Exploring the implementation of Industry 4.0 at SMEs using the Smart Industry Maturity Scan (SIMS)

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ABSTRACT,
Industrialization is on the verge of a fourth revolution: Industry 4.0 (I4.0). The use of new technologies can create a cyberphysical system in which technologies and machines are often interconnected. This leads to increasingly autonomous and intelligent systems which enables new and efficient processes that can lead to a competitive advantage for SMEs. The potential advantages of I4.0 are well known. However, according to previously conducted research, not all companies have yet made the transition to I4.0. With the use of the Smart Industry Maturity Scan (SIMS), this study explores the maturity of I4.0 implementation at two manufacturing SMEs. This SIMS scan is the starting point for a group discussion with the SMEs to observe potential factors that might prevent the companies from implementing I4.0. This research found out that the main factors that prevent SMEs from implementing I4.0 are complexity, financial barriers and knowledge scarcity.

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1. INTRODUCTION

1.1 Situation and complication

At the end of the 18th century, industrialization has begun with the introduction of water—and steam-powered mechanical manufacturing. Later on, around the start of the 20th century, the paradigm shifts towards electrically powered mass production. As of the 1970s, electronics and IT was implemented to achieve automation of manufacturing. These three paradigm shifts are called Industrial Revolutions. The fourth industrial revolution is happening at this moment, it is called Industry 4.0 (I4.0). Industry is the part of an economy that is about the activity of processing raw materials and the manufacturing of goods.

As said, we are on the verge of Industry 4.0. The term Industry 4.0 was first brought up by the German government in an attempt to promote digitization in manufacturing. Different researchers have come up with slightly different definitions of this term. According to Culot et al. (2020), there is a lack of agreed-upon definitions of Industry 4.0. Most definitions have something to do with the automation of industrial practices by making use of all sorts of Internet of Things solutions. According to Weyer et al., in Industry 4.0, field devices, machines, production modules, and products are comprised as Cyber-Physical Systems (CPS) that are autonomously exchanging information, triggering actions, and controlling each other independently.

Industry 4.0 with all its possible applications, poses many opportunities for small and medium-sized enterprises (SMEs) manufacturing firms. Some possible benefits of the implementation of Industry 4.0 into the value chain are operational agility, cost-efficiency, and problem-scanning (Masood & Sonntag, 2020).

The implementation of I4.0 offers SMEs the capability to produce single products, or product parts (Masood & Sonntag, 2020). This increase of flexibility makes it so that SMEs can react faster to alternating demand and thus provides operational agility for SMEs. Among others, machine control, demand forecasting, higher quality, and reduced operating costs entail a higher cost-efficiency (PwC, 2016). Due to the interconnected machinery and the presence of sensors, companies will be able to do more extensive scanning (Deloitte, 2015). This can prevent or find problems in the production process or perform quality control.

Adopting Industry 4.0 – often called Smart Industry – will allow SMEs to exploit the above-mentioned benefits. By doing this, they will better be able to compete with multinationals who often already have a sophisticated logistic and supply chain network and thus increase their competitive advantage.

Aside from these aforesaid benefits, there are lots of challenges and issues regarding the implementation of I4.0 for SMEs. It is known that the implementation of a system such as I4.0 is far-reaching for most SMEs, because for a variety of reasons. Lots of them have to do with resource scarcity and complexity. This will be further elaborated on in the literature review part.

It seems that Industry 4.0 has not been fully implemented in global companies just yet. According to PwC (2018), just 10 percent of global manufacturing firms have embraced I4.0, while almost two-thirds have barely or not even begun their transformation towards I4.0.

1.2 Research objective

The goal of this research is to identify factors in the process of implementing Industry 4.0 which prevents SMEs from implementing I4.0. Besides identifying these factors, this research will also focus on how SMEs implement Industry 4.0 into their operational processes.

Also, a secondary objective of this thesis is to assess small and medium-sized companies on the degree of integration of Industry 4.0. This assessment will be done via the Smart Industry Maturity Scan (SIMS) of IXIA Smart Insights. This tool will serve as a starting point to answer the research question. Two manufacturing SMEs located in the eastern Netherlands will be assessed using the SIMS scan.

1.3 Research question

This research question is based on the above-mentioned objective. The goal is to identify bottlenecks in the process of implementing Industry 4.0 in the operations of SMEs. This resulted in the following research question:

'Which struggles do SMEs encounter when implementing Industry 4.0 technologies in their operations?'

1.3.1 Answering the research question

Answering this research question consists of different segments. First, the Smart Industry Maturity Scan will be conducted among the two companies. After that, qualitative research will be conducted via a group discussion and a company tour at the two companies. As a result, this research poses a contribution to the understanding of how SMEs implement Industry 4.0 and what factors might prevent them from implementing Industry 4.0.

