Lack of specific employee competencies • Limited resources • Siloed organization

5.5.2 Effective use of existing data

By efficiently taking advantage of the data currently produced by systems and processes, IM can increase the end-to-end visibility in the operations undertaken in the KD supply chain. Increased visibility means greater process insight, easier troubleshooting, and more overall control of operations. Taking advantage of this data can improve decision-making processes and help transform IM into a more agile organization. Currently, most necessary data exist, and the problem is to make it easily available. Data is often either stored in complicated formats, in systems not easily accessible, or of such low quality it cannot effectively be used. A plan on how to make data available and on how to put it to use is therefore needed to reach this critical success factor.

Enablers

To increase data availability, automation and connectivity are key. Without automation and connectivity in information systems, much manual input is performed. Every activity where data needs to be manually transported from a system to another poses a risk for errors. These errors do not only cause problems further down the value chain, but they also substantially lower the quality of data in systems. By increasing connectivity in information systems not only does automation increase, but data also becomes available to a wider number of systems. With data availability in systems, it is possible to increase visibility and visualization. These two concepts are key to effectively put data into use. Visibility in information systems increases process understanding and the visualization of this data makes the information available to anyone, regardless of system or data knowledge.

For IM to be able to perform this, new competencies are an important enabler. Currently, the competencies needed to increase connectivity and visibility in the information system infrastructure and data storage solutions are not available at IM. These competencies are easily available if resources for employing new people are available. Managers at IM should also discuss to which extent it is possible to educate current employees, to get more internal competencies without recruiting. Leaders at IM must identify where and when more resources are needed, and when it is possible to only increase the competencies internally, without adding more people?

Challenges
The factors hindering the future effective use of existing data are not to be underestimated. Firstly, there is a problem with the old and complex system infrastructure. These systems tend to be problematic to automatically connect to other systems. The extraction of data from these systems tends to be difficult and the output data is often has complicated formatting. Most of these outdated systems also have the status of legacy systems. Resources to develop these systems are therefore not available. Another challenge for data availability is the quality of the inputted data into the systems. Manual inputs, neglect of input and poor formatting is the problem here. Errors stemming from manual inputs can be bridged by eliminating manual inputs. However, neglect of input where manual data input is needed is an organizational culture problem. Understanding the importance of correct data and every employee's responsibility for this needs to be a management priority when transforming the organization.

In Table 5.8, enablers and challenges for effective use of existing data are listed.

Table 5.8: Enablers and challenges for the critical success factor "effective use of existing data".

Critical success factor	Enablers	Challenges
Effective use of existing data	• Increase visibility and visualization • Increase automation and connectivity • Develop the right competences	• Complex and outdated system infrastructure • Lack of specific employee competencies • Limited resources • Low data quality

5.5.3 Clear digital organizational structure

To successfully digitalize IM's processes, there is an obvious need for a clear digital organizational structure. This factor relates to how resources for digitalization are used and allocated, the IT department structure of IM, and what management can do to improve digital maturity. Currently, IM's organization has some aspects supporting digitalization and other traits obstructing successful digitalization. The main trait is the lack of resources, preventing IM from further large-scale digitalization. The Digitalization and IT department works with digitalization projects both at the administrative level and at the Volvo-owned plants, even though the department only consists of three employees. The department also has the responsibility to act as technical support for any system or solution developed by the department. While being sufficiently competent enough in the systems currently used by IM, the department's employees acknowledge both more resources and competencies are needed for an overall digitalization of IM. Another relevant issue is the dependency of the CBU flow, which IM needs to manage also in the digitalization context. Important is, IM has the tools to adapt from the needs of the CBU flow, but also have the resources and competence to function independently and individually. This also regarding larger digital implementations. In this area, management must distinguish the need for more resources and the need for more competencies and act accordingly.

In addition to this, IM must figure out how to successfully utilize the decentralization of IT competencies. Decentralization could be beneficial, as the Digitalization and IT department get more agile and adaptable, possibly providing quicker solutions for IM's needs. The downside of decentralization of IT competencies is instead when the IT departments are divided and decentralized in the organization, while the resources (both financial and knowledge) still are centralized. Then, it will be difficult for the decentralized departments to have the resources available to transform processes and work with long-term projects, as most of the time will be dedicated to supporting everyday processes, troubleshooting, and short-term problem-solving. This is the current situation at IM and needs to be avoided if the the best possible conditions for digitalization should be created.

Enablers

To create a clear digital organizational structure, the initial project for IM should be to develop an ambitious digital strategy. There are many ongoing digitalization projects at the division, and an overall trend towards digitalization, but a clear digital strategy adapted by the employees has not been formulated. A formulation of strategy adapted by the employees will enable the organization to get a more obvious direction in the digitalization effort. This is presented by theory as one of the main enablers for digitalization (Vogelsang et al., 2019). To formulate this strategy, and to increase the digital maturity of the organization, managerial action is needed. Without managerial commitment and action, it is not possible to create a clear digital organizational structure. More focus must be put on increasing the readiness and creating a climate where digitalization is incorporated in IM's development work.

As for the managerial action and digital strategy, there is currently only a minor department for IT and digitalization. This situation needs to be resolved to support further digitalization. A continuation of the overall decentralization trend of IT departments in the Volvo organization seems to be an inevitable part of the future. IM must adjust to decisions taken centrally to support IM's digitalization. The decentralized departments for digitalization and IT should have sufficient resources to pursue the development of the current processes. Therefore, more resources than today are needed, to not only focus on short-term implementations and troubleshooting. There also needs to be a more efficient use of resources in these departments. Perhaps, a future action could be to divide the Digitalization and IT department into two separate divisions. Then, one of the departments could be more resource-effective in working with supporting IT processes, and the other one could focus its resources on digitalization and long-term development. The enablers of this critical success factor are closely related, as managerial action and the development of a clear digital strategy is the foundation for achieving the other enablers.

