Validation and Ranking of Challenges in Digital Transformation towards Industry 4.0
- a multi-case study in Swedish manufacturing SMEs

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Forewords

With this master thesis, we end our time as students in the master’s programme in the management of logistics and innovation at the University of Gävle. This final year has been very intense and challenging, and many things were put on end because of the coronavirus pandemic. We would like to thank everyone involved, directly and indirectly, in both companies and in the university.

More specifically, we would like thank our supervisor Jamila and examiner Maria who has been helpful throughout the thesis work. We would also like to especially thank the SMEs that participated in interviews and made our research possible.

Lastly, the master thesis work has been very interesting, rewarding and demanding, therefore we would like to say thanks and good luck in the future to each other.

Joacim Knapp

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Abstract

Introduction: The manufacturing industry is changing. Digital technologies are key to meet the competition and higher demands from customers on services and goods, and in the long run digitally transformation towards Industry 4.0 with better productivity and efficiency. There are some research on challenges that companies of different sizes and business sectors may face the subject of digital transformation and I4.0, however, the challenges are not validated in the context of Swedish manufacturing SMEs nor ranked to estimate the difficulty of them, so that is the purpose of this research. 15 challenges were chosen after ambitious literature studies.

Methods: A deductive multi-case study has been conducted with a combined qualitative and quantitative research strategy. Ten interviews were executed with managers in ten different Swedish manufacturing SMEs and the interviews contained two parts: one survey part and one part with open questions.

Findings: Early out in the data collection it was found that SMEs struggle with a general lack of resources that permeates their whole organization, affecting decisions regarding strategies, investments and other major issues. Moreover, it was found that the concept of I4.0 and digital transformation holds a lot of uncertainties that aggravates the implementation of digital technologies even further, but some facilitating factors surfaced as well. The challenges were all found to be valid and the most difficult challenges happened to be those with a direct link to uncertainties regarding I4.0 and digital transformation. The least difficult challenges were those connected with issues that are managed regularly.

Conclusion: All investigated challenges were found to be valid in the Swedish manufacturing SME context, and during the research two sub-challenges surfaced. The challenges that were perceived as the most difficult appears to have in common a direct link to future uncertainties concerning the concept of I4.0. The challenges ranked as less difficult do not carry the same level of uncertainty because companies are dealing with those challenges, or similar, regularly. Furthermore, the discussion of each challenge complement what other researches has concluded and enriches the overall understanding regarding digital transformation towards I4.0.

Keywords: Digitalization, SME, Challenges, Industry 4.0, Sweden
List of Figures

**Figure 1:** Summary of the 15 challenges and the three key dimensions.......................... 4

**Figure 2:** Conceptual framework over the digital transformation path......................... 8

**Figure 3:** Nine field of technology that transforms the production............................... 9

**Figure 4:** Different types of collaboration........................................................................ 15

**Figure 5:** Shows a brief overview over how the literature review................................. 16

**Figure 6:** A brief description of research approach.......................................................... 18

**Figure 7:** Visualization of the study plan......................................................................... 19

**Figure 8:** Summary of data collection............................................................................... 20

**Figure 9:** A pie-chart over the interviewed SMEs business area..................................... 27

**Figure 10:** A summary of the distribution of employees in the SMEs............................. 28

**Figure 11:** Visualization of main points from open questions.......................................... 32

**Figure 12:** The conceptual framework from section 2.2.3............................................... 35
# Table of contents

Abstract .................................................................................................................................

List of Figures ....................................................................................................................... 

**1. Introduction** .................................................................................................................. 1  

1.1 Background ....................................................................................................................... 1  

1.2 Purpose ............................................................................................................................. 2  

1.3 Research questions ......................................................................................................... 2  

**2. Literature review** ......................................................................................................... 3  

2.1 Definitions ......................................................................................................................... 3  

2.1.1 Small and Medium-sized Enterprise ........................................................................... 3  

2.1.2 Industry 4.0 .................................................................................................................. 3  

2.1.3 Digital technology ....................................................................................................... 3  

2.1.4 Challenges & barriers ................................................................................................. 3  

2.2 Challenges towards Digitalization and I4.0 ................................................................... 4  

2.2.1 The challenges to validate and rank .......................................................................... 4  

2.2.2 Comparison of challenges discussed in other studies .............................................. 5  

2.2.3 Conceptual framework ............................................................................................... 8  

2.3 Industry 4.0 ..................................................................................................................... 8  

2.3.1 The basic concept and ideas ...................................................................................... 8  

2.4 Adopting digital technologies .......................................................................................... 10  

2.4.1 Digitalization in SMEs ............................................................................................... 10  

2.4.2 Strategies for digital transformation .......................................................................... 11  

2.4.3 Investing in digital technologies ................................................................................. 12  

2.5 Knowledge sharing and collaboration ............................................................................ 13  

2.5.1 Importance of knowledge sharing and collaboration .................................................. 13  

2.5.2 Where collaboration and knowledge can be found .................................................... 14  

2.6 Summarization of literature review ................................................................................. 16  

**3. Methods** ...................................................................................................................... 17  

3.1 Research approach ......................................................................................................... 17  

3.2 Research design .............................................................................................................. 18  

3.3 Data collection ............................................................................................................... 20  

3.4 Interviews ....................................................................................................................... 20  

3.4.1 Selection of respondents ............................................................................................ 21  

3.4.2 Conducting the interviews .......................................................................................... 21  

3.5 Data analysis ................................................................................................................... 22  

3.5.1 Thematic analysis ....................................................................................................... 22  

3.5.2 Mean value, mode & standard deviation .................................................................... 22
1. Introduction

In this introductory section of the thesis, a background and a formulation of the research problem will be presented to disclose the research gap. Moreover, the purpose and research questions will be formulated.

1.1 Background

The manufacturing industry is changing. Customers’ requirements are more challenging now than before with higher demands on individualized goods and services (Vaidya, Ambad & Bhosle, 2018). To meet the new demands the industries and their supply chains have to adapt to manage smaller and customized batches, but at the same cost and pace of mass-production, and digitalization is considered as a key realizing these requirements (Kilimis, Zou, Lehmann & Berger, 2019). This “digital transformation” process, however, is slow for small and medium-sized enterprises (SMEs) (Ibid).

SMEs are being considered as the backbone of the economy, especially manufacturing SMEs (Mittal, Romero & Wuest, 2018). Dedication, belief and understanding of potential benefits of digitalized tools from top management is key to a successful digital transformation, but for SMEs digital transformations are often limited by the managers/entrepreneurs lack of knowledge in the ICT and digitized tools-field (Li, Su, Zhang & Mao, 2018).

According to Fonseca (2018) about 40% of SMEs in the European Union had not adopted any advanced digital technologies in 2015 and only 14% were using internet channels. It becomes clear that research has to be done on why, since it is vital to implement technological innovations in all business aspects to maintain competitiveness and, in the long run, to take the first steps into the next industrial revolution “Industry 4.0” (4.0) (Traşca, Stefan, Sahlan, Hoinaru & Serban, 2019). 4.0 will increase productivity and efficiency among many things (Rüßmann et al., 2015) as objects become intelligent (Sommer, 2015) and will form smart networks (Ivanov, Dolgui & Sokolov, 2019).

To successfully deal with challenges that SMEs faces due to high competitiveness in the market, Chen, Jaw & Wu (2016) highlighted the importance of using information and communication technology to take benefit from the market, because it added new know-how and the quality of products improves and processed productively. The process of digital transformation requires SMEs to rethink and restructure their business model to create value (Bouwman, Nikou & de Reuver, 2019)

There are some research on common challenges and barriers for SMEs in adopting new technologies (Ghobaklo, Hong, Sabouri & Zulkifli, 2012; Stentoft, Jensen, Philipsen & Haug, 2019). Ghobaklo et al. (2012) have compromised drivers influencing factors and barriers and then categorize them into external or internal factors in order to increase the
understanding of IT-adoption in SMEs. Furthermore, Zangiacomi, Pessot, Fornasier, Bertetti & Sacco (2020) have done some research in defining the path forward towards digital transformation according to the level of current digital implementation where the results are presented with common mistakes, best practices and key challenges. The same authors, however, acknowledge that their research lacks peculiarities since they are considering large companies as well as smaller from different business sectors, which implies the need of further research on manufacturing SMEs in Sweden among other areas.

The key challenges in the research of Zangiacomi et al. (2020) has been identified in the rather narrow context of Italy. Therefore, validation problems might occur if it is applied in Sweden since different countries have different cultures and, arguably, different levels of digitalization in general, implying Swedish SMEs may perceive the key challenges differently. A validation and ranking of the key challenges in the context of Swedish manufacturing SMEs would help future to focus their efforts in what might be perceived as the most challenging at this moment. Furthermore, there are frameworks with best practices overcome the key challenges, so this would provide useful information to managers in SMEs as well as researchers. The process, however, of validating theory is complicated and requires to see if observation from the given case and data from another case support the theory (Westerman, 2011).

Zangiacomi et al. (2020) presented different challenges that face both large and SMEs in Italy and authors acknowledge further research on peculiarities from different business sectors, such as manufacturing SMEs. Therefore, the gap is to evaluate and validate those challenges for manufacturing SMEs in Sweden and possibly find other challenges in the same field.

**Problem Formulation**
Are the challenges the same in Swedish SMEs, and what are the perceived difficulty of each one brought up in the research of Zangiacomi et al. (2020)?

**1.2 Purpose**
In this thesis the purpose is to validate and rank challenges towards Digitalization in the context of manufacturing SMEs in Sweden.

**1.3 Research questions**
For the study’s purpose, the following questions have been developed:

- What digitalization challenges are valid in Swedish manufacturing SMEs?
- Which digitalization challenges are considered the most difficult by Swedish manufacturing SMEs?
2. Literature review

In this section, the basic theories will be presented starting with short definitions. These theories will form the basis of the study's hypotheses, which will also be explained.

2.1 Definitions

2.1.1 Small and Medium-sized Enterprise
Shortened to SME: has between 10-250 employees, a turnover between 2-50 million Euro (approximately 20-500 million SEK) or a balance sheet total between 2-43 million Euros (20-430 million SEK). SMEs represent 99% of all businesses in Europe (European Union, 2020). SMEs are known to operate with scarce resources and little knowledge and experience in new emerging technologies (Stentoft et al., 2019), also typically, SMEs are innovative, creates new job opportunities and achieve economic growth (Lucky & Olusegun, 2012).

2.1.2 Industry 4.0
The fourth industrial revolution, or “Industry 4.0” (I4.0) is a German initiative (Zhong, Xu, Klotz & Newman, 2017; Frank, Dalenogare & Ayala, 2019), and the sources have different opinions about it (Qin, Liu & Grosvenor, 2016; Alonso, Dacal, Barreto, Amaral & Rivero, 2019). In this paper I4.0 will be referred to as a concept that integrates production processes, information technologies and techniques (Nowotarski & Pasławski, 2017). In short, objects become intelligent (Sommer, 2015) and form smart networks without the need of human interaction (Ivanov et al., 2019).

2.1.3 Digital technology
In this paper, digital technology is defined as tools that facilitate for employees to get diverse information and to connect to a large network (Oldham & Da Silva, 2015). Technologies that add value for the product lifecycle and that transforms physical operations to operations done automatically by a system (Frank et al., 2019; Yoo, Boland, Lytyinen & Majchrzak, 2009).

2.1.4 Challenges & barriers
In the context of digital transformation, some authors use “challenges” while other uses “barriers” even though they are basically referring to the same issues. As an example, Ghobaklo et al. (2012) discusses how barriers to IT adoption arise from shortage of funds and Horváth & Szabó (2019) refers to higher costs as a challenge to implement I4.0 technology. In this master thesis, challenges and barriers are considered as the same or very similar, but with caution upon reviewing literature to avoid misinterpretations. The authors of this thesis defines the essence of challenges and barriers as follow: “Problems, tasks or a set of both, specified or vague in nature, that are necessary to deal with in order to digitally transform successfully”.