1.4 Academic relevance

Industry 4.0 poses many opportunities for SMEs (Masood & Sonntag, 2020). According to a survey of PwC in 2018 conducted among 1155 manufacturing firm executives in 26 countries, the majority of Dutch manufacturing firm executives (71%) see its companies as digital novices or a digital follower. Only 8% of Dutch executives would rank their company as a digital forerunner (PwC, 2018). According to the Dutch Central Agency for Statistics, 99% of Dutch companies are so-called SME businesses.

This statistic shows that there must be factors for SMEs that prevent them from implementing Industry 4.0. Thus, from an academic point of view, it is highly relevant to look at what might affect SME businesses not to adopt the implementation of Industry 4.0. From an academic point of view, a better understanding of these factors can add value to further research on the implementation of I4.0.

1.5 Practical relevance

As mentioned before in the situation and complication section of this thesis, applications of Industry 4.0 pose many opportunities for SMEs, however, it seems like many SMEs have not implemented Industry 4.0 yet (PwC, 2018).

Therefore, it is interesting and practically relevant to look at why SMEs do not fully implement Industry 4.0 and what might cause SMEs to do this. Many opportunities are left behind by SMEs which leads to a decrease in the competitiveness of in particular SMEs and even whole economies. These implications can, later on, be implemented to eliminate these causes and foster the implementation of Industry 4.0 solutions in SME operations.

1.6 Structure of the thesis

In this part, the structure of the thesis will be shortly specified. The thesis will consist of nine chapters. After the introduction, a theoretical framework will be provided to gain an understanding about the most relevant topics for this thesis: Industry 4.0, Small and Medium-sized companies (SMEs), Challenges and Issues of Implementing Industry 4.0 for SMEs, and finally the Smart Industry Maturity Scan (SIMS) will be explained and specified. Following, the methodology of this report will be further elaborated on. After that, the results of the scan and interview will be discussed in chapter four. Based on these results, the findings will be summarized and concluded in chapter five. Then, in chapter six, the limitations of this research and future research options will be given. Consequently, a conclusion will be drawn in chapter seven. Following, the acknowledgements and references will be brought in chapters eight and nine.

2. THEORETICAL FRAMEWORK

In order to answer the research questions, it is important to have an understanding of the interrelated concepts of Industry 4.0. These concepts will give validation and understanding of existing theories. Starting with an introduction to Industry 4.0, after which SMEs, challenges and issues of implementing I4.0, and the SIMS will be discussed.

2.1 Industry 4.0

Despite that there is no commonly agreed-upon definition for Industry 4.0 (Culot et al., 2020), the term can be explained as the outcome of the fourth industrial revolution in which physical production and operational processes are confronted with automation, data exchange, connectivity, and intelligence which leads to an interconnected cyber-physical environment.

Vaidya et al. (2018) described nine pillars of Industry 4.0 that contribute to a fully integrated, automated, and optimized production flow. These nine pillars are:

- Big Data and Analytics
  Big Data and Analytics are all about the collection and evaluation of data from many different sources.
- Autonomous Robots
  Autonomous Robots are used to perform autonomous production activities more precisely and efficiently than human workers.
- Simulation
  Simulations will be used more extensively in plant operations to leverage real-time data to mirror the physical world in a virtual model, which can include machines, products, and humans, thereby driving down machine setup times and increasing quality (Rüßmann, 2015).
- System Integration: Horizontal and Vertical System Integration
  System Integration is about the integration and automation of manufacturing processes, which can be horizontal, vertical, and end-to-end.
- The Industrial Internet of Things
  The industrial Internet of Things is a term referring to a network of interconnected objects that communicate via standard protocols.
- Cyber security and Cyber Physical Systems (CPS)
  Cyber security and Cyber Physical Systems (CPS) are about the protection of CPS's from cyber threats such as for example hacking or data theft.
- The cloud
  The cloud is a digital place in which different devices share data to each other and can be accessed from any place with internet connection.
- Additive Manufacturing
  Additive Manufacturing is a term which is about the ability to produce small unit sizes of specifically customized products, often with less to no waste of raw materials. Generally named as 3D-printing.
- Augmented reality
  Augmented reality is a practice in which reality is appended with information coming from computers.

As stated earlier, there is no commonly used definition for Industry 4.0 (Culot et al, 2020). Table 1 mentions definitions used by different authors and organizations.

Author	Definition
Vaidya et al. (2018)	''The term Industry 4.0 stands for the fourth industrial revolution which is defined as a new level of organization and control over the entire value chain of the life cycle of products; it is geared towards increasingly individualized customer requirements.''
McKinsey & Company (2015)	''McKinsey defines Industry 4.0 as digitization of the manufacturing sector, with embedded sensors in virtually all product components and manufacturing equipment, ubiquitous cyberphysical systems, and analysis of all relevant data.''
Platform Industrie 4.0, Federal Ministry for Economic Affairs and Energy Germany (2021)	''Industrie 4.0 refers to the intelligent networking of machines and processes for industry with the help of information and communication technology. There are many ways for companies to use intelligent networking.''
OECD (2017)	"The use in industrial production of recent, and often interconnected, digital technologies that enable new and more efficient processes, and which in some cases yield new goods and services. The associated technologies are many, from developments in machine learning and data science, which permit increasingly autonomous and intelligent systems, to low-cost sensors which underpin the IoT, to new control devices that make second-generation industrial robotics possible"

Table 1, Definitions of Industry 4.0

2.1.1 When is a technology defined as an Industry 4.0 application?

After elaborating on the different definitions and the nine pillars of I4.0, it remains unclear what makes a certain technology be seen as a technology which contributes to the Industry 4.0 or smart industry. In other words, when can a technology be seen as an I4.0 application?