Challenges

There are several challenges for this critical success factor. Today, there is a perceived shortage of resources at IM to enforce change. However, as the importance of having a digitalized supply chain increases, it is fair to assume more resources will be dedicated to long-term digital development. Probably, there will always be a feeling existing resources are not enough. Nevertheless, through management commitment and a clear digital strategy, it should be possible to digitalize the supply chain further even with resource limitations. Relating to this, the lack of resources and specific digitalization competencies in the Digitalization and IT department is also a challenge. To ensure sustainability in this area, the recruiting procedures and the internal education within Industry 4.0 and digitalization must be improved.

There are also some organizational traits challenging the digitalization work. Overall, there is a low organizational maturity for digitalization. Hopefully, this will change through the use of digital change management. The organization's maturity must be improved to create optimal digitalization conditions. There are also organizational silos present, obstructing large-scale development work in the entire organization. Here, digital change management, managerial action, and a digital strategy may work as antidotes for silo thinking (Vogelsang et al., 2019). Another challenge, frequently discussed in this master thesis, is the IM's high dependence on the CBU flow. This is a factor not likely to change in the foreseeable future, and IM must continue to adapt and adjust to this reality. As mentioned by some of the interviewees, this can also work in IM's favor. This, as the division may function as a testing environment for new solutions, given the financial stakes are not as high as for the CBU flow. This is an area IM should develop and exploit further, where the digitalization process could be supported to a higher extent than earlier. To pursue this, management commitment and buy-in from involved actors are needed.

In Table 5.9, enablers and challenges for having a clear digital organizational structure are listed.

Table 5.9: Enablers and challenges for the critical success factor "clear digital organizational structure".

Critical success factor	Enablers	Challenges
Clear digital organizational structure	• Develop an ambitious digital strategy • Managerial action • Decentralized IT department • Effective use of resources	• Limited resources • Lack of specific competencies • High dependence of CBU flow • Low organizational readiness • Siloed organization

5.5.4 Summary of critical success factors

Table 5.10 below shows a summary of all critical success factors and their enablers and challenges.

Table 5.10: Summary of the critical success factors for digitalization, with enablers and challenges.

Critical success factor	Enablers	Challenges
Digital change management	• Management commitment • Organizational understanding of the need for change • Long-term buy-in from all stakeholders	• Low current management commitment • Lack of specific employee competencies • Limited resources • Siloed organization
Effective use of existing data	• Increase visibility and visualization • Increase automation and connectivity • Develop the right competences	• Complex and outdated system infrastructure • Lack of specific employee competencies • Limited resources • Low data quality
Clear digital organizational structure	• Develop an ambitious digital strategy • Managerial action • Decentralized IT department • Effective use of resources	• Limited resources • Lack of specific competencies • High dependence of CBU flow • Low organizational readiness • Siloed organization

5.6 Digitalization risks

As mentioned in Section 3.3.4, Manuj and Mentzer (2008) and Norrman and Jansson (2004) uphold supply chain risks are important to identify, assess and manage in modern supply chains. The digital environment is ever-changing, and new risks are identified continuously. Below, identified risks with the digitalization work at IM are presented, as well as mitigating activities for each risk. The risks are also classified according to Norrman and Jansson (2004) supply chain risk matrix, to facilitate further risk management.

5.6.1 Data risks

When working with digitalization, and specifically with visibility and visualization of data, there will always be data security risks. Volvo and IM take data security seriously, and they need to continue doing this in a further digitalized environment. With higher visibility and more visualizations, direct measures to ensure high data security need to be taken. This to prevent sensitive data from being visible and more importantly prevent possible modification of the data. With more data available, security classification of the data would give the users opportunities to act according to the classification. To further mitigate data leakage or modification, sufficient education for handling the data should also be provided by the company. With more effective data available, the organization will also be more vulnerable to data hacking. Possible security precautions should be taken according to the damage leaked or modified data could result in. The probability of issues related to data security is high, as similar issues are getting more frequent, especially for large manufacturing supply chains (McKinsey & Co, 2015). The impact of data security issues are deemed as high, as this may compromise or modify confidential material relating to strategy or manufacturing. Rigorous measures to avoid data security issues are needed.

5.6.2 Regulatory risks

There may also be regulatory risks relating to the increasing amounts of available data. For instance, data privacy could become an issue (Deloitte, 2018). It is important IM is continuously aware of laws and regulations for data handling and has protocols in place supporting the correct handling of the data. The probability for data laws, regulations, or privacy issues is deemed as medium-sized, as most of the data IM manages should be accepted by most data policies. The impact of issues relating to data laws, regulations, and privacy are deemed as minor. This, as these issues will not have large organizational impact, and may mostly lead to minor policy changes. For mitigating this risk, IM should monitor updates of regulations and laws closely and change policies accordingly. Employee training on data handling could also mitigate this risk. These issues should be easy to avoid, although some effort will be required to keep the organization informed.

5.6.3 Technology risks

Another risk identified is the high dependency on the technology working. With a high degree of digitalization, many operations are heavily dependent on the technology functioning. If there are major technological malfunctions, this will affect the processes greatly. If there are large malfunctions in IM's systems, the risk of processes being interrupted and order and deliveries being delayed is high. However, the overall digitalization work is carried out partly to decrease the risk of malfunctions and other supply chain contingencies. The expectation is system errors or malfunctions will decrease with developed connectivity and automation. However, if relying heavily on automation and connectivity between the systems, a large technological malfunction can have substantial negative consequences on the business value. The risk for this is evaluated as low, as one of the main reasons for the implementation of new technology is to avoid these problems. However, it is not possible to completely dismiss issues occurring, and the supply chain impact of these issues is high. IM should maintain and update the systems used to avoid major malfunctions, and there should also be contingency plans as well as backup systems for the most crucial parts of the process.