3
2.2 Challenges towards Digitalization and I4.0

2.2.1 The challenges to validate and rank

<table>
<thead>
<tr>
<th>Investments in I4.0 technologies</th>
<th>Ability in perceiving the path towards digital transformation</th>
<th>Knowledge sharing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Defining a specific strategy, avoiding stand-alone implementation of a new technology</td>
<td>Understanding how the company business model changes after technology adoption</td>
<td>Adopting collaboration with external sources of knowledge</td>
</tr>
<tr>
<td>Understanding relevant technologies to focus on accordingly to the specific business and needs</td>
<td>Awareness of the implications on the organization beyond IT infrastructure</td>
<td>Exploit connections with local ecosystem (e.g., universities, innovation centers, policy makers)</td>
</tr>
<tr>
<td>Starting with small projects and limited investments, exploiting scalability of I4.0 technologies</td>
<td>Awareness of existing implementation supporting measures and means at policy level</td>
<td>Recognizing the importance of sharing and spreading best practices for successful I4.0 implementation</td>
</tr>
<tr>
<td>Recognizing the need to invest also in training and culture</td>
<td>Awareness of the continuous increase in accessibility and exploitability of many I4.0 technologies</td>
<td>Adopting new approaches for knowledge transfer</td>
</tr>
<tr>
<td>Adoption of lean management approaches before investing in I4.0</td>
<td>Proactivity rather than reactivity in defining resources, processes and procedures to adopt I4.0 technologies</td>
<td>Increasing knowledge base on I4.0 technologies and talent management</td>
</tr>
</tbody>
</table>

*Figure 1: Summary of the 15 challenges and the three key dimensions by Zangiacomi et al. (2020).*

The starting point of the analysis in the paper of Zangiacomi et al. (2020) is three dimensions that are very important from a managerial point of view in the digital transformation towards I4.0. Furthermore, they have identified five challenges for each dimension that are shown above in *figure 1*. All challenges are presented with suggestions and practices to deal with them, however, those are not shown nor explained in this paper. Regarding the three dimensions, they need to be seen as interrelated to each other and has to be considered in an integrated way to manoeuvre through a digital transformation path towards I4.0. The first dimension “Investments in I4.0 technologies” has a great impact on the other two dimensions, actually, those dimensions are a part of “Investments in I4.0 technologies”.

4
The first four challenges in the first dimension “Investments in I4.0 technologies” does derive logically from its topic, but for the last challenge “Adoption of lean management approaches before investing in I4.0” may seem confusing at first, but makes sense as Zangiacomi et al. (2020) discuss how lean management approaches is the best practice in all implementation stages of new technologies. The second dimension “Ability in perceiving the path towards digital transformation” is more concerned with beforehand awareness and understanding of potential implications that are necessary to deal with systematically in order to digitally transform successfully. The third dimension “Knowledge sharing” is concerned with collaboration and exploitation of internal and external sources of knowledge. Knowledge sharing is a key dimension in other domains as well, like for innovation purposes, but in this case, it is focused on partnerships and transferring of skills related to the implementation of I4.0 technologies. Collaboration is required for complementary reasons among other numerous purposes (ibid).

2.2.2 Comparison of challenges discussed in other studies

The 15 challenges identified by Zangiacomi et al. (2020) are the results from an analysis of internal documents in companies and many in-depth interviews with CEO’s, research and development managers and operations managers in Italian companies of different size and business sectors. This paper has chosen those particular challenges for several reasons; the research was done very recently and published in 2020 and it is of high relevance. The authors also acknowledge that their research lacks peculiarities since they are considering large companies as well as smaller from different business sectors, which implies the need for further research on manufacturing SMEs.

Zangiacomi et al. (2020) study is based on three key dimensions that are concerned with both soft matters (knowledge, training, understanding, etc) and hard matters (investments, strategies, etc.). Both matters are very important, and since both are included, they give a complete picture in the research scope. Moreover, a formal comparison was made between challenges identified in different papers presented in Table 1 below and it was found that they covered a wider range than the others in the three key dimensions. Note that the authors of this master thesis have interpreted how other outspoken challenges and barriers connects to the 15 challenges after analyzing their definitions and explanations, implying they might not fit perfectly, but satisfactory.

As presented in Table 1 below and in the previous section so Zangiacomi et al. (2020) study discuss challenges in digitalization from different perspectives and different phases before, during and after implementation. Challenges in relation to technology, organization, lean production and human factors. Glass, Meissner, Gebauer, Stürmer & Metternich (2018) identified challenges related to the implementation of industry 4.0 in German companies, the barriers were related to technology in terms of maturity and infrastructure, barriers in the organization when it comes to the procedures for adopting
concepts around industry 4.0 and also raises barriers related to human factors in terms of knowledge and experience, some barriers were related to the government concerning policies and regulations.

Challenges that have been pointed out by Horvath & Szabo (2019) are related to human factors in terms of experience and skills and issues related to cybersecurity also lack of financial resources and managerial challenges regarding skills and experience of leaders and lack of planning and goals. Ghobaklo et al. (2012), as well as Glass et al. (2018), identified challenges related to the government in terms of assistance and regulations. Ghobaklo et al. (2012) consider barriers linked with adopting new technologies is due to less acceptance from SMEs regarding costs and risks, and not forget lack of ICT knowledge among employees. Stentoft et al. (2019) also discussed challenges from the technological implementation in term of financial resources, knowledge and managerial experience of new technologies as a challenge for companies to adopt and implement industry 4.0 technologies.

Briefly, similarities between the studies are inappropriate or lack of a formal strategy and knowledge of new technologies as a challenge for companies as well human factors and lack of resources. Three out of five studies raised up policies and legislations.
Table 1: Challenges identified by Zangiacomi et al. (2020) to the left, with minor configurations to be more general for comparison purpose. Challenges identified in other papers are then crossed in each column and explained in short how they connect.

<table>
<thead>
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<tbody>
<tr>
<td>1. Defining clear strategies for implementing digital technologies</td>
<td>X</td>
<td>X (Develop an overall strategy)</td>
<td>X (Lack of conscious planning: defining goals and steps)</td>
<td>X (Inappropriate strategies)</td>
<td>X (Lack of knowledge about I4.0)</td>
<td></td>
</tr>
<tr>
<td>2. Understanding relevant technologies</td>
<td>X</td>
<td>X (Low maturity level for new technology)</td>
<td>X (Lack of knowledge about I4.0)</td>
<td>X (More focus on operations at the expense of developing the company)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Exploit scalability of I4.0 technologies</td>
<td>X</td>
<td>X (Lack of knowledge about I4.0)</td>
<td>X (More focus on operations at the expense of developing the company)</td>
<td>X (More focus on operations at the expense of developing the company)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. Recognize the need to invest in training and culture</td>
<td>X</td>
<td>X (Lack of knowledge about I4.0)</td>
<td>X (More focus on operations at the expense of developing the company)</td>
<td>X (More focus on operations at the expense of developing the company)</td>
<td></td>
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</tr>
<tr>
<td>5. Adoption of lean management approaches</td>
<td>X</td>
<td>X (Lack of knowledge about I4.0)</td>
<td>X (More focus on operations at the expense of developing the company)</td>
<td>X (More focus on operations at the expense of developing the company)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6. Understand how business models change after technology adoption</td>
<td>X</td>
<td>X (Lack of knowledge about I4.0)</td>
<td>X (More focus on operations at the expense of developing the company)</td>
<td>X (More focus on operations at the expense of developing the company)</td>
<td></td>
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<tr>
<td>7. Awareness of implications on the organization beyond IT infrastructure</td>
<td>X</td>
<td>X (Lack of knowledge about I4.0)</td>
<td>X (More focus on operations at the expense of developing the company)</td>
<td>X (More focus on operations at the expense of developing the company)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8. Awareness of necessary support measures when implementing digital technologies</td>
<td>X</td>
<td>X (Lack of knowledge about I4.0)</td>
<td>X (More focus on operations at the expense of developing the company)</td>
<td>X (More focus on operations at the expense of developing the company)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>9. Awareness of I4.0 technologies among partners and other stakeholders</td>
<td>X</td>
<td>X (Lack of willingness to cooperate)</td>
<td>X (More focus on operations at the expense of developing the company)</td>
<td>X (More focus on operations at the expense of developing the company)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10. Proactively define resources, processes and procedures to adopt I4.0 technologies</td>
<td>X</td>
<td>X (Develop an overall strategy)</td>
<td>X (Lack of conscious planning: needed resources)</td>
<td>X (Lack of required resources)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>11. Adopting collaboration with external sources of knowledge</td>
<td>X</td>
<td>X (Lack of knowledge about I4.0)</td>
<td>X (More focus on operations at the expense of developing the company)</td>
<td>X (More focus on operations at the expense of developing the company)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>12. Exploit connections with local ecosystems (universities, policymakers etc.)</td>
<td>X</td>
<td>X (Lack of knowledge about I4.0)</td>
<td>X (More focus on operations at the expense of developing the company)</td>
<td>X (More focus on operations at the expense of developing the company)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>13. Recognize the importance of sharing experiences for successful implementation of I4.0</td>
<td>X</td>
<td>X (Lack of willingness to cooperate)</td>
<td>X (More focus on operations at the expense of developing the company)</td>
<td>X (More focus on operations at the expense of developing the company)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>14. Adopting new approaches or knowledge transfer</td>
<td>X</td>
<td>X (Lack of knowledge about I4.0)</td>
<td>X (More focus on operations at the expense of developing the company)</td>
<td>X (More focus on operations at the expense of developing the company)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>15. Increasing knowledge base on I4.0 technologies, and talent management</td>
<td>X</td>
<td>X (Lack of knowledge about I4.0)</td>
<td>X (More focus on operations at the expense of developing the company)</td>
<td>X (More focus on operations at the expense of developing the company)</td>
<td></td>
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</tr>
</tbody>
</table>
2.2.3 Conceptual framework

The conceptual framework in figure 2 visualize challenges in the digital transformation path towards I4.0 for manufacturing SMEs. From the left SMEs are trying to move towards I4.0, but along the way the SMEs face different challenges that has to be dealt with.

![Figure 2: Conceptual framework over the digital transformation path and challenges in focus in this paper (own).](image)

2.3 Industry 4.0

2.3.1 The basic concept and ideas

I4.0 is a concept in manufacturing industries covers many activities from the design phase to logistics activities (Zheng et al., 2018), and the digital transformation that is required, is taking place in whole supply chains (Kilimis et al., 2019). The adoption of I4.0 leads to technological progress in terms of customizing products and increasing the productivity of resources and improving the information sharing (Zangiacomi et al., 2020). I4.0 is a concept that integrates production processes within information technologies and techniques (Nowotarski & Paslawski, 2017) to add value to the whole product lifecycle (Frank et al., 2019) and facilitate communication (Lu, 2017). Manufacturing I4.0 consists of information exchange and production units and machines work intelligently (Qin et al., 2016). Hirman, Benesova, Steiner & Tupa (2019) presented nine fields of technology that change production from standard to an automated production, which consist of robots, simulation, big data, horizontal and vertical system integration, additive manufacturing and augmented reality, internet of things (IoT), cybersecurity, cloud computing. Zhong et al. (2017) have lifted up the three last technology field, all the nine technologies are summarized in figure 3 by Rüßmann et al. (2015). Still, many companies are not conscious of I4.0 challenges and consequences that they will face during the implementation (Alonso et al., 2019). The
idea with I4.0 is to improve the quality and the production as well increase the flexibility in manufacturing and allows industries to offer a customized product in short lead-time (Zhong et al., 2017). According to Rüßmann et al. (2015), I4.0 will increase productivity, efficiency in logistics among many factors and enhance cooperation between human to human and machines. Furthermore, the authors claims that great changes must take place in business models, organizational structures, partnerships and standardizations.