To answer this question, one must get a clear understanding of the basics of Industry 4.0. According to Rüßmann et al. (2015), characteristics of Industry 4.0 applications are in fact that they will transform production. Isolated cells will be combined into a fully integrated, automated, and optimized production flow, leading to greater efficiencies and changing production relationships among suppliers, producers, and customers, likewise between human and machinery. This whole ecosystem of combined cells can then be called an interconnect cyber-physical environment. Concluding, a technology can be seen as an I4.0 application, as long as it contributes to that interconnected cyber-physical environment by either connecting, optimizing, or automating the different production cells or the system as a whole. This can be done via for example data analysis (optimization), the use of robots (automation), or cloud computing (connection).

2.1.2 Types of Industry 4.0 integration

According to Tay et al. (2018), I4.0 describes a future scenario of industrial production that is characterized by new levels of controlling, organizing, and transforming the entire value chain with the life cycle of products, resulting in higher productivity and flexibility through three types of effective integration. These three types of integration are horizontal, vertical, and end-to-end system integration.

Vertical integration involves the creation of flexible and reconfigurable manufacturing systems by the seamless integration of hierarchical systems inside a company (Foidl et al., 2016). E.g., integration across all organizational departments, from design to production to logistics.

Horizontal integration refers to create inter-corporation collaborations within an efficient ecosystem where material, information (data), and finance flow smoothly between different companies or factories. For instance, Company X can order a product from Company Y without any human contact, through a fully automated supply chain network.

End-to-end integration is based on integration across the entire value chain (Stock & Seliger, 2016). It is based on a combination of vertical and horizontal integration. It aims to create a full digital integration and automation of manufacturing processes, as well as an automation of communication and cooperation along processes (Erol et al., 2016).

Figure 1 gives in a schematic illustration of how the three different types of integration work across different companies and the relationships between the types of integration.

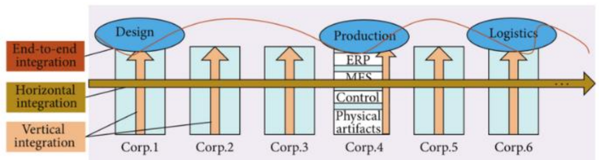

Figure 1, Industry 4.0 integration from Hoidl et al. (2016)

2.2 Small and medium-sized enterprises (SMEs)

SME stands for small and medium-sized enterprises. The term is used by different international organizations with slightly different definitions. As this research will be conducted at two SMEs based in the Netherlands, the SME definition of the European Commission will be applied to the context of this thesis.

According to the European Commission (2003), the main factors for determining SMEs are staff count and turnover or balance sheet total.

To qualify as an SME, a company needs to have less than 250 employees, less than €50 million in turnover, or having less than €43 million on its balance sheet (European Commission, 2003).

2.3 Challenges and issues of implementing Industry 4.0 for SMEs

The implementation of Industry 4.0 across an entire organization does not happen overnight, especially for SMEs as they do not have the resources that bigger companies might have.

There have been lots of different literature and research about the challenges and issues which companies might encounter when implementing Industry 4.0. Various authors have found distinctive kinds of challenges for implementing I4.0, it involves many different facets, including technological, organizational, economic, and social problems.

Table 2 will provide an overview of the main challenges and issues which apply to SMEs regarding the implementation of Industry 4.0, as found by different authors.

Author	Challenges and issues for implementing I4.0
Schröder (2017)	- The development of an appropriate strategy - Difficulties with a cost-benefit analysis of the relevant technologies - Lack of data security and uniform standards
Rüßmann et al. (2015)	- Cyber Security: With the increased connectivity and use of standard communications protocols that come with Industry 4.0, the need to protect critical industrial systems and manufacturing lines and system data from cyber security threats increases dramatically
Luthra & Mangla (2018	- Low understanding on Industry 4.0 implications - Poor company's digital operations vision and strategy - Lack of global standards and data sharing protocols - Unclear economic benefit of digital investments
Cellary (2019)	- Challenge to future employees requiring new educational methods - Challenge to fixing errors in complex software and training datasets - Challenge to responsibility of complex software designers, developers, and integrators.
Wang et al. (2016)	- Intelligent Decision-Making and Negotiation Mechanism: In I4.0 systems, machinery need more autonomy and sociality capabilities. Whereas today's machines lack in autonomy and social capabilities. - Manufacturing Specific Big Data and Its Analytics: It is a challenge to ensure high quality of the data recorded from manufacturing. Also, analysing different kind of data from different repositories is a challenge. - Cyber and Property Security: the necessity to protect systems, data and

	manufacturing processes from cyber threats.