5.6.4 Strategic and implementation risks

Other risk areas consider the implementation of digitalization. Every major transformation induces financial risks, as the profits made from digitalization may not outweigh the implementation costs. This must be accounted for. To mitigate these risks business cases are a viable solution. Even if the business cases may not completely reflect the reality, they certainly facilitate an internal understanding of the financial risks. Large implementations, like digitalization, may often result in a long payback time. In this case, the probability of long pay-back times for the involved projects is evaluated as high. This, as the costs of digitalization, are high, and may not lead to financial positive results short-term. However, this is often the case with digitalization, as the alternative cost of not digitalizing will be high, since the supply chain competitiveness then may be threatened. The impact of long pay-back time is evaluated as medium-sized. Long payback time is not financially positive for the division. Although, if the alternative is not staying competitive, it is a necessary risk. Other than business cases and scenarios, having financial flexibility in the digitalization work will mitigate the consequences of a long payback time.

The next risk identified is the digitalization strategy not aligning with the long-term corporate strategy of both IM and Volvo, or that the digitalization strategy is not adopted by the employees. As this is one of the main enablers for the critical success factors, this risk is not probable to occur as it should be mitigated in the earlier phases of digitalization. Even with the low occurrence probability, it should be avoided as this would compromise and undermine the entire digitalization process and have a very high impact on the supply chain. As digitalization should be an essential part of IM's future, the progress must fully align with the rest of IM's strategy. To do this, the digitalization strategy should be continually evaluated and improved. Through evaluation and improvement work, management will be able to ensure the digitalization strategy is aligned with the corporate strategy. Also important is digital change management, which will help the employees understand the digitalization strategy, which makes it easier to anchor it in all levels of the organization. Connected to this is the risk of employees not being open to digital change, which will undermine the digitalization work (Deloitte, 2018). To avoid this risk, change management, including having sufficient education and communication, is the most important mitigating action.

5.6.5 Summary of risks

In Table 5.11, the identified risks with digitalization are presented, as well as proposals of mitigating activities for the risks are presented.

Table 5.11: Risks relating to the critical success factors presented and mitigating activities.

Risk	**Mitigating activities**
Data security	• Data classification • Data handling protocols • Employee training
Data laws, regulations, and privacy issues	• Data handling protocols • Employee training • Monitoring changes in laws and regulations
High vulnerability in operations due to digital malfunction	• Contingency plans in place • Continuous maintenance and updates of the systems • Opportunities to use backup systems
Long pay-back times	• Business cases and scenarios • Maintaining high financial flexibility
Digital solutions not aligning with corporate strategy	• Change management • Continuous strategy evaluation and improvement work
Employees not open to change	• Change management • Communication • Education

The risks listed in Table 5.11 are also evaluated in the risk assessment matrix, developed by Norrman and Jansson (2004), illustrated in Table 5.12. The risks are classified on the probability of occurrence and their impact on the supply chain if they occur. Through the table, it is possible to see in which order the risk should be prioritized, and which of the risks that needs to be managed more closely.

Table 5.12: Risk assessment matrix for digitalization at IM. Adapted from Norrman & Jansson (2004).

Probability	Very high				
	High		• Long pay-back time	• Data security issues	
	Medium	• Data laws, regulations and privacy issues		• Employees not open to change	
	Low			• System malfunction and/or breakdown	• Digital solutions not aligning with strategy
		Low	Medium	High	Very high
		Impact			

6 CONCLUSIONS

In this chapter, conclusions drawn from the analysis and results will be presented as answers to the research questions. Proposals and recommendations for the case company on how to proceed in this area are presented. Furthermore, this chapter aims to discuss the generalization of results and how the research results of the thesis contribute to research. The chapter also seeks to identify areas for future research and limitations of the research conducted.

6.1 Answers to research questions

RQ1: *Which processes are sufficiently digitalized, and which are neglected?*
The answer to this question is divided into two parts. The first part is what operational processes are deemed digitally neglected. The second is how IM is lacking strategic and tactical processes.

To answer the first part of RQ1, a map of the different information systems used to facilitate the operational activities was made (Figure 6.1). This map shows the entire process of IM's order and delivery department is digitally neglected, throughout the supply chain. 21 manual inputs were identified when mapping the systems, and it is estimated around half of the systems used daily is legacy systems. To get sufficiently digitalized, the manual inputs must be reduced to a minimum, and the legacy systems must be exchanged. This will not be possible in the foreseeable future, but the aim be placed here.

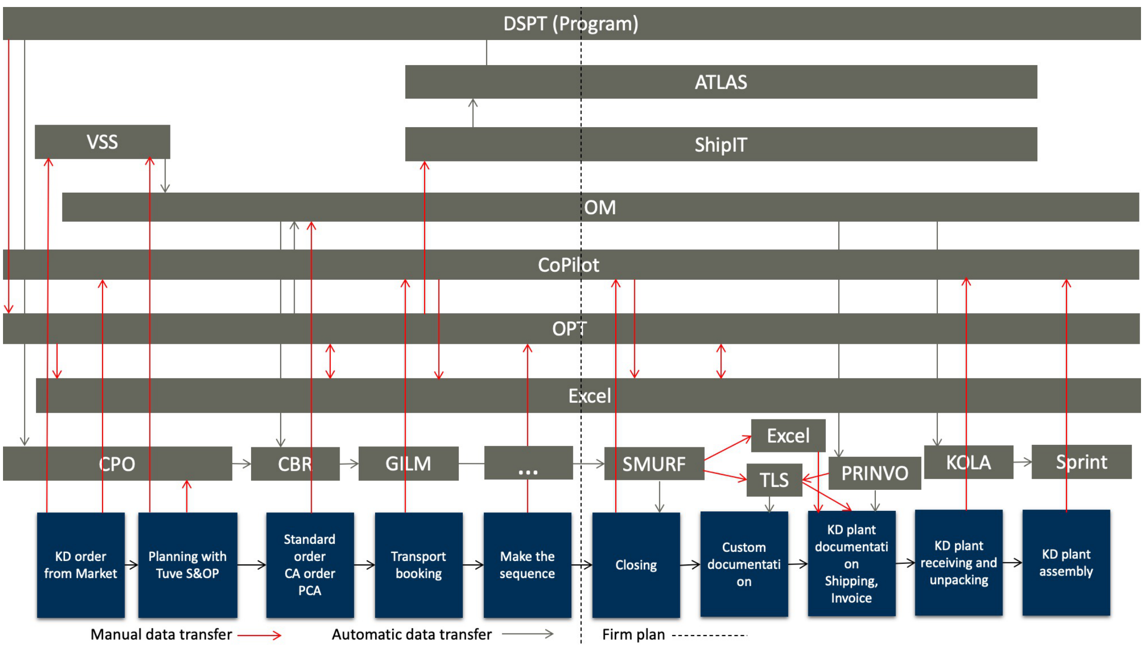

Figure 6.1: Second repetition of map of the systems used in the IM supply chain, highlighting neglected digital processes at IM.