![Figure 3: Nine field of technology that transforms the production (Rüßmann et al., 2015)](image)

I4.0 has great potential in offering extensive benefits in manufacturing; flexibility, resource efficiency, operational efficiency as well as productivity and is expected to results in higher revenue and competitiveness for companies (Fatorachian & Kazemi, 2018). It also provides decrease lead time and costs (Lu, 2017). Industry 4.0 can also help for building sustainable companies since products, water and energy can be used in an effective way (Stock & Stiger, 2016). Mejtoft (2011) has shown that IoT can provide value creation in different domains in a company, in manufacturing, for instance, all items can be tracked throughout an entire supply chain and potentially customised. Furthermore, IoT can collect data that carries value for both customer and industry in creating even more value, also, IoT aids in co-creation by collaboration. IoT is combining global reach and capabilities to manage, coordinate and control the physical industries with its goods, machines and infrastructure (Dutta, Kumar & Sindhwani, 2019).
2.4 Adopting digital technologies

2.4.1 Digitalization in SMEs

Manufacturing companies develop their Digitalization capabilities and create value with their customers to offer new products by connecting and integrating processes and product functionalities to differentiate themselves. Manufacturing industries adopt Digitalization to achieve a servitization strategy (Lenka, Parida & Wincent, 2017). Docters, Tilstone, Bednarczyk & Gieskes (2011) describe an example of how digitization can be a business project, which defines digitization as something beyond information to decision logic and automated measures. Authors believe that Digitalization has revolutionized devices, manufacturing, tools and services from being physical operations to something that could be done automatically by a system. The authors emerges the importance of implementing a project in SMEs in order to introduce methods for Digitalization and IT systems to accelerate production (Nowotarski & Pasławski, 2017).

Due to the high competitiveness in the market, SMEs faces many challenges that affect their business. Companies that use information communication technology in a good way have a chance to benefit from the market, new knowledge is added and the product quality is improving and processed effectively (Chen et al., 2016). Growing competition is leading companies to increase the variety of their products (Weyer, Schmitt, Ohmer & Gorecky, 2015) in order to better meet the needs of their customers, by using mass customization (Luder, Schleipen, Schmidt, Pfrommer & Hencen, 2018). In addition, they must increase the flexibility of their production systems, whether in terms of resource capacity, quantities produced and technologies used (Luder et al., 2018; Weyer et al., 2015). In order to better respond to the competitive market (Ghobakhloo, 2018). Despite the production system, manufacturing companies also want to shorten their products life cycle to be able to respond to customer demands quickly (Luder et al., 2018; Weyer et al., 2015).

Due to digital transformation SMEs create and add value. Large opportunities from digitalization can affect business model, but SMEs have lack of time and resources to deal with that and implement new strategies, it also put a pressure for SMEs to restructure their business model (Bouwman et al., 2019). According to Hartl & Hess (2017) culture has a great impact on the business model and support the transformation of the business model and impacts the way of exploiting digital technologies.

To run the project of digitalization it needs both knowledge and experience in digitalization, which is hard to find both competences in SMEs (Heberle, Löwe, Gustafsson & Vorrei, 2017). Authors indicates that digitalization support both companies vision and strategy and need to be clarified, which is the first step to go toward in the project.
The first step for any SME with the ambition to digitalize themselves is to identify what tasks and operations throughout an entire value chain will give them the greatest benefit in accordance to their specific key performance indicators, with consideration of cost-effectiveness. Every company has its own level of digitalization, skills and infrastructure, therefore the implementation of different digital technologies will impact companies differently. Common for all companies though, is that they should include the shopfloor workers in the digital transformation process from the beginning to overcome fears and utilize the employees experiences and skills (Kilimis et al., 2019).

2.4.2 Strategies for digital transformation

Glass et al. (2018) claims that SMEs often lack developing strategies for implementation of new solutions, and shortage of skilled workers with relevant experience in the I4.0 field is a great issue. Digital transformation begins with strategic leadership and digital organisation strategy. In order to digitally transform successfully, a supportive culture, new business processes and excellent leadership is required and will in long-term create a positive benefits for an organisation. From a pure technological perspective in digital transformation, businesses are taking advantage of new softwares, hardware and the accessibility and availability the internet provides to create new products and services. The technological aspect is not the only aspect in digital transformation strategy according to Heavin & Power (2018), the others are the role of people, the organisational culture and formal strategic planning. It is of high importance to align these aspects, operationally this means that company culture at a fundamental level should be compatible with adoption of different technologies. Moreover, a strategic plan or vision must be grounded in a deep understanding of customer needs and technological opportunities. Most employees feel challenged because of the digital revolution with the idea that the new technology will be direct substitutes for tasks that are regularly performed by people (Balsmeier & Woerter, 2019).

There is a strong link between innovating business models and strategy. SMEs are, as previously discussed, struggling with a lack of time and resources, but if an SME is set to digitally transform they are required dedicate resources to innovate and rethink their business model (Bouwman et al., 2019). Digital transformation is for improving process and products, and other than influencing the business model, affects the supply chain which creates challenges for firms (Horváth & Szabó, 2019). Dedication, belief and understanding of potential benefits of digitalised tools from top management is key to a successful digital transformation, but for SME’s digital transformations are often limited by the managers/entrepreneurs lack of knowledge in the ICT and digitalised tools-field (Li, Su, Zhang & Mao, 2018). Horváth & Szabó (2019) agreed that lack of skilled employees and retrain process to adapt for changes are one of the barriers, difficulties in coordination are also a challenge that companies may meet. Schwertner (2017) confirm that barrier for digitization are human factors and not due to technologies since employees may have some resistance for changing, lack of
motivation and employees don't have the applicable knowledge. Arendt (2008) assume that SMEs are afraid to invest in trainee to their employees because their qualification will be higher and employees might leave to larger companies or companies that will offer higher salaries.

From the other side Li et al. (2018) raises the difference between large and SMEs, is that large companies are able to develop their own digital platform unlike SMEs that should rely on a third company digital platform. Sommer (2015) added that the smaller an SME is the risk is higher to be an offer instead of beneficiaries of the industrial revolution. SMEs adopt informal strategies and tend to be reactive instead of proactive (Ghobadian & Gallear, 1997).

2.4.3 Investing in digital technologies

Since manufacturing is an economic force that drives innovation and provides job opportunities as well as improving lives with a variety of products, so investing in digital technologies is an important step for manufacturing industries to be competitive in the world economy (Bosman, Hartman & Sutherland, 2019). Fonseca (2018) also acknowledge the creations of jobs and economic growth that comes with digital transformation, but mentions that it will come with a considerable cost of jobs that does not require high skills. Love & Matthews (2019) estimated that the underlying motive for investing in digital technologies is to give managers the opportunity to get fast information with high quality in order to improve the decision-making, follow up trends and also to reduce costs, the investment needs to be planned and managed because it's challenging. Collaboration and communication have been improved due to the development of digital technologies (Yoo et al., 2009). Digital technologies contributes to sustainability since systems operates in a limited way which reduces energy and by resource efficiency related to decrease in material dependence. Authors mentioned that company that has a sustainability strategy expect digitalization to influence it (Demartini, Evans & Tonelli, 2019).

Firms may invest in highly skilled employees or invest in automation, it shows that there is no impact for firms that only invest in technologies such as ERP (Balsmeier & Woerter, 2019). According to Najib & Kiminami (2011) SMEs have difficulties to develop new product and update their technologies due to budget. Investing in IT does not provide a competitive advantage but creates a unique IT resource and also knowledge that affects a company's business in a positive way (Chen et al., 2016). Authors added that it doesn’t require for SMEs to do huge investment in computing system, which leads to reduction in costs (ibid). SMEs should start with doing investment for developing the culture and building teams in order to bring employees together but it should start from the entrepreneurs itself to overcome barriers and gain more knowledge (Li et al., 2018).
Lean management is wide of methods and principles that help industries to control and plan the supply chain in an effective way while digitalization is focused on technologies but both have the same objective is to make the complexity of the production system manageable. Even so, SMEs are afraid of the cost when implementing lean without considering the economic outcomes which in turn is challenging. SMEs need first to understand the concepts of lean and digitalization and get an idea of their content by getting methodological support (Hoellthaler, Braunreuther & Reinhart, 2018).

Haddud & Khare (2020) raised the lack of research about the correlation between digitalization and lean and indicates that digitalization make the use of lean practices smoother but new challenges may appear and it is of huge importance to know the impact of industry 4.0 on the supply chain. Some risks defined by Denner, Püschel & Röglinger (2018) when selecting digital technologies, among this risks is that it's expensive or doesn't fit the company business model or don't have the potential, the company may had a bad experience before and become not able to manage it. Schwertner (2017) consider that among risks there is risks related to data security issues, the company lose the ability to use information with their existing IT systems, and lack of control.

2.5 Knowledge sharing and collaboration

2.5.1 Importance of knowledge sharing and collaboration

One main driver of changes in operations management strategies in manufacturing companies are the development of information and communication technologies (Agrifoglio, Cannavale, Laurenza & Metallo, 2017). An important factor to consider in Digitalization strategy is the sharing and integration of skills and knowledge within the company as well as to external business partners. By enhancing collaboration via such information networks, core competencies and business processes can be exploited more effectively that ultimately will strengthen the competitiveness (Fatorachian & Kazemi, 2018). The role of coordination and collaboration is important since the business models changes into a process of Digitalization, communications and buyer digitalization (Ruiz-Alba, Guesalaga, Ayestarán & Mediano, 2019).

When it comes to technology, SMEs are dependent on external sources which means that cooperation is needed, which is not easy for SMEs since other companies sees each other as competitors (Najib & Kiminami, 2011). SMEs should be aware of the benefits that are associated with cooperation. Cooperation can compensate to lack of resources and expertise, furthermore, it can minimize risks of investments and implementation. However, there are also risks that SMEs need to be aware of regarding cooperation; partner-dependencies, data security and eventual loss of know-how are serious matters that must be taken into consideration (Schneider, 2018). To realize the concept I4.0 requires collaboration between organisations, processes and mechanisms (Camarinha-Matos, Fornasiero & Afsarmanesh, 2017). The way of creating collaboration and
choosing the right partner in order to get access for knowledge and expertise is a challenge for SMEs (Hutchinson & Quintas, 2008). Employees may not see the benefits from sharing knowledge or they not get sufficient from the top manager (Cabrera & Cabrera, 2002).

Knowledge is an important factor for competitive advantage, the size of SMEs help to accelerate the knowledge flow. Industry 4.0 can be challenging for SMEs until they form a good strategy that combine knowledge with technology in order to innovate (Ngah & Wong, 2020). Managing knowledge requires companies to align culture, measurement, technology and infrastructure where the challenge is to merge both methods and approaches to tackle business needs, top manager has an important role in the success of knowledge management, also organization culture need to be taken into consideration (Du Plessis, 2007). Knowledge is the main point in knowledge management, where knowledge management is described by Matayong & Mahmood (2013) as a systematic approach that increase knowledge by providing procedures. Knowledge sharing and communities of practices are some approaches for knowledge management practices where the aim of this approaches is to share and learn. Developing an approach regarding knowledge sharing companies should be prepared to face some challenges also approaches dedicated to knowledge sharing should include and involve individuals (Fernis, Green, Weller & Newcombe, 2003). Individuals are not willing to share information because they are afraid of sharing secrets and also sharing wrong information may cost companies a lot which in turn can affect the way resources are shared and used among partners (Fawcett, Magnan & McCarter, 2008).