Table 2, Challenges and issues for implementing I4.0

Concluding, one can say that there is a variety in challenges and issues that might come into play when a SME wants to implement I4.0. To assess the maturity systematically of the two manufacturing SMEs studied in this research, the Smart Industry Maturity Scan (SIMS) will be used. Then, the SIMS will serve as a starting point for a group discussion with the two SMEs, to reveal the challenges and issues regarding the implementation of I4.0 at the two companies. The SIMS will be introduced in the following part.

2.4 Smart Industry Maturity Scan (SIMS)

The Smart Industry Maturity Scan (SIMS), will be used in this report to assess the maturity of the two companies. The scan is developed by Ungerer (2018) and consists of 7 aspects of a company. The aspects are Value Chain, Technology & IT Management, Strategy & Oranisation, Customer Interfaces, People & Organisational Culture, Institutional awareness, and Products & Customer Service.

3. METHODOLOGY

3.1 SMEs Description

The two SMEs participating in this research will be called Levo and Trams. These names are fictitious and are not the actual names of the companies.

The company Trams is active as a supplier of a product in the automotive industry. They produce customized floors for vans to which wheelchairs can be connected. Their turnover is approximately €18 million, and they employ 20 FTE. The business model is business to business, of which most of the revenue comes from selling directly to automobile manufacturers.

The SME named Levo is a producer of city bicycles and electric bikes. Its business model is business to consumer, as they sell their products directly via their website to their clients. Their estimated revenue is between €25 million and €50 million, and they employ roughly 15 FTE.

3.2 Data collection

In order to answer the research question of this thesis, primary and secondary data will be used. Primary data is collected first-hand. Secondary data is information that has been collected by someone else earlier.

The primary data for this research will be collected via an in-depth case study. This will be performed qualitatively via a group discussion, and a company tour. Next to that, as said, the Smart Industry Maturity Scan (SIMS) scan will be carried out. This will serve as a starting point for the discussion sessions with at least two representatives of the companies. The secondary data has been collected in the literature review part of this report, mostly via publicly available academic sources.

3.2.1 Smart Industry Maturity Scan

The Smart Industry Maturity Scan (SIMS) used in this research is developed by Ungerer (2018).

A maturity model conceptually represents phases of increasing quantitative of qualitative capability changes of a maturing element in order to assess its advances with respect to defined focus areas (Kohlegger & Thalmann, 2009).

The SIMS starts with an introduction to the company in which it asks for general information, such as a revenue estimation, number of employees, and the role of the respondent at the company.

After this introduction of the scan, it will measure the maturity of the respective company on seven different aspects.

These seven different aspects are:

- Strategy and organisation
- People and organisational culture
- Products and customer services
- Customer interfaces
- Value chain
- Technology and IT management
- Institutional awareness

The maturity of the seven aspects will be measured via 5 questions for each aspect. The five questions will be asked via a unipolar Likert scale. The unipolar Likert scale is a set of statements offered for a real or hypothetical situation under study. Participants are asked to show their level of agreement (from '(1) not at all' to '(5) fully') with the given statement (items) on a metric scale (Joshi et al, 2015) (Ungerer, 2018).

3.2.2 Discussion session

After conducting the SIMS scan, a discussion session with the company representatives will be held to present the outcomes of the scan and to initiate a discussion to gather data for the research question of this thesis. This data collection method is particularly interesting because it generates the opportunity to collect data from the group interaction and it allows to explore topics and to generate hypotheses (Nyumba et al., 2018). As I was the leader of this session, I tried to streamline the discussion with four open-ended questions, with the purpose to gather factors that might prevent the two SMEs from implementing Industry 4.0. These questions were: 1. *To what extent is Industry 4.0/Smart Industry a relevant topic in your company?* 2. *What is your digitization strategy?* 3. *What kind of Industry 4.0 applications are utilized in your company?* 4. *If so, how are these applications integrated company-wide?*. The data from these discussion sessions will later on be used in the results segment of this thesis.

3.2.3 Company tour

Before conducting the SIMS scan and discussion session, a company tour was given in order to introduce me to the company and to demonstrate its processes. The tour at Trams was done by the owner, and at Levo the tour was given by the logistic manager. The tour of Trams showed that their production process was a long and complicated process, with no automation. Throughout the production process, various types of heavy machinery are used. These machines were not connected, and thus were isolated cells. The tour at Levo showed that its production process was less complex, as the manufacturing process was mainly assembling different components together. The observations of the company tour can contribute with providing a confirmation of findings, more comprehensive data, and an increased validity (Bekhet & Zauszniewski, 2012).

3.3 Data analysis

The gathered data from the scan will be analyzed by a mean score for each aspect and a general score of the company's maturity level (mean of all aspects). The scores will be on a scale from 1 to 5, with 1 being the poorest extent of I4.0 implementation, and 5 the highest. Table 3 shows to which level and extent of implementation these scores belong.