The second answer to this research question was found by applying *Industrie 4.0 maturity index* (Schuh et al., 2020) to IM, and relates to the Industry 4.0 maturity of IM's organization. IM's framework results is illustrated in Figure 6.2. There are many areas where IM needs to focus on becoming a more digitalized organization. Mainly, the areas *information system* and *culture* is where IM needs to become more digitally mature. The maturity degree is higher when it comes to *resources* and *organizational structure*, but also in these areas, IM shows digital neglect. IM shows a clear lack of digitalization in how they communicate internally and how data is automatically processed. IM is considered to be sufficiently digitalized in its external supply chain communications. Overall. it is possible to view IM as an organization located in the second stage of the framework, connectivity, meaning that they are barely digitalized, organizationally.

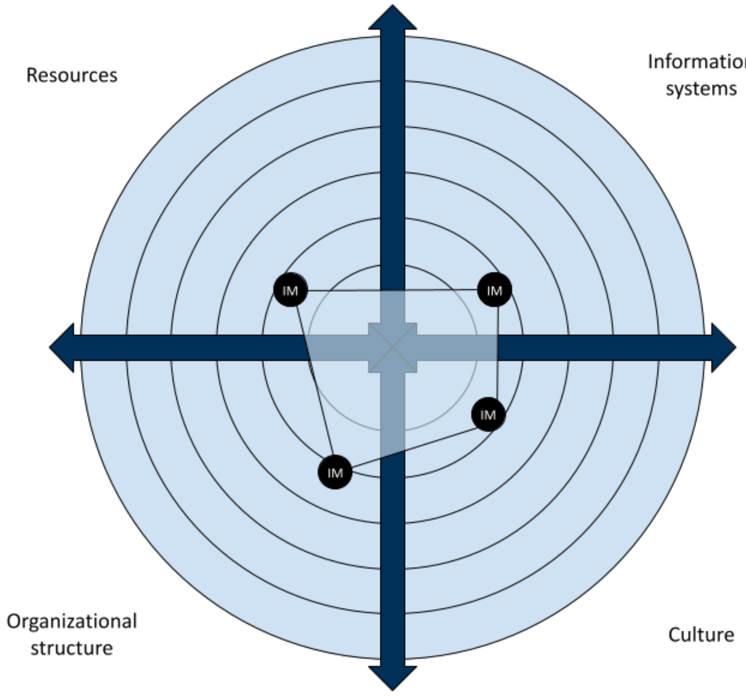

Figure 6.2: Repetition of IM's digital maturity mapped in the Industrie 4.0 maturity index, to illustrate digitally neglected areas at IM. Adapted from Schuh et al. (2020).

RQ2: *What enablers and challenges to digitalization are there?*
RQ2 was answered by studying literature related to digital transformation and by analyzing the results from the interviews, survey and workshops conducted with Volvo employees.

- **SQ2.1:** *Which are the main enablers and challenges to digitalization in the manufacturing industry?*
  Four enablers for digitalization in the manufacturing industry were identified: *Automation and connectivity*, *visibility and visualization*, *effective use of existing data*, and *effective use of resources*. Challenges were are also identified: *Having tools and knowledge for data analysis*, *efficiently utilizing digital capabilities*, and *introducing and maintaining an agile organizational structure*.

- **SQ2.2:** *How does the specific design of IM's supply chain affect its digitalization?*
  The attributes related to IM's digitalization was found to be *Low visibility and visualiza-*

tion, *frequent manual inputs, automation and connectivity opportunities*, *data exist and is collected*, and *lack of resources*. In addition, challenges to digitalization were found to be the *effective use of existing data* and having available *resources for increasing automation, connectivity, visibility, and visualization*.

By combining the answers to the two sub-questions and the two research questions, it became possible to identify critical success factors for digitalization, and their enablers and challenges. The critical success factors identified are: The application of *digital change management*, the *effective use of existing data*, and having a *clear digital organizational structure*. These critical success factors helps to achieve the purpose of this thesis.

How the research question were answered
The purpose of this thesis was to inform IM of critical success factors, enablers, and challenges for digitalization and how these can be used to further digitalize IM's supply chain. To assist in answering these questions, two research questions were formulated, RQ1 and RQ2. To support the answering of RQ2, two sub-questions were formulated, SQ2.1 and SQ2.2. The thesis was constructed with the objective of answering these questions, to eventually be able to achieve the purpose of the thesis. To answer RQ1, a comprehensive case study was deemed necessary. This, to map and evaluate the digitalization of different parts constituting IM's supply chain. The answer of RQ2 consists of two parts. This is reflected in the two sub-questions formulated for RQ2. To answer SQ2.1 the extensive literature review performed was required and for SQ2.2 the answer was developed from the case study conducted. How the RQs and SQs were answered, and how the purpose was achieved, is illustrated in Figure 6.3.

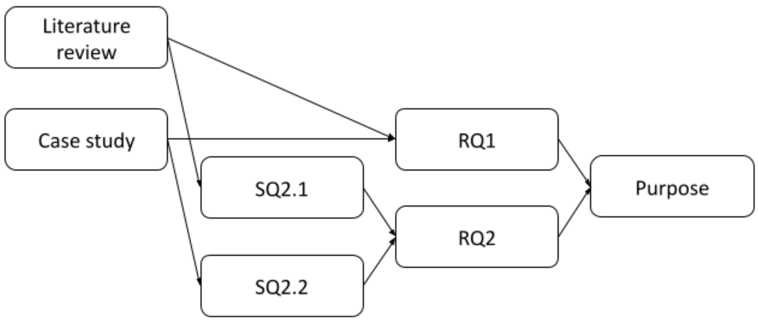

Figure 6.3: How the different activities performed in the master thesis supported achieving the purpose.