2.5.2 Where collaboration and knowledge can be found

Knowledge is seen as a collaborative process where shared information is generated from different sources (Olazabal, Chiabai, Foudi & Neumann,2018). Sharing knowledge means individuals within an organization share and receive information, ideas and expertise with others and new knowledge might develop (Podrug, Filipović & Kovač, 2017). The authors lifted up factors that influence knowledge sharing within an organization among them is the desire to share information and encourage employees also uses technologies in order to make the transmission easy (Ibid).

Successful collaboration relies on good communication and trust among partners to get close cooperation and be able to create a competitive edge at a lower cost (Gumbo & Gichira, 2015). Due to technological changes and high competitiveness, SMEs have difficulties to become innovative, in order to exploit the expertise and the know-how, SMEs try to develop collaborations and find a collaborative agreement which is important for the economic development (Franco, 2003). There is different type of partners, the collaboration between supplier and customer, there is a collaboration with universities and research institutes, both collaborations have a strong impact on the companies innovation (Tobiassen & Pettersen, 2018).
Universities often solve problems based on the capabilities of science and they focus on research that engages practical problems that provide new ideas (Bruneel, D’Este & Salter, 2010). Radas & Bozic (2009) discussed the external collaborations between SMEs and knowledge centers that includes universities, innovation and technology centers as well as consultants. Authors added that collaborating with research centers provides companies with ideas and advanced knowledge which affects the radical innovation. From supply chain perspectives, Barratt (2004) divided collaboration into vertical and horizontal where the vertical includes external collaborations with suppliers and customers while collaboration with other organization and competitor is representing the horizontal collaboration see figure 4 below for more details. Nauwelaers & Wintjes (2002) discussed the turn of policymakers in SMEs and says that among the consequences is that they have difficulties to foresee the future, authors added that policymakers play a big role when it comes to improve innovation outputs by providing innovation inputs and increase their availableness.

Figure 4: Different types of collaboration (Barratt, 2004).

Large enterprises are less attracted to SMEs for partnership (Tobiassen & Pettersen, 2018). Organization culture have an impact on knowledge, employees think that they share knowledge well, and this what causes failure of knowledge tools and processes (McDermott & O'Dell, 2001). Collaboration between industries and universities faces a lot of challenges, among challenges is that companies process of knowledge and knowledge exchange related to the company know-how to gain competitive advantage may be closed and private. Companies conflict against universities may be due to time, research topic or the disclosure results (Bruneel et al., 2010). Which is supported by Radas & Bozic (2009) that there is problems between SMEs and knowledge centers and this should be supported by policies.
Collaboration requires a good management of the process of connecting knowledge among different actors, challenges related to knowledge is connecting knowledge to create value, which requires the company to build a good infrastructure to facilitate both the internally and externally knowledge transmission. Collaboration requires good management of the knowledge process (Von Stamm, 2004). Transforming a collaboration from an agreement to a productive partnership is challenging especially in the early stages of collaboration. Authors added that cultural differences is seen as challenging but it has positive benefits for both partners since they will use their knowledge and experiences for the benefit of the cooperation (Kelly, Schaan & Joncas, 2002).

2.6 Summarization of literature review

Figure 5 below visualize how the literature review relates to the conceptual framework in Figure 2, but with general approach without the specific key dimensions. The first yellow “bubble” from the left shows the main points of what the literature says about SMEs, the second bubble shows the main points regarding digital transformation and related challenges, and the last bubble show the main points concerned with the concept of I4.0.

Figure 5: Shows a brief overview over how the literature review relates to the conceptual framework in figure 2 (own).
3. Methods

In this section the research approach, design, strategies will be presented and motivated, also, criticism of methods and ethical aspects will be discussed.

3.1 Research approach

Alvehus (2019) & Bryman & Bell (2017) describe two ways of explaining the relationship between theory and practice. A deductive approach means that the researcher starts from theory and formulates hypotheses that are then tested using the empirical data collected. Instead, the inductive approach means that the researcher generates theory based on the collected empiricism, or as Alvehus (2019) define it that in an inductive approach it takes the starting point in the empirical material without a theoretical understanding and build conclusions.

Bryman & Bell (2017) argue that a deductive research approach is usually associated with a quantitative research strategy and that an inductive research approach is most often associated with a qualitative research strategy. Authors added abductive that is a mix of inductive and deductive, and starts with a problem that should be explained. Abductive is considered by Alvehus (2019) as a switch between the empirical and theoretical reflection, working with the theory, returning to the empiric, new aspects may be discovered of what is being studied that cause the theory to be modified and developed and then the renewed theoretical insight meets with the empirical material.

The study was deductive since theories provided by Zangiacomi et al. (2020) was tested with the intention of validating the pattern and verify theories and try to draw conclusions from a theory that is already there. The topic of the study arose when the importance of digitalization among companies was noticed and interest has grown during the study time. This was followed by searchers to find previous studies and established theories that have been the basis for the formulation of the purpose and research question. When empirical data then was collected, adjustments of selected theories were made to connect the result and theoretical part in the analysis.

The study follows a combination of qualitative and quantitative research strategies, since the study design follows the qualitative case studies, but also a survey was used and filled by the researcher while conducting the interviews.

According to Bryman (2018), surveys and structured interviews are typical methods for quantitative research, and qualitative research are using focus groups and semi-structured interviews. The author added that quantitative research can be regarded as a research strategy if the study contains a deductive view of the relationship between theory and practical research, where the emphasis is on testing theories, which corresponds to this study. See figure 6 below
In this master thesis a reflexive methodology approach was taken. According to Alvesson & Sköldberg (2017) it is important in all analysis work that reflections and conclusions are not influenced by any subjectivity from the researchers, and that is what reflexive methodology is all about. Reflexive methodology deepens the understanding of different investigations by reflection in four areas:

1. The empirical materials and structuring of data
2. Interpretation of data
3. Critical mindset
4. Self-criticism
5. Linguistic reflection

Figure 6: A brief description of research approach

3.2 Research design

There are five different commonly used forms of research design according to Bryman & Bell (2017): experiments, survey studies, longitudinal studies, case studies and comparative studies. A case study is an in-depth or detailed study of a specific case, it can be an organization, individual or a community (Ibid). A case study is used to analyze a situation to get to an hypothesis or propositions to explain why and what happened in a certain environment, it also facilitate the use of different methods (Descombe, 2014). In a case study, the researchers often aims to create a complete picture over reality, for later description and analysis of the chosen phenomenon (Blomkvist & Hallin, 2015).

A case study that includes more than one case is called a “multi case study” (Yin, 2003). In this study a multiple case study was chosen with various manufacturing SMEs all over Sweden, active in different areas to gather different opinions and be able to find similarities and differences among companies and also be able to compare them. Where
the main focus is to validate whether challenges mentioned in an earlier study is seen in the same way in Swedish SMEs or is there any other kind of challenges.

How the study is designed appears in figure 7 below follows with a brief description of each step.

Figure 7: Visualization of the study plan (own).

1. **Design:** Is the first step to start. This is to come up with a purpose and problem formulation followed by preparation of interview questions and questionnaire that was filled by the researcher while conducting the interview. The report structure was determined and conceptual framework was designed.

2. **Prepare:** Here start the step of looking for SMEs manufacturing active in different branch and contact the selected companies for the case study. An appointment of 15 minutes up to 20 minutes with the company CEO or someone that manage projects related to digitalization or that has knowledge about this area was planned to validate the challenges and also to ask the three open questions.

3. **Collect:** Different information is gathered from both theory and empirical data to compile them both latter in the analysis section.

4. **Transcript:** In this step a vocal text were converted into a written text by hand since a ranking system was followed make it easy to fill and in the end a graph is built as a summary of the answers received, the open questions were also filled by hand during the interview time, to further be able to form an overall picture of the received answers, which is the basis for the results part, then the answers were compared with the theories, in order to do analysis and further draw conclusions.

5. **Analyse:** In this part it allows researchers for this study to use the analytical sense to understand the case from all the collected data and from it deduce several lessons by combining empirical and theoretical data.

6. **Summarize:** Is the last step where everything that is planned must be clear and conclusions are drawn also it allows researchers to confirm or deny the study hypothesis.
3.3 Data collection

The study conducted interviews as data collection method. The interviews contained two parts; the first part was a survey with quantitative results and the second part held three open questions with potential follow-up questions for qualitative results. As part of data collection, a literature collection was conducted in the area of our study to capture different ideas and lessons before evaluating. See figure 8 below.

Figure 8: Summary of data collection (own).

3.4 Interviews

Interviews can be open, focused or semi-structured interviews, the last one is the most commonly used form. In an open interview, the aim is that the interviewee talks as freely as possible about their experiences (Dalen, 2015). This study has largely followed the workflow described by Kvale & Brinkmann (2014) which includes seven different steps; thematization, planning, interviewing, transcript, analysis, verification and reporting.

This study is based on structured interviews, but followed up with three open questions conducted rather semi-structured, because according to Biggam (2008) open questions stimulates the interviewee to give deep and meaningful answers, and allows the interviewer to explore new insights. However, there is a risk that the interviewee tries to answer in a way only to satisfy the interviewer (ibid). Preparation is very important for interviews (Blomkvist & Hallin, 2015), like literature studies, training of interviewing skills and development of the interview questions. Follow-up questions are a convenient way handle unpredictable events and answers, but the interviewee must beware of the risk of influencing the interviewees answers (Andersen & Schwencke, 2013). The advantage of an interview is that the researchers can process the questions and avoid errors that can occur. The interviewee may misunderstand the questions which lead that the interviewee records the answer incorrectly or that questions are not clearly formulated, so having an interview make interviewer actively act and explain when needed.
In physical interviews there are visual contact between the people involved which provide contextual information and other information like body language. This is not the case for telephone interviews, however, that does not mean that telephone interviews are not as good as physical interviews because contextual information and information from the surroundings can be misinterpreted (Novick, 2008).

3.4.1 Selection of respondents

The SMEs were selected based on their relevance in the manufacturing industry in Sweden. The interviewees were selected based on their roles in the organizations and their insight in production, each interviewee held managerial responsibilities when it comes to strategic decisions or was involved in projects related to digital development. The firms were selected based on their branch and size, in order to differentiate.

As a first step to find companies Google maps was used first to select the ones in the area, a table was created as a checklist with the necessary informations to make it easier. In the table were about 35 companies selected. Then the website allabolag served to find if they are more companies and make sure that the 35 selected companies belong to small-medium sized enterprises by verifying the revenue and number of employees. From 35 companies were 10 companies selected for interviews, the reason for eliminating the rest 25 companies was either they have employees between 3 to 10 persons or they have a higher revenue, others were subsidiary of another company located outside of Sweden. Some SMEs were affected by the pandemic which means that their time were spent on getting the company to survive.

3.4.2 Conducting the interviews

The most common thing when conducting interviews is to book time for an interview in advance, but before that, the number of interviewers must be determined and also decide the group of persons to be interviewed. Before the meeting, interview questions should be prepared and think through how the interviews should be documented (Hallin & Hellin, 2018). During the interview it is important to invest time in building trust between the interviewee and the interviewer, which can be done by informing the interviewee about the purpose of the interview, who the researchers are and letting them know they are free to cancel any time. It is also important to give the interviewee time to think over their answers (Andersen & Schwencke, 2013).

Initially, contact was made with a senior manager in the companies by phone, short initial talks were conducted. The average time for each interview was about 15 minutes. The interviews were transcribed, it is about trying to find patterns, similarities and differences, in the answers and try to interpret what the respondents said. The transcription was made very soon after each interview since Andersen & Schwencke (2013) claims that the memory and the overall feelings and sense of nuances tends to get lost over time.
3.5 Data analysis

Collected data have been analyzed based on both quantitative and qualitative methods of analysis. The interviews concerning open questions were qualitatively analyzed using a thematic analysis to answer the first research question: “What Digitalization challenges are valid in Swedish manufacturing SMEs?”. Quantitative analysis was used to answer the second research question. “Which digitalization challenges are considered the most difficult by Swedish manufacturing SMEs?”. The analysis were carried out by calculating standard deviation, mode and mean. The aim of analyzing data is to obtain a better understanding of a subject and be able to describe, explain and interprets how and what the element of the subjects stands for (Denscombe, 2014).