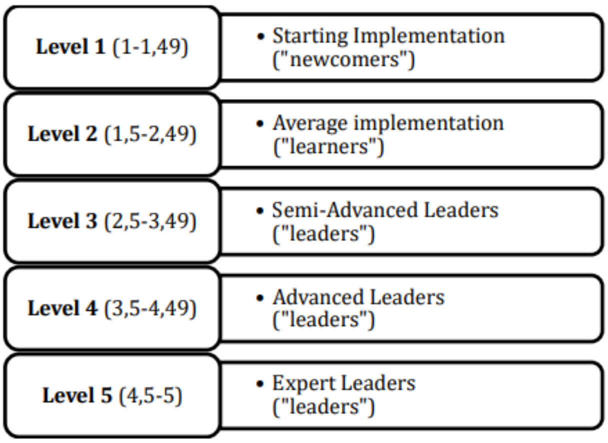

Figure 2, Smart Industry maturity levels from Ungerer (2019)

The data gathered from the SIMS scan and the discussion session are going to be used to answer the research question.

4. RESULTS

In this chapter, the results will be presented and analyzed. It consists of two parts. In the first part, the results of the Smart Industry Maturity Scan (SIMS) are displayed. Subsequently, the results from the group discussion will be given in the second part. Next to that, a cross-case analysis between the two companies will be conducted. The SIMS was filled in by one representative of each company, the group discussion consisted of two participants at Trams, and three participants at Levo.

4.1 Smart Industry Maturity Scan (SIMS)

4.1.1 SIMS at Trams

A summary of the results of Trams per dimension can be found in Figure 3. Trams has a total average score of 2.63. This belongs to a maturity level of three, with advanced implementation.

Trams scores highest in the aspect 'Customer interfaces' (4.2), which indicates advanced implementation. The dimension with the lowest scores is 'Products and customer services' (1.6) and 'Technology and IT management' (1.8), which both indicate that there is average implementation.

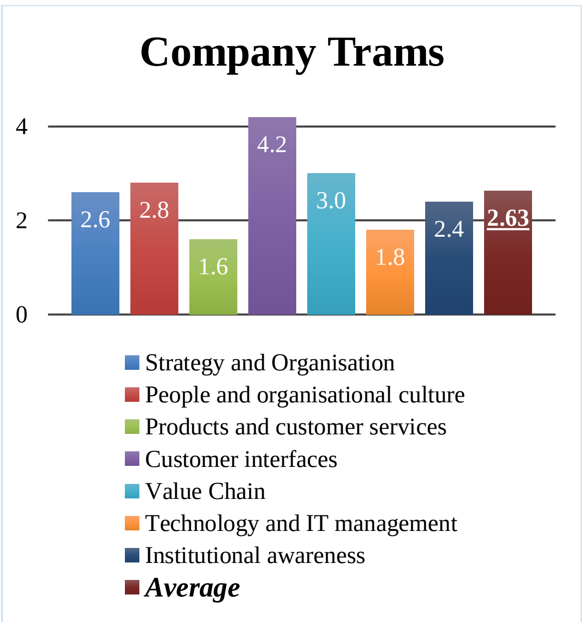

Figure 3, SIMS results Company Trams

4.1.2 SIMS at Levo

An overview of the results of Levo per dimension can be found in Figure 4. Levo has a total average score of 2.54, this belongs to maturity level 3 and indicates semi-advanced implementation.

Levo's highest dimension score is 'Customer interfaces' (3.6), which belongs to a maturity level of advanced leaders. Its lowest scores are 'Technology and IT management' (1.8) and 'Institutional awareness' (1.6) this indicates that Levo is a learner in the respective aspects regarding I4.0 implementation.

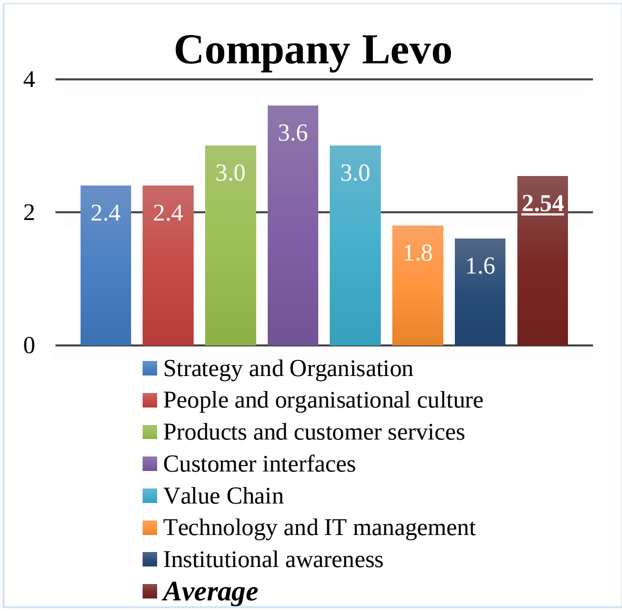

Figure 4, SIMS results Company Levo

4.2 Group discussion

In this part, the results of the group discussion will be presented. The outcome of the SIMS per aspect served as a starting point for the discussion. The discussion with Trams was held with two people, and the discussion with Levo had three participants.