6.2 Recommendations for IM

The results of the research work highlight IM should investigate how to implement the critical success factors presented in Table 5.10. By utilizing the enablers presented in the same table, and by taking action to mitigate the challenges, IM should be able to transition into an organization with increased visibility, data availability, and increased overall digital capabilities.

By implementing a robust procedure for digital change management with managers as the driving actors, IM will be able to start to implement the other solutions. When appropriate measures have been taken to ensure change management is deployed, IM should begin to implement new solutions in automation, visibility, and visualization to further increase the data availability within the organization. In parallel, an ambitious digital strategy should be developed, in which the organization should aim to be more agile and efficiently spend more resources on long-term digitalization.

A way for IM to fund digitalization projects and get resources for this could be to market itself as a platform for VGTO to pilot digitalization projects. This, since failures or misjudgements of IM projects mean a lower impact on the business value than this taking place in the main assembly main supply chain.

IM should perform a more comprehensive assessment of the organization with the *Acatech Industrie 4.0 maturity index*. The assessment performed in this study can be used as a guideline, but a more initiated assessment over time should be done when possible post COVID-19 pandemic. IM should not hesitate to bring in consultants to do this if there is a perceived lack of competencies or resources. By doing an extensive assessment, IM will be able to identify the areas where they need to develop their digital capabilities. A solution here could be to have continuous digital audits, where the digitalization effort is continuously evaluated and improved.

When progressing with digitalization, IM must be aware of the risks. With digitalization, there are risks connected to data security and data privacy, where mitigating measures and risk management are needed continuously. Further, IM must ensure the digital strategy chosen going forward aligns with the corporate strategies of both Volvo centrally, and IM's corporate strategy. IM also needs to make sure employees are on board with the digital change, mainly through change management. These risks are the ones having the most impact on IM's operations if they occur, and should therefore be subject to thorough risk management.

6.3 Generalization of results

The thesis is written as a single case study the results are developed for a specific unit of analysis. Therefore, the particular solutions identified for IM should not be seen as generalizable for every organizations interested in how to further digitalize. Neither should the critical success factors be seen as applicable to most organizations. However, an organization with similarities and comparable digital capabilities to IM could use the results of this thesis as recommendations for how to improve their digitalization effort. The authors of this thesis acknowledge IM is a unique organization and the possibilities of this occurring is low. However, the methodology used for assessment and analysis can be applied by other organizations seeking to develop their digitalization plan. This is especially true for organizations or divisions similar to IM, as global manufacturing companies or divisions, possibly dependent on a larger, central organization. Some of the conclusions drawn specifically for IM in this thesis could also be applied to VGTO in a larger context. This, since the two organizations have many contact points and much in common. Other organizations within Volvo could also look into the conclusions drawn and reflect whether these could fit their needs.

6.4 Contribution to research

The case research done in the area of digitalization within supply chains is limited. The research could therefore contribute as an example of this. The extensive literature review performed together with the study of the case company resulted in research with insight into both the academic state of the art, but also how the industry is faring in this subject. Therefore, this case study may be used as an research example for someone interested in the gap between industry and academia. Through the literature review and the analysis, a set of critical success factors were developed which possibly could be used in other research on the subject of supply chain digitalization. These critical success factors are admittedly developed specifically to fit IM's further supply chain digitalization. Although, since the critical success factors are developed by studying previous research on the area, it is possible to see them as first steps for organizations striving to digitalize their supply chain.

6.5 Limitations and future research

Even though some generalizations can be done from this research, it is a single case study exploring how IM should act to further digitize their supply chain. This makes the research of less value to other organizations. The thesis was of the exploratory sort and mainly qualitative data was used to develop the proposed solutions to the research questions. To further strengthen the case, quantitative data as a business case to find out benefit and cost ratio of the proposed solutions could be developed to ensure the proposed solutions are financially beneficial.

By including more organizations in the case study, making it a multiple case study, the thesis results could be more generalizable. If more supply chains like IM's were studied and the same general themes were identified in all of them, the external validity of the research would be stronger. This research could be used as an example of how organizations should act when starting to digitalize. A multiple case study of different units at Volvo or organizations like IM is proposed as further research. Another limitation is some of the literature used, which discussed digitalization for SMEs. Even though IM as a division if seen as an individual company, could be regarded as an SME, the entire Volvo organization could not. However, this literature was supplemented by other relevant literature to provide a comprehensive theoretical background on the digitalization of manufacturing supply chains.

A limitation of this study was the lack of time available for conducting the second round of structured interviews with IM employees. This would have been beneficial, as a round of structured interviews would have increased the amount of quantifiable data collected. This would in turn have increased the internal validity of the thesis. This issue was to some extent mitigated by the survey performed, which provided quantitative empirical data. The COVID-19 pandemic did not allow for the authors of this thesis to spend time at Volvo or to perform any travel to visit the KD assembly plants. This hindered the data collection by limiting the empirical observations of the thesis. A consistent presence at IM and some field visits could have benefitted the research work by giving a more holistic experience of how IM's daily operations and continuous access to IM employees for questions.

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APPENDIX

Appendix A

Below, the interview guide used for the interviews can be found. All interviews were performed remotely on video calls, through MS Teams. Given the unstructured nature of the performed interviews, not every question in the interview guide was asked to every interviewee. However, it provided a guideline and structure for the interviews. It is estimated approximately 80 percent of the questions in the interview guide was asked to every interviewee, on average.

Interview guide

The context below was presented to every interviewee before the interview questions were asked.

Context
We are writing a master thesis about the digitalization of the supply chain at IM. Our work will consist of firstly mapping the physical supply chain and then map the systems supporting it. From this mapping, the goal is to explore and evaluate how well your supply chain is digitalized. To achieve this objective, your help is needed. We have chosen to perform the interviews with people with either a great understanding of the KD supply chain, people who have great insight into the systems, or people who are working with the digitalization effort at Volvo. The purpose of this thesis is to identify enablers, challenges, and critical success factors for the digitalization of the KD supply chain. Two research questions deemed necessary to answer for this thesis to achieve its purpose have been developed. These are:

- RQ1: Which processes are sufficiently digitalized, and which are neglected?
- RQ2: What enablers and challenges to digitalization are there?