3.5.1 Thematic analysis

Thematic analysis has been followed by structuring data from interviews under different themes and summarizing the results based on it. The analysis procedure is as follow:

- First the answers in a text format from open questions were reviewed and selection of text that is relevant for the research questions was marked
- Secondly answers were grouped under different themes (Investment, awareness and knowledge/collaboration) and made a brief definition of each theme
- From that a theory was built related to each theme so that it becomes coherent
- Then one theme at a time was taken and went through the entire text to summarize the answers with own words and fill the results section.

One possible problem that can arise in coding according to Bryman & Bell (2017) is that the flow of the conversation may fall away. To avoid that researchers tried to ensure that everything is mentioned in the right context by continuously going back to the transcription material.

Graphic representations generally provide the best overview. There are curves, bar charts and pie charts. Curves are suitable for illustrating developments over time. Bar graphs are mainly used when absolute numbers are presented. Pie charts are great for relative numbers as a percent, making it easy to see how many percent each "cake piece" stands for (Ejvegård, 2009). For the study a pie chart was used to present the branch the interviewed SMEs are active on and bar graphs to illustrate number of employees.

3.5.2 Mean value, mode & standard deviation

The mean and the mode is known as a type of the descriptive statistics that measure the central tendency which is an average score in a distribution. That gives a general overview when the authors have a large set of different score (Bui, 2020). Standard deviation shows the spread around the mean value in a population, and if the standard deviation is high there might be a risk that the mean value is not representative of the population (Blomkvist & Hallin, 2015). The standard deviation was calculated as a step to validate the quantitative data from the interviews.
3.6 Methods criticism

3.6.1 Validity & reliability

Bryman & Bell (2013) claims that there are internal and external dimensions of reliability and validity in qualitative studies:

- External reliability relates to the replicability of the study.
- Internal reliability is how well the researchers agree on the interpretations of the work.
- External validity refers to how well the results are generalizable and applicable in different situations.
- Internal validity means that there should be a high and clear correlation between the empiricism and the new theory proposed by the researchers.

In case studies, reliability means that if a researcher follows the described methods of a particular paper, the researcher will get the same results and will draw the same conclusions. High validity requires high reliability in a study. Validity in this context means that the right things are being studied, and reliability means that the study has been conducted in a correct manner (Yin, 2003).

Semi-structured interviews combined with thematic analysis, however, have some reliability and validity issues as the categories and the understanding of the phenomenon may change over time, which might make interviews conducted early in the study less valid and reliable (Blomkvist & Hallin, 2015). For a qualitative method, there is always some level of subjectivity as the researcher’s thoughts and judgements are what the research is built upon. Therefore the repeatability of a study will be a challenge (Bryman & Bell, 2013) but of great importance since Yin (2003) and Bryman & Bell (2013) argues that reliability in case studies is determined to a high extent on the repeatability of the study.

However, concepts of reflexive methodology was always considered in this research to minimize the influence of subjectivity and bias. Bell & Waters (2016) argue that validity is the same as designing a research in order to give credible conclusions and the results that the investigation lead to should provide strong support for the interpretations that are made. The authors continues that the researchers should be able to rely on whether the data that has been used really measures and describes what has been intended from the beginning.

In order to ensure high validity, only peer-reviewed articles were used for related theory, to check if articles are peer reviewed "Ulrich's Periodicals" was used. In prior to interviews, interview skills was trained. The interviews was confidential so the interviewees do not get exposed in unpleasant ways and helps them to freely express themselves. Follow-up questions were asked to handle unpredictable and unexpected
answers, they were also used to ensure a correct understanding of the answers given. At the end of each answer, the interviewer made a brief summary about what the respondent have said. In order to further increase the validity, short definitions were provided about the area, to ensure that the interviewee shared the same understanding and view of digital technologies and I4.0. Since it was SMEs each of the researcher took five SMEs for the interview which means that the interviews over the phone was held by one person, but for ensuring the quality of the answers and the transcription, researcher developed a survey with a ranking system to facilitate the task.

Filling the survey by hand and over the phone regarding the ranking system, it allows the researchers to get a better overview and control the situation by reacting rapidly in case the person does not understand what the challenge stand for or need more explanation. From the voice tone, the interviewer can understand if the interviewee is unsure of the answer which provides a possibility for deepening around the challenges which creates a short discussion where the interviewee can argument with examples. This in itself can confirm the answer, which increases both validity and reliability.

3.6.2 Generalisability
Blomkvist & Hallin (2015) argues that if the study’s quality is high throughout its sections and methods, the results will be generalizable, so great efforts will be made in ensuring high quality and that the study will be repeatable. However, due to the shortage of time, the delimitations in the research and the wide range in the definition of SMEs, the generalisability can be an issue and should, therefore, be thoroughly discussed with the results. Due to lack of time to conduct interviews, it limited the interviewer to make 100% sure that the interviewee had the same view and understanding of the dimensions, challenges, the concept of I4.0 and the reference to “digital technology”.

Some problems with generalisability case studies discussed by Denscombe (2014) that the results of case studies are not to be considered as final. They are in need of confirmation from other research, which can check its validity, or the results can be seen as an ongoing process where they are used to refine ideas developed in previous research.

The definition of an SME covers a wide spectrum of companies with different prerequisites due only to the turnover and number of employees, and it cannot be overseen that if the research was focused merely on the smaller SME, or the opposite part of the spectrum, the results could have turned out quite differently. In addition, it should be taken in consideration that different manufacturing niches might experience challenges differently.
3.7 Ethical aspects

According to Bui (2020), under this heading the authors describes the followed process that includes the participants consent about the study and the permission and also how authors avoid risks that may affect the members and finally that the information requirement has been fulfilled by presenting a copy of the cover letter in the Appendix. In our case the interviews were conducting by phone so there were no letter sent this part were taken orally.

The study follows the four research requirements announced by the Swedish Research Council (2002) & Blomkvist & Hallin (2015). Which are the information requirement, the consent requirement, the confidentiality and utilization requirement. In this study all the four requirements have been fulfilled:

- **Information requirement**: Authors should inform those concerned about the study purpose and brief description about how the study will be conducted. It should include the author's and institutions name. The requirement was met by first introducing ourselves and the university and thereafter inform each company about the purpose of the research and the goal with the study as well what the study is based on.

- **Consent requirement**: Participants have the right to decide on their participation and conditions they should participate in. Information about the participants taken from existing government register does not require consent. The requirement was fulfilled by informing participants that the research is optional, no information about the interviewee will be used or published. Participants had the right to decide the day and time to do the interview. Information concerning numbers of employees, revenue and branch was taken from existing government register allabolag.se but the SMEs was aware about it, the information was double-checked for verification. The right to use that information has been given by the interviewed companies on the condition that the company name or city is not mentioned.

- **Confidentiality requirement**: The information about individuals and company name is confidential, personal data should be stored in a way that unauthorized persons can not access them except person involved in the project. Requirement is fulfilled since interviewees personal data is confidential and also company name and location are anonymous, only persons that took deal of the information are project members that include authors, supervisor and examiner. In this study putting details in the results section was avoided because according to the Swedish Research Council (2002), if the data is sufficiently detailed it make it possible for some readers to identify any individual. Great efforts were made to ensure confidentiality of interviewees and their specific answers.
• **Utilization requirement**: Collected information must not be used for commercial or other non-scientific purposes. The collected data in our case will only be used for research. Interviewees were informed about how the data would be used.
4. Findings

In this section, the findings from the interviews and survey will be presented in tables, diagrams and text.

4.1 Results

4.1.1 Branches & number of employees
The companies from small medium-sized enterprise were interviewed situated in different cities in Sweden and out of the 10, three SMEs were mechanical industry, two offer products related to construction, and one in the timber industry, automotive, aluminium frames and the last one is an industry that offers products related to bicycle and furnitures as shown below in figure 9. What is common between this SMEs manufacturing is that they are subcontractors.

Figure 9: A pie-chart over the interviewed SMEs business area (own).

As seen in figure 10 below employees in the interviewed SMEs were between 19 and up to 158, two companies had the same among of employees which is 30 employees. The X-axis shows the number of SMEs that have responded and the Y-axis shows the number of employees in each company.
4.1.2 Evaluation of challenges

During the interviews, it was found that all challenges truly were not easy tasks, which is supported by the fact that for eight challenges no one rated the challenge as 1 “Not a hard challenge” on the 1-5-scale, and for those challenges that were rated as 1 the mean value and mode still exceeded 2 which is presented in table 2 below.

The mode represents the value that occurs more often as presented in the table below. For example, the first challenge 4 companies out of 10 ranked it as 3 which means fairly difficult so 3 is the value that appeared most.

Standard deviation is also calculated to indicate to what degree the mean value is representative of the population. The standard deviation values are between 0.77-1.2, where 1.2 is relatively high on the scale 1-5, however, the value span is satisfactory. Furthermore, the mean of mean values for each dimensions is calculated.
Table 2: Mean, mode and standard deviation for each challenge based on the interviews

<table>
<thead>
<tr>
<th>Challenges</th>
<th>Mean</th>
<th>Mode</th>
<th>Std. dev.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Defining clear strategies for implementing digital technologies</td>
<td>3.4</td>
<td>3</td>
<td>0.77</td>
</tr>
<tr>
<td>2. Understand which digital technologies that are, or can be relevant and can contribute with value</td>
<td>2.7</td>
<td>3</td>
<td>1.20</td>
</tr>
<tr>
<td>3. Exploiting scalability of digital technologies.</td>
<td>3.5</td>
<td>2 &amp; 5</td>
<td>0.8</td>
</tr>
<tr>
<td>4. Motivate investments in training and company culture</td>
<td>2.8</td>
<td>2</td>
<td>1.02</td>
</tr>
<tr>
<td>5. Adoption of lean management principles and methods</td>
<td>2.6</td>
<td>2</td>
<td>1.00</td>
</tr>
<tr>
<td>6. Understand the business models can change after implementing of digital technologies</td>
<td>3.2</td>
<td>3</td>
<td>0.87</td>
</tr>
<tr>
<td>7. Awareness of the consequences that digital technologies have on the organization, other than on IT infrastructure</td>
<td>3.3</td>
<td>4</td>
<td>0.83</td>
</tr>
<tr>
<td>8. Awareness of necessary support measures when implementing digital technologies</td>
<td>3</td>
<td>2</td>
<td>1.00</td>
</tr>
<tr>
<td>9. Awareness of I4.0 technologies among partners and other stakeholders</td>
<td>3.1</td>
<td>3</td>
<td>0.83</td>
</tr>
<tr>
<td>10. Understand in advance what resources I4.0 processes and other procedures requires.</td>
<td>4</td>
<td>4</td>
<td>0.98</td>
</tr>
<tr>
<td>11. Adopting collaboration with external actors who can contribute knowledge.</td>
<td>2.1</td>
<td>2</td>
<td>0.87</td>
</tr>
<tr>
<td>12. Exploit opportunities that come from universities, innovation centers and policymakers.</td>
<td>2.8</td>
<td>2</td>
<td>0.98</td>
</tr>
<tr>
<td>13. Understand the benefits of sharing successful implementation approaches to others</td>
<td>2.8</td>
<td>2</td>
<td>1.19</td>
</tr>
<tr>
<td>14. Adopt new approaches for knowledge sharing.</td>
<td>3.4</td>
<td>3</td>
<td>0.92</td>
</tr>
<tr>
<td>15. Increase knowledge within the company for digital technologies and I4.0, including talent management</td>
<td>2.9</td>
<td>3</td>
<td>0.94</td>
</tr>
</tbody>
</table>

4.1.3 Evaluation and ranking of dimensions

Table 3 below present the mean and mode of each dimension based on the table above.
As mentioned before each dimension is divided into 5 challenges.
- Challenge 1 to challenge 5 is related to Investment in I4.0 technologies
Challenge 6 to challenge 10 is related to Ability in perceiving the path towards digital transformation
Challenge 7 to challenge 15 is related to knowledge sharing

As shown in table below the second dimension is ranked highest based on the Mean value and also the mode where 3 (fairly difficult) and 4 (difficult) where most selected by the companies

Table 3: Ranking of the three dimensions based on the mean values from the evaluation of the 15 challenges.