In order to guide the discussion, four open-ended questions were used. These questions were: 1. *To what extent is Industry 4.0/Smart Industry a relevant topic in your company?* 2. *What is your digitization strategy?* 3. *What kind of Industry 4.0 applications are utilized in your company?* 4. *If so, how are these applications integrated company-wide?*.

The results of the group discussion are shown in the succeeding seven parts, covering all aspects of the Smart Industry Maturity Scan. First, the results of Trams will be presented, whereafter the results from Levo will follow. The maturity score of the company is in brackets behind the company name at each different aspect.

4.2.1 Strategy and Organisation

This aspect measures to what extent the strategy contributes to an organization in which Industry 4.0 can be implemented.

Trams (2.6)

Trams indicated during the group discussion that Industry 4.0/Smart Industry is not really a topic for them. They stated that there is no exigency for them, as they are currently market leaders and are way ahead of their competitors. Nevertheless, during the discussion they did admit that it might be a good idea to come up with some kind of strategy, to maintain their competitive advantage.

Levo (2.4)

Levo stated that there was no digitization strategy in place until two years ago. The main reason for this was their rapid growth, they have been able to double their revenue each year since their founding in 2013. This rapid growth had as a consequence that there was no time and resources left to build a solid digitization strategy, as all time and, financial resources went to the expansion of the business. This went on until two years ago.

In 2019, the company decided to create a digitization strategy. They decided to put more focus on the customer journey. In order to do this, they hired an employee whose job is purely dedicated on improving the customer journey. This will be further elaborated in the aspect Customer interfaces.

4.2.2 People and organizational culture

This aspect is about the extent to which there is a culture present in a company which contributes and facilitates the implementation of innovations.

Trams (2.8)

Only a few employees of Trams are involved with the implementation of Smart Industry, all of them are managers or supervisors. The production workers are not involved in this process because they are usually poorly educated. They will be confronted with a – technological – change as soon as it gets implemented. An example of this is the implementation of a so-called Failure mode and effects analysis (FMEA). This is a tool which analyses potential mistakes in the production process. The product engineer, planner and supervisor run this analysis and come up with quality checks to implement in the production process. The production workers are then being trained to perform these quality checks and to document the data into the company system.

Levo (2.4)

At Levo only a few people are coping with I4.0. These people are all working in the office. The reason why the other personnel are not involved in this is because they are mostly part-time employees who assemble the bikes which the management do not want to bother with topics what they say are too complex for them. Levo for example implemented the use of a handheld computer which is integrated with their Enterprise Resource System (ERP). This system will purely be used by the production workers. The production workers were taken along in the implementation process, and they got to know the technology as soon as the change was implemented.

4.2.3 Products and customer services

This aspect measures the extent to which the company's products are accommodated with smart techniques and to what extent these products support servitization.

Trams (1.6)

Products and customer services is the aspect on which Trams scores the lowest. The products which Trams produces are not suitable for smart techniques, such as for example sensors. As they produce custom floors to which wheelchairs can be connected, they must meet all kinds of safety standards and regulations. The floors must be as strong and lightweight as possible. The implementation of for example a sensor would compromise these two product requirements.

Levo (3.0)

Industry 4.0 is highly integrated into the products of Levo. The electric bikes of Levo contain a SIM card which automatically sends data to the company. For example, average biking distance, number of users, and battery status is being send to the company. Also, Levo can provide updates to the bike via this connection. The user of the bike automatically gets notifications when the bike needs maintenance based on the user data. On top of that, a GPS module is built into the bike via which the company can help the owner to retrace its bicycle when it is stolen.

4.2.4 Customer interfaces

There are various channels through which clients can communicate with a company. This aspect measures to which extent a company can facilitate this customer contact.

Trams (4.2)

Customer interfaces is the highest scoring aspect of Trams. Most orders of Trams come in through an Electronic Data Interchange (EDI) system. Via EDI, a customer can place an order into the management system of Trams which is then automatically implemented in the production planning of the company. The customer automatically gets an invoice. The EDI system also automatically informs the customer when there is a delay in the production process. All other customer interaction within Trams is also digital.

Levo (3.6)

This is the highest scoring aspect of Levo. All the contact customers have, go via the digital channels of the company, the most important one being their website where customers can place their orders. As mentioned at Strategy and Organisation, the company had no digitization strategy until two years ago. The company hired a customer journey specialist, she is responsible for improving the whole customer journey. The information supply towards customers have been totally renewed and automated. Currently, when there is a delay in the production process the customer gets automatically notified via e-mail. Whereas earlier this had to be done manual, which is a time-consuming job. Another I4.0 implementation is that whenever a product is out of stock, the website gets updated automatically and the customer gets a prediction of when the product is back in stock.