As authors of this thesis, we have chosen to be open about the meaning of digitalization and instead try to come to a definition through these initial interviews. In this context, digitalization means automation, connectivity, and the elimination of so-called *media breaks*. With media breaks, it is meant processes where information must be moved manually from one system to another or any other place in the systems where errors can occur due to manual work. Automation is, of course, a part of this but with automation, the elimination of manual data collection, documentation, order planning, and execution is also intended. The connectivity term to us is the communication between systems and physical processes, i.e. if something is changed in one system it is also changed in all other systems.

We are aware of some of the projects of digitalization taking place right now. Both "One Information Chain" and "The Great Shift" and are interested in your opinions and thoughts about these projects. There is also awareness present these projects are not affecting the IM outbound supply chain as much as other flows.

The work has until now mostly been a literature study where relevant literature on the subjects of digitalization, information flows, and Industry 4.0 have been compiled. Important factors for digitalization found are the availability of data and the infrastructure for handling this. The anticipated benefits of these new technologies are that they will add value to production or reduce costs within production, supply chain, employees, etc. Challenges are unwillingness to change, education, organizational challenges, and cost. The critical success factors identified in the literature are communication, training, pilot studies, information exchange with other departments or companies, the use of the technologies already in place, and having a clear strategy of how the implementation is to be conducted.

Initial questions

- Would you like to tell us about yourself, your background, and your work at Volvo?
  - What are your daily tasks? What are your long-term tasks?
  - How long have you worked at Volvo and what are your experiences?
- What kind of information do you need to do your job?
- How do you get this information, what systems?
- What kind of data do you currently miss?

Questions on processes

- Would you like to describe your work process?
- What time horizon do you usually work with?

Questions on systems

- What systems are you working with?
- Are any systems particularly outdated or not satisfactory digitalized?
  - What can be done?
- What happens when errors in the systems occur?
- Advantages/disadvantages with this setup?

Questions on digitalization

- How would you describe digitalization?
- How well does Volvo's digitalization overlap with your view?
- How are your tasks connected to the process of digitalization?
  - How do you work with digitalization?
  - How does your department/group work with digitalization?
- How digitalized would you say the KD supply chain is?
  - Is it comparable to other companies or parts of Volvo?
- What drawbacks can you see with a more digitalized organization?
- What is important to further digitalize Volvo?
- What obstacles are hindering digitalization?
- Are there any problems with communication hindering further digitalization?
- Would you say that your organization is ready for further digitalization?

Questions on the supply chain

- Do you know the term media break? Is it something you work with?
- Is it a problem within your processes?
- What can be done to reduce the number of media breaks?
  - How would this affect processes?

Quesntions on improvements and changes

- Are there any projects going on right now aiming at changing processes or systems to become more modern, digitalized, or automated?
- Have you heard about the "2021 Supply Chain deliverables"?
  - Will it affect your tasks?
  - Is it a relevant project?
- Have you heard about "the Great Shift"?
  - Will it affect the IM and KD supply chain?
  - How?
- Is IoT relevant for your processes?
  - Can it improve them?
  - How?

- Is AI deployed in any way in the SC?
  - Is it used in any way at Volvo?
  - How do you think AI could improve the Volvo/KD supply chain?
- Is big data used?
  - In what way?
  - Could it be used to improve your processes?

Final questions

- Do you want to add anything not yet brought up?
- Do you have any advice for us?
- Are there any persons you think we should contact?

Interview information

In the table below, a repetition of interviews, by interviewees' position, department, date of interview and topics discussed in the interview can be found.

Table: Repetition of list of interviewees by position, department, date of interview, and topics discussed in the interview.

Interviewee	Position	Department	Date	Relevant topics discussed
Interviewee A	Volume and capacity manager	S&OP	2021-02-15	Data availability, forecasting, information sharing, systems, S&OP process
Interviewee B	VP Digitalization and IT	Digitalization and IT	2021-02-16	Change management, data availability, IT decentralization, supply chain integration, technology implementations
Interviewee C	Logistics coordinator	Order and delivery	2021-02-16	Change management, connectivity, data availability, systems, supply chain process, connectivity, visibility/visualization
Interviewee D	Senior project manager	Digitalization and IT	2021-02-19	Automation, change management, data availability, IT decentralization, systems, technology implementations
Interviewee E	Logistics coordinator	Order and delivery	2021-02-22	Change management, data availability, information sharing, IT decentralization, supply chain process, systems, visibility/visualization
Interviewee F	Business solution portfolio manager	Digitalization and IT	2021-02-23	Change management, data availability, IT decentralization, recruiting, technology implementations
Interviewee G	Logistics development and project manager	Logistics	2021-02-23	Change management, data availability, technology implementations, visibility/visualization
Interviewee H	Connected supply chain senior developer (VGTO)	Production logistics	2021-02-19 & 2021-02-25	Change management, information sharing, supply chain integration, technology implementation, visibility/visualization
Interviewee I	Logistics development and project manager	Logistics	2021-03-05	Change management, data availability, automation, systems, technology implementations

Appendix B

In the appendix below, the survey conducted at IM can be found. The survey was constructed in MS Forms and distributed by URL through email. The survey was distributed to 25 IM employees, and 14 of them answered. The survey was distributed by email 2021-04-12, and answers were collected until 2021-04-23.

6.5.1 Survey questions

Below the questions of the survey are presented.

Digitalization at IM

The survey will take approximately 7 minutes to complete.
The results of this survey is planned to function as empirical data for our master thesis being written about the digitalization effort at IM. The survey aims to quantify the overall attitude towards further digitalization in the processes related to the KD supply chain and the digitalization work at IM in general. The expectation is the answers from this survey will help us support and validate conclusions drawn from earlier interviews. All answers are anonymous, and results will only be aggregated, not presented individually. We thank you for taking your time to conduct this survey.