<table>
<thead>
<tr>
<th>Rank</th>
<th>Dimensions ranked from the hardest to the easiest</th>
<th>Mean</th>
<th>Mode</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Ability in perceiving the path towards digital transformation</td>
<td>3.32</td>
<td>3 &amp; 4</td>
</tr>
<tr>
<td>2</td>
<td>Investments in I4.0 technologies</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>3</td>
<td>Knowledge sharing</td>
<td>2.8</td>
<td>2</td>
</tr>
</tbody>
</table>

Brief summary based on table 2 and table 3

**Investments in I4.0 technologies**
Based on the mean value in table 3 challenges related to this dimension was listed as fairly difficult (3) with mean value of 3. From the interview, questions were ranked as fairly (3) to slightly (2) despite Q3 was ranked from three companies as slightly difficult (2) and three companies ranked it as very difficult (5) as shown in table 2

**Ability in perceiving the path towards digital transformation**
Based on the mean value challenges related to this dimension was listed as fairly difficult (3) with mean value of 3.32. From the interview, questions were ranked as fairly (3) to difficult (4) despite Q8 was ranked as slightly difficult (2)

**Knowledge sharing**
From the mean value presented in table 3 above, challenges related to this dimension was listed as slightly difficult (2) with mean value of 2.8. The companies agreed that employees should be integrated for the benefit of the transformation process and also should be trained to adapt to the situation. Since the companies are subcontractor and some of them are sub-contractors for large companies so they get benefits from that in term of knowledge and collaboration. From the interview the last four questions (11-15) was ranked as slightly (2) to fairly (3) difficult except Q10 was ranked as difficult (4), the motive for that is that since they are small companies they don't have enough knowledge around it and lack of resources, so they only buy what they need depending on how much it costs.
4.2 Ranking of challenges

Below the challenges are ranked in separate tables with priority to the mean value. The mode was intended to separate challenges with same mean, however, if both are the same they are considered as equally hard even though a greater sample probably would separate those in the ranking. The critical challenges according to the interview as shown in table 4 were in the area of strategy and planning (management) based on the five first challenges. No consideration to standard deviation is taken in ranking, it was only calculated to validate the quantitative results.

Table 4: Ranking of challenges from difficult to slightly difficult depends on the Mean value

<table>
<thead>
<tr>
<th>Rank</th>
<th>Challenges ranked from the hardest to the easiest</th>
<th>Mean</th>
<th>Mode</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>10. Understand in advance what resources I4.0 processes and other procedures require</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>2</td>
<td>3. Exploiting scalability of digital technologies</td>
<td>3.5</td>
<td>2 &amp; 5</td>
</tr>
<tr>
<td>3</td>
<td>14. Adopt new approaches for knowledge sharing</td>
<td>3.4</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>1. Defining clear strategies for implementing digital technologies</td>
<td>3.4</td>
<td>3</td>
</tr>
<tr>
<td>4</td>
<td>7. Awareness of the consequences that digital technologies have on the organization, other than on IT infrastructure</td>
<td>3.3</td>
<td>4</td>
</tr>
<tr>
<td>5</td>
<td>6. Understand how the business models can change after implementing of digital technologies</td>
<td>3.2</td>
<td>3</td>
</tr>
<tr>
<td>6</td>
<td>9. Awareness of I4.0 technologies among partners and other stakeholders</td>
<td>3.1</td>
<td>3</td>
</tr>
<tr>
<td>7</td>
<td>8. Awareness of necessary support measures when implementing digital technologies</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>8</td>
<td>15. Increase knowledge within the company for digital technologies and I4.0, including talent management</td>
<td>2.9</td>
<td>3</td>
</tr>
<tr>
<td>9</td>
<td>4. Motivate investments in training and company culture</td>
<td>2.8</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>12. Exploit opportunities that come from universities, innovation centers and policymakers</td>
<td>2.8</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>13. Understand the benefits of sharing successful implementation approaches to others</td>
<td>2.8</td>
<td>2</td>
</tr>
<tr>
<td>10</td>
<td>2. Understand which digital technologies that are, or can be, relevant and can contribute with value</td>
<td>2.7</td>
<td>2</td>
</tr>
<tr>
<td>11</td>
<td>5. Adoption of lean management principles and methods</td>
<td>2.6</td>
<td>2</td>
</tr>
<tr>
<td>12</td>
<td>11. Adopting collaboration with external actors who can contribute knowledge</td>
<td>2.1</td>
<td>2</td>
</tr>
</tbody>
</table>
4.3 Results from open questions and dialogue

4.3.1 Are there any other challenges or barriers that you can think of?

4 out of 10 directly addressed lack of resources in terms of money, time, skills and knowledge as another challenge and barrier and also since SMEs are looking for quick solutions make them don’t rely much on universities, but all companies addressed the issue indirectly and discussed how it permeates entire organisations and relates to all daily operations and the dimensions that the 15 challenges are divided into. One interviewee discussed how it is especially hard in small cities to find skilled staff and acquire adequate knowledge. In figure 11 below

Other interviewees highlighted how the lack of time does not allow people to focus on anything other than the daily production processes and how it prevents them from freeing up time for training. Moreover, training and knowledge acquisition is known among many companies to be expensive and implementation of various approaches requires a lot of energy and resources. Furthermore, another interviewee discussed how investments on a larger scale would be problematic since it requires more investment in term of training and maintenance. Also if top manager lacks in-depth knowledge of the I4.0 concept and what resources are required to benefit from it, but another issue is that benefits are not always obvious, and also, the rest of the company needs to understand the concept as well.

Figure 11: Visualization of main points from open questions (own).
4.3.2 Do you have any strategies or plans to overcome these challenges or barriers?

Regarding strategies or plans the companies answer very differently. Some companies have started with risk analysis that allows them to find out risks that may occur in processes or information flows and actions to be taken in case of problem, and a few has drawn long-term strategies and started to implement I4.0 supportive measures such as building a good IT-infrastructure to manage the increased data traffic, while two companies had no concrete plans or strategies whatsoever regarding I4.0.

To overcome barriers and challenges regarding investments of expensive technologies, it is important to see the direct benefits in an obvious manner according to a couple of interviewees, like return-on-investments, otherwise it can be hard to motivate the expenditure of both money and time. Furthermore one company developed this answer, saying that they also include external actors for evaluation and drawing plans concerning major investments. One interviewee said that no investments would be made if there will be obstacles (other than general-like issues for all investments).

4.3.3 From those challenges you ranked as not very hard, were any of them hard previously?

*Four* of the interviewed SMEs doesn’t notice any changes and it has always been as they ranked it despite *one* company that argue that it's hard to see the changes. *One* company has managed to reduce challenges related to the third dimension “knowledge sharing” by mapping out a strategy to work toward competences by recruiting people with high competence and knowledge around digitalization also have planned several projects to improve their processes and strategies.

*Two* companies added that in the beginning was difficult to justify the implementation of digital solutions to employees since digitalization was new concept and computer was a new device, but with time employees acquire experience and IT knowledge and feel more confident which made it easier. *One* company feel that they are working on reducing challenges since they are collaborating with large companies so they share their technology expertise with them but as an SMEs they also contribute with suggestions and ideas to large companies to show interest and are also open for collaborations with universities. *Another company* added that by doing risk analysis in advance make them avoid many problems and set up the actions.

4.3.4 Other surfaced challenges and issues

New technologies sometimes carry obvious opportunities, like internet and social media, and it would be “straight out foolish” not to exploit the opportunities. Internet for example is a network tool, or in other words a transaction tool that transmits operational instructions as much as information. That will allows the manufacturing SMEs to reduce the time and cost of designing a new product, by giving the means to
monitor logistics efficiently, however, it was found that bad attitude among workers undermines implementation of technologies that might compete with them. Thinking about Digital Transformation is anticipating what will happen, with the firm intention of using technology to make the company business prospe, but all implementation processes carry challenges that cannot be foreseen, and regarding what is to be implemented, the obviousness of specific support measures varies. As well some SMEs have long-term plan, but not have a concrete idea on exactly which technique will be implemented.

Investment-related evaluation and discussion with partners are harder when it covers uncertainties, and there are many in I4.0. One senior manager reasoned that companies deals with uncertainties of different levels regularly, but can develop good strategies to manage them, however, for the I4.0 concept which is abstract and somewhat alien to many, it will be extremely hard.

Many respondents emphasized the importance of good training and sharing of knowledge, but to identify or even develop new, adequate approaches for knowledge sharing is hard and a challenging task. To this, another respondent added that in regards to knowledge sharing and learning new trades, it should to some extent be customized to the individual, yet the customization use pretty much the same “standard” practices only a different mix of them, and for many trades the successfulness rely heavily on the supervision and mentorship the individual receives. Top manager should act as a mentor, keep update of news and inform the rest of employees about the news. Also there are some scepticism towards sharing successful approaches and ideas to others than close and trusted partners due to competitiveness

One interviewee point out the lack of common and concrete definitions of digitalization and industry 4.0 concepts and more studies should be done on those areas. Because it's a very strong subject that is still misunderstood, often seen through the prism of new technologies but it is more a way of thinking about the business that is completely different from the way the company work today, the interviewee added that digitalization become as a forced transformation more it accelerates more the SME faces challenges and it accelerates the fall of non-digitized companies. This why the interviewees SME look for value-creating partnership with large companies that have knowledge and implemented the concepts since the internal innovation in the SME is facing it owns limits.
5. Discussion

In this section the findings and the literature review will be discussed with regards to the purpose and to answer the research questions.

5.1 Validation discussion

All challenges in the research by Zangiacomi et al. (2020) are, according to the results from the interviews, validated in the context of Swedish manufacturing SMEs. Not a single respondent perceived the challenges as easy or irrelevant. Furthermore, only a few of the challenges was evaluated as not very hard (1), nevertheless no mean or mode value were less than 2. If standard deviation would be subtracted from any of the mean values, no challenges would score less than 1, which strengthen the validation.

Regarding the dimensions, the mean value of perceived difficulty of challenges were all very close to three: 3.32; 3; 2.8.

5.2 Discussion of dimensions and challenges

5.2.1 Overview of main points and ideas

In figure 12 below the conceptual framework from figure 2 (section 2.2.3) is slightly configured and complemented with the main points and ideas from discussion. All challenges are validated in Sweden, moreover, aggravating and facilitating factors surfaced in findings and discussion that influence many or all of the challenges are positioned where the Swedish manufacturing SMEs (from a general point of view) are currently situated in the digital transformation path.

![Diagram](image-url)

*Figure 12: The conceptual framework from section 2.2.3 complemented with main points and ideas derived from findings and discussion (own).*
5.2.2 Dimensions
According to the results from the survey the ranking of the dimensions where as follows, from the hardest:
1. Ability in perceiving the path towards digital transformation
2. Investments in I4.0 technologies
3. Knowledge sharing

The three key dimensions are interrelated (Zangiacomi et al., 2020). The first dimension “Investments in I4.0 technologies” are mainly concerned with “hard values” like procurement of machines and strategy. The second dimension “Ability in perceiving the path towards digital transformation” seems to be dealing with those hard values systematically and the third dimension “knowledge sharing” are about “soft values” and these three dimensions together gives a complete picture of the scope they are concerned with.