4.2.5 Value Chain

The value chain is the whole process of activities from order to the delivery of the product. This aspect measures the extent to which I4.0 technologies and applications are implemented in this process.

Trams (3.0)

The value chain of Trams is digitized to some extent. They do collect data in the value chain, for example lead times and quality assessment data. These quality assessments are performed multiple times during the production process, this is then manually documented into the databases of Trams. They do not use any I4.0 applications to gather this data automatically. The production process at Trams is very labour intensive and consists of many production stages. In many of these production stages, machinery is often being used. However, these machines are not automated, and data is not automatically being collected. They have looked at automating some stages of the production process, but this turned out to be too expensive and would have a negative return on investment (ROI). The expected gain in efficiency and productivity would simply not outweigh the capital that must be invested.

Levo (3.0)

As mentioned earlier, the production process of Levo consists mostly of assembling different components together. Thus, the production process consists of no machine work as everything is done manually. The workers make use of a handheld computer which is connected to the ERP system. Via this device, workers are navigated through the warehouse to the components they need, in the fastest way possible. It prevents them from grabbing wrong components or forgetting some parts. This has led to a significant increase in efficiency.

4.2.6 Technology and IT management

This aspect is about measurement of the extent of data protection and usage regarding the Industry 4.0 technologies.

Trams (1.8)

This aspect has one of the lowest scores for Trams. Because Trams has not enough IT knowledge in-house, almost all IT projects are being outsourced to specialized companies, including data protection and IT system integrations. Trams does make use of predictive analysis regarding their production planning. When production is below its maximum capacity, Trams produces products in advance based on historical order data. This lack in IT expertise is according to Trams also a big influence on not choosing for a further adoption of I4.0, as they would then be too dependent on their IT suppliers for their production processes.

Levo (1.8)

This aspect is also one of the lowest aspects for Levo. The company mentioned that business IT is so sophisticated and complex these days, that it is not possible for a company with 15 employees to manage it sufficiently by themselves. They said that every IT job needs some degree of specialism which one or two dedicated IT employees could not take care of. Because of the lack in IT expertise, they outsource almost every IT related project. They do have an employee who regulates all IT and technology related projects.

4.2.7 Institutional awareness

Companies must comply to lots of different regulations and laws concerning, privacy, safety, and security. Examples of this are intellectual property laws and privacy data requests regarding GDPR. This aspect measures to which extent these topics are known and being complied to at the company, in relation to I4.0.

Trams (2.4)

Trams states in the discussion that not all employees are aware of the implications for their customers in terms of GDPR. This insight led them to consider giving a workshop to their office employees to improve their knowledge of GDPR. The data protection and security are sufficient, as they mentioned that this is regularly being checked by their IT supplier.

Levo (1.6)

This aspect is the lowest score for Levo. They mentioned that there is almost no attention among the employees for data protection/GDPR. They did not put much attention on this aspect mainly because of the rapid growth of the company, this aspect was more or less seen as a peripheral matter, as other projects and aspect had a higher priority. This recently came into practice when an employee sent an email to roughly 100 clients while not putting them in 'BCC', thus these 100 clients could see each other email addresses. This was for the Trams sign to put more attention to data protection and security, as they are now in the process of educating their employees regarding these topics.

4.3 Summary of results

The aim of this research is to analyse which factors that might prevent SMEs from implementing Industry 4.0 technologies. In this section, the main findings of the group discussion will be summarized, in order to get a structured view of the factors that might prevent SMEs from implementing I4.0. This paragraph will focus on aspects with a relatively low maturity score, as they might uncover potential factors that prevented the SMEs from implementing I4.0

For Trams, the fact that they are way ahead of their competitors has led them to not adopt an Industry 4.0 strategy. According to them, I4.0 implementation is therefore not a necessity.

Levo mentioned that they have been growing exponentially the past few years. This massive growth made them to prioritize the growth process above the implementation of I4.0, as all their time and financial resources was spent on the company expansion.

Also, the product which Trams produces is not suitable for implementing I4.0 technologies as these would possibly jeopardize their safety and weight requirements.

As mentioned, the production process of Trams is very labour intensive and utilizes lots of machines. The implementation of I4.0 technologies, and thereby creating an autonomous and automated network of machines, would result in a negative return on investment. The investment for this process is just too expensive for the company.

Furthermore, Trams as well as Levo mentioned that a lack of knowledge played a huge role for them for not implementing I4.0. This was clearly visible in the SIMS scan, as they both scored a 1.8 at the aspect of Technology and IT management. This knowledge scarcity has been a big reason for them to not further implement I4.0.

In conclusion, the results of this research found several factors that influence the decision for SMEs to not implement I4.0. These factors are a too expensive investment with a negative ROI, a lack of in-house knowledge, complexity and a lack of resources and time.

5. DISCUSSION

In the discussion section of the thesis, the practical implications for SMEs are given. It will focus on how SMEs can overcome the challenges and become more successful in implementing I4.0.