* Required

1. Which is your position within Volvo?

2. Which category does best describe your job? *

- Operational
- Project leader
- Administrative work
- Manager

Digitalization

A key concept for this master thesis is 'digitalization', a term widely used today. Digitalization is used rather broadly to describe the activity of computerizing processes. To avoid any ambiguity in what is meant with digitalization, we would like to define further digitalization at IM as the: "increase of connected systems, data visibility and automation of simple tasks".

3. How well digitalized is the KD supply chain? *

1 2 3 4 5 6 7

4. Please elaborate

5. To what degree are resources for further digitalization available at IM? *

1 2 3 4 5 6 7

6. Please elaborate

7. To what degree do IM have sufficient internal competences for further digitalization? *

1 2 3 4 5 6 7

○ ○ ○ ○ ○ ○ ○

8. Please elaborate

9. To what degree are managers committed to further digitalization at IM? *

1 2 3 4 5 6 7

○ ○ ○ ○ ○ ○ ○

10. Please elaborate

11. To what degree is further digitalization of the KD supply chain's processes necessary? *

1 2 3 4 5 6 7

○ ○ ○ ○ ○ ○ ○

12. Please elaborate

Data availability

To be able to make decisions based on the correct data, the data must be available. Data can be inaccessible in a number of ways, either by not being extractable from a system, being of low quality, or being available in a format rendering it useless.

13. To what degree is necessary data easily available for your work? *

1 2 3 4 5 6 7

○ ○ ○ ○ ○ ○ ○

14. Please elaborate

Visibility and visualization

Whether the purpose is to increase understanding, to gain a quick overview or to convey information visualization is key to understand complex processes and flows. Visualization is highly connected to data availability and visibility.

15. How is overall visibility within process *

1 2 3 4 5 6 7

○ ○ ○ ○ ○ ○ ○

16. Please elaborate

17. To what degree is the processes related to the KD supply chain visualized? *

1 2 3 4 5 6 7

○ ○ ○ ○ ○ ○ ○

18. Please elaborate

Systems integration

An important part of the digitalization process at IM identified is how to connect and integrate legacy systems together. Systems which are well connected and integrated do not need unnecessary manual data transfers and are communicating with its related systems.

19. To what degree are information systems integrated and connected? *

1 2 3 4 5 6 7

20. Please elaborate

21. How important is change management for further digitalization? *

1 2 3 4 5 6 7

22. Please elaborate

23. To what degree does IM apply change management to process or system changes? *

1 2 3 4 5 6 7

24. Please elaborate

Almost done

25. Would you like to add anything?

6.5.2 Survey answers

In the table below, the mean, median, and mode answer on the quantifiable questions asked in the survey is presented.

Table: Results from the quantifiable questions asked in the survey.

Question	Average answer	Median answer	Mode answer
How well digitalized is the KD supply chain?	3.6	3.5	3, 4
To what degree are resources for further digitalization available at IM?	3.2	3.0	3
To what degree does IM have sufficient internal competencies for further digitalization?	3.8	4.0	4
To what degree are managers committed to further digitalization at IM?	4.5	4.5	3, 6
To what degree is further digitalization of the KD supply chain's processes necessary?	5.8	6.0	6
To what degree is necessary data available for your work?	4.4	5.0	5
How is overall visibility within processes?	3.8	4.0	3
To what degree are the processes related to the KD supply chain visualized?	3.6	3.5	3, 4
To what degree are information systems integrated and connected?	3.5	3.0	3
How important is change management for further digitalization?	5.7	6.0	6
To what degree does IM apply change management to process or system changes?	4.1	4.0	5

In the table below, text answers from the survey are compiled. Answers as *"no comments"* or *"I do not know"* were discarded.

Table: List of text answers from the survey.

Question	Relevant answers
How well digitalized is the KD supply chain?	• Quite a lot of manual work and Excel files. • Starting to be more digitalized onwards. • We are relying on the mother plants digitalization solutions to make our Supply Chain work, However due to a lot of special solutions in KD we do not have the stamina to pursue implementation of all solutions, Also a contributing factor is that some of the "main" solutions are not considering all functionality required in KD Supply Chain, The culture in IM also is forgiving to the "Excel-based" way of working, Management need to drive more for digitalization. • Difficult to answer, For sure there are improvements to be done. • CBU has come further and KD have a longer way to go, One information chain is improving supply chain to the packing platforms (improvement for both CBU and KD), But within KD we have a lot of systems not used globally by all, For example RT is not using GILM, OPT and COPILOT. • Existing digital solutions not fully deployed yet. • We have system support for managing the daily operation but there is still a big potential of using our data in a more efficient way. • I think it lacks the red thread of connection throughout the systems. • Continuous progress on visibility. Continuous progress on connected systems. Low progress on automation of simple tasks. • Difficult to visualize the supply chain situation in a fast and efficient way, Many media breaks and manual handling of data. We still have old legacy systems, that works well for the purpose, but it will be difficult to develop into Industry 4.0 if we stay with set-up as of today. • Many manual steps in the process, data is not always accurate.
To what degree are resources for further digitalization available at IM?	• I really do not know what resources we have. • If D&IT department should be in the driving seat more resources is required. • I believe we have some people interested, but they need to be encouraged and promoted to spend time on this. Maybe in a smaller network. • The feeling is that digitalization is something we do on spare time. • I think we need education to understand the potential in digitalization. We also need outside support to get more systems etc. aligned. • Lean organization with a high workload makes it hard to free-up necessary resources and time. IM is a very lean organization today and the current room for taking on new roles that will be required for boosting digitalization, e,g, data engineers/data scientists are quite limited. • Not highest priority and consequently limited resources allocated. • Our Digitalization & IT department do not have enough resources to drive the needed changes. Besides that we do not have enough roles to support the digitalization journey in the rest of the organization (ex. data translator, business analyst, data scientist/engineer). • Think we can competence develop the resources we have to be better on digitalization. Very limited today and no real "experts" available.
To what degree do IM have sufficient internal competences for further digitalization?	• There are in general good understanding of digit solutions. • I believe we lack some actual technical competence in cloud tools (Power BIs etc.) I think it is part of the strategy to not have that internally, professionals from other business areas should be utilized, but I am not sure • For me this question is equal to the previous. • I do not know, maybe someone do have the competence. • Limited competence, needs to be expanded upon within the entire IM organization. • Not really sure of what competence we have today, a survey in this area might be good to conduct to get a better understanding, I estimate it to a "4". • The trainings are not always pushed by the organization. The level of each person is much related to the interest of this person for the new technologies. • I believe we have a lack of competence in the organization to identify what opportunities we have and to develop/implement them. We need to map the current gaps and decide if we should work with upskilling or find the right resources outside the organization. • Very limited today and no real "experts" available in the organization today but I believe we can find persons in the organization that can be developed and grow in this area.
To what degree are managers committed to further digitalization at IM?	• Managers are very positive, make it happen is maybe a bit harder. • Very little. • If you read the strategy and road maps they seem committed but not much actions are seen. • I cannot really answer for all managers but mine, John Doe, is committed to drive this change. • Hard to assess, so far limited interest, will most likely increase with the new VGTO strategy highlighting digitalization as an enabler. • As far as I know and the managers I work with, quite a lot. • I think all managers would like to further digitalize IM, but we might have a lack of competence of what is needed and how to support/drive the journey. The understanding and commitment from management is one of the most important parameters going forward.