5.2.3 Challenges
From table 4 in findings section the challenges were ranked with regards to mean and mode value, and in this subsection each challenge will be discussed from the hardest.

1. “Understand in advance what resources I4.0 processes and other procedures require”

The hardest challenge according to the interviews was “Understand in advance what resources I4.0 processes and other procedures require”, which is validated in theory by Alonso et al. (2019) who claimed that many companies are having trouble to foresee what challenges and consequences they will face during implementation of I4.0 technologies.
The companies who had long-term plans regarding digitalization and I4.0 reasoned that even though they have a common vision, it is very hard to know the exact implication of potential implementations, and therefore foresee and understand what is required for the I4.0 concept to work. One interviewee added that they will implement various digital technologies, but in long-term they do not know exactly what techniques and in what order they will be implemented, which complicates the issue even further. Here the role of risk analysis in the interviewed SMEs is used to gain some understanding and kind of estimate the future of the technology the company want to acquire by compiling risks that are followed by actions.

2. “Exploiting scalability of digital technologies”

In linkage to this challenge, Schwertner (2017) claimed that there are data security risks, and that the new technology is not compatible with existing IT-infrastructure and a lack of control might be a consequence of it. Which in certain degree among the priority things that interviewed SMEs consider was to have a good IT infrastructure and choose the most appropriate technology. Two interviewees reasoned similar to what is stated above in challenge 10; other than investing in training, it is very hard to foresee and
understand what is required for different digital technologies to work on a larger scale. Also, they added that the hardness of the challenge is much dependant on what technology that potentially will be implemented, because if some people has experience or knowledge from a technology it is very helpful to both management and to those who are supposed to use it. One interviewee explained that most of the major investments in technology are taken after discussion and evaluation together with external partners and suppliers to make sure that the dedication to the task of all relevant parts are satisfactory if an investment are agreed, a statement supported by what Li et al. (2018) discussed regarding a successful digital transformation. However, the interviewee continued and added that no investment-related discussion and evaluation are the same, and with consideration to the uncertainties towards I4.0 the discussions and evaluations will be very tough.

3. “Adopt new approaches for knowledge sharing” and “Defining clear strategies for implementing digital technologies”

In the third place two challenges ranked with the same level of difficulty with a mean value of 3.4. Heavin & Power (2018) pointed the importance to put strategic plans but Glass et al. (2018) claimed SMEs often lack concrete strategies and that the shortage of skilled and experienced personnel is one reason to it. Furthermore, Bouwman et al. (2019) argued that due to lack of resources and time it becomes difficult for SMEs to form strategies. Which is to some extent relevant to the answers provided from the interviews of those that did not have any strategies or plans related to digitalization but motivated as due to time. Most of the interviewees acknowledged the importance of good strategies and claimed that they make great efforts in developing good strategies, but the “uncharted ground” of I4.0 is a great challenge as nobody (in the companies interviewed) has any experience or knowledge in it. One senior manager said that they deal with uncertainties on a regular basis, and even though they are aware of the benefits digital technologies and ultimately I4.0 carry, developing an adequate and hopefully good strategy towards something radical and hard-to-grasp concept is very hard. A lack of knowledge and experience seems therefore to be the greatest obstacles in strategies, which is supported and validated by Heberle et al. (2017) as they claimed that strategies need to be clarified as a first step and Heavin & Power (2018) said that strategies must be grounded in deep understanding.

Regarding the 14th challenge knowledge is the focus area in knowledge management, where sharing knowledge is an approach for knowledge management with the aim of sharing and learning (Matayong & Mahmood, 2013), but developing an approach from Fernie et al. (2003) point of view is not that easy and companies will face challenges therefore companies should include individual, and according to Du Plessis (2007) merge both methods and approaches to deal with the needs. The interviewees had trouble in visualising how new knowledge sharing approaches could look like and work. Most of the respondents were positive towards trying new approaches as they acknowledged the importance of knowledge sharing, however, it is very challenging to find or come up with adequate, new approaches to adopt.
4. “Awareness of the consequences that digital technologies have on the organization“

Is ranked fourth. Where defining successful strategies might be hard since I4.0 and advanced technologies can be considered as “uncharted ground”, and the results motivated that more than half of the interviewed SMEs doesn't have any plans or strategies, they only consider a risk analysis before buying new machinery. Nevertheless, the development of ICTs are a driver for changes in strategy, at least regarding operations management according to Agrifoglio et al. (2017). Rüßmann et al. (2015) stated that I4.0 will bring many benefits and opportunities to companies but it will requires drastic changes in organizational structures, partnerships and standardizations. A few interviewees discussed how different technologies have different purposes in the business, but altogether in highly digitalised and advanced environment some scepticism regarding the implications on the human roles surfaced. A couple of respondents added the concrete example - that also can be found in literature - of people undermining and showing bad attitude in the implementation process of technologies since it will compete with human workers. This statement is worrying, nevertheless valid to some extent as Balsmeier & Woerter (2019) stated that people can feel challenged by technology and Fonseca (2018) claimed that a digital transformation might lead to job creations, but at a considerable cost of jobs requiring low skills. Here does a concrete sub-challenge surface, and it will be exemplified as a question: “how to motivate people that are directly competing with digital technology as they sense a risk of losing their job?” which is indirectly supported by Li et al. (2018) and Heavin & Power (2018) as they discussed how dedication and company culture is of high importance in digital transformation.

5. “Understand how the business models can change after implementation of digital technologies”

The challenge ranked at fifth place is also well validated in the literature as Chen et al. (2016) claimed that companies can benefit from markets if they use ICTs and Horváth & Szabó (2019) added that business models does change as a digital transformation changes (improves) processes and products, and that whole supply chains are affected and acknowledged by Ruiz-Alba et al. (2019). Furthermore, Bouwman et al. (2019) claimed that SMEs need to dedicate resources to innovate and rethink their business model if their digital transformation will be successful, and also that business models and strategy is strongly linked which is supported by Rüßmann et al. (2015) as they discussed how radical changes in business model must take place. According to Ghabaklo et al. (2012) and Glass et al. (2018) there is a lack of skilled and experienced personnel in this field, a fact that surely contributes to the difficulties linked to this challenge.
No interviewees talked about the link between business models and strategy directly, however, some interviewees did mentioned how new technology may carry new opportunities and it would be “straight out foolish” as one manager put it, not to take obvious opportunities in consideration in business development. No reasoning regarding I4.0 technologies connected to this challenge were made, indicating and also further validating, the hard nature of this challenge.

6. “Awareness of I4.0 technologies among partners and other stakeholders”

The challenge is sixth in the ranking system and are discussed and the importance are well validated in literature. SMEs are dependent on cooperation (Najib & Kiminami, 2011) and I4.0 technologies, IoT for instance, can aid in co-creation and collaboration (Dutta et al., 2019). As Camarinha (2017) raised up that the realization of the I4.0 concepts don’t rely only on collaboration between organizations but different aspects should be considered. It is important for SMEs to share skills and knowledge to partners to operate more efficiently and enhance competitiveness (Fatorachian & Kazemi, 2018). In the fact that the interviewed SMEs are subcontractor for other companies, so it is natural for them to be aware of what is happening among partners, if they have a tight relation and depends on each other’s, this might not be the case with stakeholders since SMEs have lack of time to reach to all their stakeholders and also some stakeholders prefer to focus their efforts on large companies and therefore do not always respond to requests from SMEs to put a dialog and inform about the actual technologies.

7. “Awareness of necessary support measures when implementing digital technologies”

The seventh challenge in the ranking are arguably one of the broadest challenges since different technologies might require implementation measures, however, the challenge is validated in literature. Schneider (2018) argued that cooperation can bridge gaps in skills and knowledge, which will be existing for SMEs as they lack resources in general (Bouwman et al., 2019). Moreover, Denner et al. (2018) claimed there are risks of digital technologies not fitting business models, and if a company had bad experience from managing implementations of other digital technologies they avoid them - implying those companies doesn’t know what support measures that are required to implement digital technologies successfully. Alonso et al. (2019) stated that unconsciousness of SMEs toward the consequences that occurs during the implementation phase of I4.0 is low. For some digital technologies it is obvious what is needed in order to make it work even though there are always some hidden challenges that are very hard to foresee in all implementation processes, one interviewee reasoned. Here does another concrete sub-challenge surface: to mitigate the implementation challenges for I4.0 technologies a common picture of the I4.0 concept would be helpful, at least within a company and its closest partners since Schneider (2018) claimed that cooperation can bridge many difficulties SMEs face, as it would provide a tangible
vision to strive after that employees and managers can work their minds around and in that way increase awareness of necessary support measures.

8. “Increasing knowledge within the company for digital technologies and 4.0”

The challenge is ranked in the eighth place. Which is supported by Horváth & Szabó (2019) that lack of skilled employees and retrain process to adapt for changes are one of the barriers and which continued by Schwertner (2017) that among barriers are the resistance and the knowledge of employees. Podrug et al. (2017) reflected on the desire of employees to share the information and use technologies are factors that influences the sharing of knowledge. The mentioned authors agreed that the human factors are the barriers and not technology since SMEs according to Li et al. (2018) can rely on a third company to manage their digital platform.

Kilimis et al. (2019) considered that including shop floor workers may help companies to use the experience and skills from its employees in the first phases of transformation. Balsmeier & Woerter, (2019) mentioned that companies may do investment to get high skilled employees. This typical point of increasing knowledge are most of the interviewees SMEs working on by holding training by external consultants which is costly and involve employees in order to increase the motivation. Many of the SMEs in this research are located on the countryside, and a few of those expressed difficulties in acquiring workers with skills and relevant knowledge regarding advanced digital technologies.

9. “Motivate investments in training and company culture” and “Exploit opportunities that come from universities, innovation centers and policymakers” and “Understand the benefits of sharing successful implementation approaches to others”

Three challenges ranked ninth with a mean value of 2.8. For the first challenge as Arendt (2008) mentioned that investing in trainee are SMEs afraid of because they are afraid to lose their employees after gaining higher qualification and skills, which is not the case for the interviewed SMEs where the first step is to get employees informed and plan training for employees, one company preferred to employ people with the required knowledge to assist and improve the internal knowledge within the company. Organization culture as mentioned by (McDermott & O’Dell, 2001) has an impact on knowledge from employees side and due to different culture, that’s the reason why the interviewed companies always keep employees aware of the benefits of sharing knowledge and always keep updates.

When it comes to the second challenge so Bruneel et al. (2010) points of view is that many challenges faces the collaboration between industries and universities and is due to many issues such as the priorities where SMEs are more focused on gaining competitive advantage that in turn lead to difficulties for universities to get the needed informations and also conflicts might arise due to time or topic. Actually none of these
conflicts has been mentioned by the interviewee on the contrary, they were open for collaboration with universities and see it as an advantage since they have skills about that area and can contribute with ideas, knowledge and sometimes with solutions. Which is compatible with what Bruneel et al. (2010) and Radas & Bozic (2009) said. The role of policymakers were raised by Nauwelaers & Wintjes (2002) that they have a big impact when it comes to innovation actually none of the interviewed companies insisted on their collaboration with policymakers only that they are aware about it and the type of collaboration is superficially.

Regarding the last challenge many respondents in this paper have well-developed collaborations with external actors and partners, having joint programs for use of some techniques and technologies. It seems in general that the companies have an understanding of the importance to share successful implementation approaches to close and trusted partners, but when including others than trusted partners in the discussion a couple of respondents were found to be more sceptical due to the chance of losing a potential competitive market position to others by revealing successful approaches. As Fawcett et al. (2008) pointed out that among causes to not share informations are the fear of revealing secrets and costs that can turn against the company due to false information.