After that, the limitations of the study are mentioned, following with recommendations for further research.

5.1 Practical implications

In this part, suggestions will be given on how SMEs could overcome the challenges which they encounter when implementing I4.0, and thus become more successful in implementing I4.0.

Knowledge scarcity and complexity are found to be two factors which prevent the SMEs from implementing I4.0. These two factors are partially related to each other. As mentioned, SMEs struggles with the complexity which comes along with the implementation of I4.0 technologies. This complexity can be tackled by the application of knowledge of I4.0 technologies. However, as said, most SMEs do not have this specific kind of knowledge and skills in-house.

Therefore, it is recommended for SMEs to somehow gather these knowledge and skills. This can be done by offering training and education to their current employees. However, the process of educating current employees can be rather time consuming, as this is a very sophisticated and complex topic. Next to educating employees, companies can also 'buy' knowledge by either hiring new employees or outsourcing the I4.0 implementation. These two options are costly but can be implemented faster. Thus, SMEs should make a consideration whether they want to go for a more time-consuming method by educating own employees or going for the quickest solution by buying in the needed knowledge.

Another factor which turned out to be challenging according to the results of the group discussion, was that the implementation of Industry 4.0 into the production process was found to be too expensive, with having a negative ROI. According to Schröder (2016) this can be tackled by getting a banking loan, he mentions that the low interest rates and easy credit terms provide favourable financing options for SMEs. Next to that, there are also subsidies and financing arrangements available which companies can make use of (RVO, 2021). Both loans and financing options would make the implementation of I4.0 easier accessible for SMEs.

5.2 Limitations

A limitation of this research can be that it is based on a study of two companies. The sample size is too little to make general assumptions of how SMEs implement Industry 4.0 and what might prevent them from doing this. Next to that, the results can differ at other SMEs with different characteristics, e.g., companies acting in other industries, another geographical location or a different size in terms of revenue and employees.

Also, the Smart Industry Maturity Scan consisted of five questions per dimension. In order to get a more valid view of the maturity of the SME, more questions and more specific questions could be asked. This could be done by using the Extended SIMS scan instead of the basic SIMS scan.

Next to that, the group discussions at both two SMEs were held with employees in executive functions. The results of the group discussion could have been different if production workers would also be a part of it.

For future research, it would be an idea to research SMEs implementation of I4.0 and factors that might prevent them from implementing I4.0 on a bigger sample size. This would increase the validity of the research.

On top of that, conducting quantitative research on the effect of different company characteristics on the extent of I4.0 implementation at SMEs would be an interesting topic to perform future research on. By doing this, one could find possible correlations between a SME's characteristics and its extent of I4.0 implementation, such as for example the effect of SME revenue on the extent of I4.0 implementation.

Furthermore, another suggestion for future research is to focus less on SMEs as a whole. A company with €5 million revenue could have more or tougher challenges regarding the implementation of Industry 4.0 than a company with €45 million revenue. These differences in challenges can be an interesting topic to perform further research on.

6. CONCLUSION

This study was focused on finding out how SMEs implement Industry 4.0 and what factors might influence SMEs on not choosing to implement I4.0. This was formulated in the following research question: '*Which struggles do SMEs encounter when implementing Industry 4.0 technologies in their operations?*''. This research was based on the use of a Smart Industry Maturity Scan. The SIMS measured the maturity of two SMEs in terms of Industry 4.0 implementation on seven different company dimensions. After this, a group discussion was held with employees of both SMEs to discuss the outcome of the scan and to gain more insight on the I4.0 implementation of the specific SMEs.

Both companies turned out to be semi-advanced in the process of implementing Industry 4.0, as Trams had a score of 2.63 and Levo scored 2.54. Despite this moderate score, both companies had two negative outliers. These negative outliers are particularly interesting to get an answer to the research question.

Trams scored a 1.6 at Products and Customer services and a 1.8 at Technology and IT management. Their reasoning behind the low score at Products and Customer services was that their products were simply not suitable for I4.0, as it was not possible to apply I4.0 applications in their product. Besides, the score of 1.8 with regards to Technology and IT management was devoted to the fact that they did not have sufficient IT knowledge available in the company. Also, Trams did not implement Smart Industry into the production process. Their explanation for this was that according to their calculations, this investment would have a negative ROI.

Levo recorded a 1.8 at Technology and IT management and a 1.6 at the aspect of Institutional awareness. Regarding Technology and IT management, they had the same reasoning as Trams. There is too less IT knowledge in the company. Also, they found that IT was too specific to do themselves. The low score of Institutional awareness was, according to Levo, mostly because of the rapid growth of the company which led them to prioritize other topics over Institutional awareness.

Concluding, the reasons why SMEs do not implement Industry 4.0 are diverse. Both companies stated that IT implementation was too complex to handle it by themselves. Also, it is often not possible to implement I4.0 in certain processes or products, as they are not suitable with I4.0 applications.

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