Continuation of table	
Question	**Relevant answers**
To what degree is further digitalization of the KD supply chain's processes necessary?	• Digitalization will increase flexibility and efficiency. • To follow the development of the rest of the world, and rest of the group we need to accelerate. • There are already today lots of ideas for further digitalization, if the knowledge would be higher and we would know what was possible I think that the potential would be even higher. • To manage our goals for 2030 we need absolutely to increase/develop the digitalization within IM. • Need to capture relevant data across the supply chain to draw correct conclusions and make fact based decisions. • It is important to utilize the power of digitalization to stay competitive, however you should not underestimate the journey from today's level to a "fully" digitalized way of working. • It is both now and the future. • Lack of common view and related waste of time remaining in a lot of domains. • To stay competitive this is one of the key success factors for Volvo AB, including IM/KD. • To have better control and to be able to predict better.
To what degree is necessary data easily available for your work?	• Data is available but manual work to compile. • Most data are available. Integration need collaboration with stakeholders outside IM organization. • I believe there is lots of scattered data available, but it is less structured. • Many reasons, old systems, unavailable data, not enough attention to having the data correct. • The Program process is quite good, Volvo, RT and Mack is using DSPT (also UD when we worked with them). A few years ago we used different systems in Volvo vs RT vs. UD. But improvements are always needed, Like better forecasting, quicker information sharing between systems, if shortages, what to prioritize etc. • Reliable data is of course key for the entire IM organization. Taking decisions based on the wrong facts can be bad. • For my work needed data is quite okay, however not working very active today with the new digitalization possibilities within VGTO (e.g. the Windows Office 365 suite). • The biggest constraint is data accuracy and this requires to be prioritized and recognized to work on this topic. • Difficult to pull the reports needed and to easily visualize the situation. Data might be available in many cases, but sometimes it takes a lot of time-consuming manual work to use the information to present status etc. Sometimes the data quality is low and not completely trustworthy. Target should be to work pro-actively and take actions before, not after, but we lack this data and connected triggers.
How is overall visibility within processes?	• Could be more visible. • Depending on which process, in KD "in-house" we have some visibility but it is difficult to reach out to our partners processes. • Actions are ongoing to improve. • To have good visibility we need same systems and use them in the same way. • Limited visibility. • We have both good examples where we have quite good visibility in the system (e.g., OPT) and other areas where data is not shown in a visible way. • This needs to be prioritized. • For me the visibility and visualization should be easily accessible for all people in the organization, and we are not there today.
To what degree is the processes related to the KD supply chain visualized?	• Could be more explored. • It is visualised to people who has access, but we need to spread this visualisation. Display on Violin, Teamboards, DIBs (TV screens in VGHQ!). • Actions are ongoing to visualize the high level process. Ocean transport is not good. Hopefully Ocean insights can help here. • It is critical to make complex data available and easily interpreted and understood. • We have the processes mapped on a high level and more detailed in some areas, but easily visualized.
To what degree are information systems integrated and connected?	• This is the way forward we have stared with for example the TM1 project. • We have a complicated system map were Stripe is only partially implemented which has lead to more systems being implemented without the ability to remove legacy systems. Same job needs to be done in several systems. • Okay, until parts arrive to packing platform, packed into boxes and containers, Very little system support in KD plants (and therefore little integrations). • Systems are quite often integrated, but if they are not fully implemented the existing integrations does not help as they are not used. • Information in our main systems are today integrated in our system landscape MTM. • What is the strategy on this topic? • Too many media breaks and manual interference.

Continuation of table	
Question	**Relevant answers**
How important is change management for further digitalization?	• Very crucial. • We need to request from management and also be aware to take risk to give people time to explore. • I think that digitalization is well anchored from top management. Signs of digitalization in the society is everywhere so I think that the general employee acceptance is high, What is needed is management commitment, real management commitment and not only to have that written in a MS Powerpoint. • The mindset in the organization needs to change, to adapt digitalization as an enabler, not a threat. • For people to understand what effect the digitalization journey will mean for you as individual is key for success. • Strong support required within IM for change management. • It is very important to be aware of change management and how to drive changes in the best way. For me the key is to be aware of the change curve, but most of all to make everyone feel included, to inform and explain, again and again.
To what degree does IM apply change management to process or system changes?	• When needed - on demand. • There are methodology available but we are not using it. • We do apply change management, but the process is quite cumbersome and slow. Both good and bad depending on the initiative. • We could be better at change management when it comes to include and inform everyone about ongoing changes. We need to make sure everyone is working at the same goal and therefore the strategy and targets need to be very clear and understood by all in the organization.