10. “Understand which digital technologies that are, or can be, relevant and can contribute with value”

The challenge ranked as lowest among the last ranks with difference of 0,1 from the previous challenges is “Understanding which digital technologies that are, or can be, relevant and can contribute with value”. A recurrent subject in the interviews are the uncertainties and uncharted nature of I4.0, but short-term many respondents states that there are various existing digital technologies they would like to acquire with many obvious benefits to them, but that the lack of resources and some uncertainties regarding direct profits seems to act as deterrent, and probably in particular for I4.0 technologies that holds a long-term perspective with even more uncertainties. Here where cooperation can be relevant according to Schneider (2018) to get access to the needed resources. Another statement interpreted by Denner et al. (2018) is that companies that experienced failure become unable to handle which digital technologies are relevant, so far the participant SMEs are taking small steps to avoid making mistakes that leads to failure.

11. “Adoption of lean management principles and methods”

The challenge before the last and ranked as lowest with difference of 0,5 from the last challenge in the list. Lack of research as Haddud & Khare (2020) raised and the worry of cost related to implementation of lean that Hoellthaler et al. (2018) pointed so SMEs don't have enough knowledge around lean and digitalization therefore they are afraid of costs while implementing lean. But these were not experienced from the interviewed companies since they have a form of production so they use lean principles but actually
no one mentioned or showed the connection between lean and digitalization, which raised Haddud & Khare (2020) point of view that lack of knowledge around the connection between the two concepts may have a sort impact on the SMEs and causes obstacles while implementing digitalization. That leads to a reflection, since the interviewed SMEs feel safe while adopting lean principles, that this will not prevent them from challenges that may arise during the implementation of digitalization or industry 4.0.

12. “Adopting collaborations with external actors”

The lowest ranked challenge was related to “adopting collaborations with external actors”, nevertheless no respondent thought the challenge was irrelevant or particularly easy, but for the interviewed SMEs everyone collaborates with external actors, so it seems like a domain they are relatively comfortable in. All authors acknowledged that collaboration can be both externally and internally. As agreed by Najib & Kiminami (2011) and Schneider (2018) SMEs are dependent on external collaborations and that they get benefit from such collaboration in terms of resources and expertise that follows with lowers risks in investment, which is corresponds to the answers from the interviews. Follows by Fatorachian & Kazemi (2018) that saw digital strategy as a way of sharing knowledge to external partners and the use of information networks lead to improved partnership. Yoo et al. (2009) added that digital technologies may develop collaboration and communication among partners. The cultural difference between companies may be beneficial for the improvement of the partnership (Kelly et al., 2002).

- General discussion about the challenges

It seems that the challenges with a direct link to future uncertainties and visions, namely challenges ranked between level 1-7, are perceived as the hardest. This is supported by what the majority of the interviewees discussed, and since the concept of I4.0 is to some extent “uncharted ground” and requires cutting edge -or not yet developed- technology it is logical. Which make the implementation of digitalization difficult in its first appearance but over time become easier due to the confidence, knowledge and experience that employees acquire. This is supported in the paper of Kilimis et al. (2019), as they claimed that companies should include shopfloor workers in the beginning of digital transformation processes’ to overcome fears of new technology (which would be I4.0 technologies in this case) and to make use of skills and experiences from the workforce. From the interviews it became clear that from experience, it depends on what technology will be implemented and that it might be problematic to generalise to much, but it definitely helps if someone in the workforce has experience and knowledge from the technology beforehand.

The challenges ranked between level 8-12 are also involved in future events in this context of course, but it is not on the same uncharted ground as the others. Collaboration for different purposes, lean management and managing knowledge are
challenges that almost all modern companies are dealing with, and has been dealing with a long time, indicating the “fear of the unknowing” is not present. Digital tools has been presented as well for quite some time now, but for clarifications sake, it is highly advanced digital technology (compatible with the concept of I4.0) this paper refers to with digitalization.

Throughout the research it has become clear that digitalization can contribute to sustainability. Demartini et al. (2019) claimed that digital systems operates in way that can increase energy and resource efficiency. Resource efficiency is something recurrent in most papers discussing the perks with digitalization and I4.0.

5.3 Issues surfaced in dialogue and open questions

All interviewees addressed directly or indirectly the lack of resources as a main challenge no matter the task is and this fact is valid for all the 15 challenges in this paper. The lack of resources in SMEs, especially time and money as Schneider (2018) & Bouwman et al. (2019) addressed, permeates the entire organisations of the Swedish manufacturing SMEs looked into, and possibly the majority of all manufacturing SMEs in an international context.

However, as some interviewees argued that uncertainties with new and expensive technologies were a major barrier, they also claimed that many barriers and challenges with that of uncertain nature can be managed by identifying tangible and direct benefits so investments are motivated to everybody. For I4.0 this can be problematic as it still is a not-yet-realized concept anywhere, and here lies a challenge for the research community and other pro-I4.0 actors. Stentoft et al. (2019) believed that SMEs focuses on developing their business activities which causes a backlogs to invest in new technologies that needs to be processed

Digital technologies are expensive and may not fit the company's business model (Denner et al., 2018) which the interviewed companies agreed on that investing in digital technologies is not easy it requires a lot of resources and a good infrastructure. Another point according to Heberle et al. (2017) was finding both knowledge and experience in SMEs in the area of digitalization is hard and it has been motivated by one company, as while a concept or a device is new it's always hard to get used to in the beginning, further some of the interviewed SMEs are trying to work toward that particular point by putting strategies for recruiting skilled profiles to combine both knowledge and experience. Many interviewees mentioned that there might be huge differences between different digital technologies since some technologies requires less efforts and other requires a huge data set and a good planning because the losses become huge.

A statement interpreted by Cabrera & Cabrera, (2012) is lack of knowledge sharing between the top manager and employees are considered as a barrier. Training of less experienced employees is seen as a method of sharing knowledge in the interviewed
SMEs, who are rarely financial and requires investment, this point might prevent top manager to invest in and explain the lack of knowledge sharing, which so far is not the case of the participant SMEs. In such situation companies should develop internal strategies in order to be able to share knowledge efficiently and until now everything related to knowledge sharing is seen coming from external sources. Thus, strategies related to sharing knowledge internally get less interest and the focus goes to enhancing external strategies, in that point companies should find a balance.
Digitalization is an unavoidable reality. Large companies are not the only ones who have to adapt their practices to survive. Faced with this major challenge to keep and develop their competitiveness, SMEs must approach digital transformation with an innovative mindset as they are required to rethink their business model, organisational structures and cultures, a challenge that too many SMEs struggle to cope with. Like any major transformation, it involves risks that should be anticipated and prevented, in particular through a large-scale digital education effort. The aim of this study is to validate and rank challenges towards digitalization in the context of manufacturing SMEs in Sweden. Lastly talking about “digital transformation”, so there is a consideration of subjects related to sustainability, because digitalization can have a positive impact on sustainability and which motivates by the studies done.

6.1 Theoretical contribution
The base of this master thesis was formed from the research of Zangiacomi et al. (2020), in which they presented three key dimensions in digital transformation towards I4.0 along with 15 challenges together with common mistakes and best practices to overcome them. Their research was conducted in Italy with companies of different sizes and business areas, and even though their research is great in many ways it has validation problems if it is applied in another and more specific context, which is something they are acknowledging. The theoretical contributions of this master thesis are the validation of all 15 challenges in the context of Swedish manufacturing SMEs, the two sub-challenges that surfaced during the research and the ranking system that indicates the difficulty of each challenge. Furthermore, challenges 1, 10 and 15 was covered by other researches (see table 1), and the discussion about those challenges can contribute to those researches and the individual discussion of all challenges pointed out in both empirical and theoretical data may enrich this scientific field.

6.2 Practical contribution
Digitalization and industry I4.0 have a major impact on companies and changes how companies are structured and organized. What has emerged in this paper is that a restructuring of IT infrastructure is required and all parts of business needs to be coordinated and integrated (business model, strategy, culture, people) and external collaboration and cooperation are needed. Increased competition in the market means that SME companies must embrace an innovative mindset to find new adequate ways to do business. In addition, the digital transformation entails large costs for SMEs and it is important to spend their resources on cost effective and value-creating activities since the majority of respondents stated that investment in new technologies often are
expensive and is a major barrier to advance in transformation. The study has also contributed to an increased understanding of the need to have a way of thinking and acting regarding processes and strategies as well a clear goal about Digitalization and I4.0. Furthermore, both aggravating and facilitating factors has been pointed out, which can aid manufacturing SMEs to deal with the discussed challenges successfully.”

6.2.1 What digitalization challenges are valid in Swedish manufacturing SMEs?
It was found that all 15 challenges investigated are valid for Swedish manufacturing SMEs. During the interviews and discussion, two concrete sub-challenges surfaced. One sub-challenge are connected to the many uncertainties the future and I4.0 carries; a common, tangible picture for workers and managers to work their minds around would be very helpful. The second sub-challenge will be exemplified as a question: “how do you motivate people that are directly competing with digital technologies as they sense a risk of losing their job?”.

6.2.2 Which digitalization challenges are considered the most difficult by Swedish manufacturing SMEs?
The top three most difficult challenges are: “Understand in advance what resources I4.0 processes and other procedures require”, followed by “Exploiting scalability of digital technologies” and together on third place was “Adopt new approaches for knowledge sharing” and “Defining clear strategies for implementing digital technologies”. The three least difficult challenges are: “Adopting collaboration with external actors who can contribute with knowledge”, “Adoption of lean management principles and methods” and “Understand which digital technologies that are, or can be, relevant and can contribute with value”.

The most difficult challenges, ranked 1-7, appears to have in common a direct link to future uncertainties concerning the concept of I4.0 and therefore has some fears and anxiety into them, whereas the challenges ranked between 8-12 does not carry the same level of uncertainty because companies are dealing with those challenges, or similar, regularly.

6.3 Limitations
The greatest limitations in this study was shortage of time and the difficulties linked to the Corona pandemic. The plan was to get more interviews but SMEs were more focused on their cash flow and survive during the pandemic so only 10 companies not equally spread out over the country were able to participate. As defined in the definition section so SMEs can have up to 250 employees, which was not the case for the selected companies, where the highest employees number were 158. Another issue due to Covid-19 was that the distance between the authors of this thesis was troublesome and the remote work caused communication problems since a large part of communication is done through phone calls or message which can be difficult to capture all non-verbal
information. Sometimes it takes longer time to express clearly the idea to the other person. The study also focuses only on specific business sector which is the manufacturing SMEs.

6.4 Future research

As digitalization and I4.0 seems to be constantly changing, further research in the concepts are constantly relevant which is also raised up in the interviewees. Challenges linked with future uncertainties and visions are top in rank, implying that future research are more urgent in those areas in order to mitigate the task of overcoming them by providing a greater scientific base, unveiling the “uncharted ground” of I4.0.

The study focused merely on manufacturing SMEs, but due to lack of time only ten interviews was conducted and therefore it would be interesting to:

- Re-rank the challenges with more companies since many results are similar.
- Orientate the study to large companies in Sweden and in other business sectors.
- Comparing both large and SMEs manufacturing in Sweden regarding the challenges presented in the study.
- Go deep into the sub-challenges that surfaced.
- In-depth study that focuses only on how digitalization or I4.0 contributes to sustainability in manufacturing SMEs.
- Since this study do not include SMEs with employees between 200-250 persons, further research might be required for SMEs in that spectrum of the SME definition.

Many interviewees mention that there might be huge differences between different digital technologies, so future research could go deeper into specified digital technologies to find peculiarities and specific challenges for implementing specific digital technologies.
Reference


