What challenges will bring Smart Industry for manufacturing SME

Autor: Lars Bieleman

University of Twente

Enschede, The Netherlands

Abstract

Since the first public mentioning of the terms Industry 4.0 in 2011 researchers and companies are occupied with working on definitions and mentioning the great things that will happen the coming years to the manufacturing industry. Larger companies have the resources to work on these issues and already benefit from this revolution. This research is developed to contribute to the research area focussed on SMEs and the challenges these enterprises will be facing with regard to the Industry 4.0 and Smart Industry revolution. The research finds several general challenges that are common among every company size and industry. But the relevance of challenges can differ between different company sizes. This is substantiated with the help of literature review and case study at a SME.

Graduation Committee members:

First supervisor: Dr. R.P.A. Loohuis

Second supervisor: Ms. H.G. Hanna

1. Introduction

Smart Industry is the term frequently used for the digitalization and automation of organizations. Similar and frequently used terms for Smart Industry are Industry 4.0 and Smart Factory. After the first public mentioning at the Hannover fair in 2011 (VDI, 2011) the industrial and scientific interest increased. Despite the proposed benefits and the demand for smart production, so far the application of smart manufacturing has been the domain of large companies, often supported and assisted by large service providers (Nieuwenhuize, 2016). SMEs play an important role in the Dutch economy, out of the 345.000 companies with more than 1 employee, 99% is SME (CBS, 2019). While the importance of SMEs for the Dutch economy is obvious, the terms Smart Industry or Industry 4.0 are not well known for SMEs. At a survey conducted among 1.194 Dutch SMEs just 15% mentioned knowing the terms Smart Industry or Industry 4.0 and know a bit about the meaning of the terms (Smetsers, 2016).

There is already a substantial amount of research conducted in the Smart Industry domain. As for research focused on SMEs in the field of Smart Industry, due to a low attention given to this group as well as an incomplete understanding of their future production prospects, new research would be necessary (Radziwon, Bilberg, Bogers, & Madsen, 2014). The worldwide manufacturing industry is rapidly changing, due to digitalization, low-cost countries and changing environmental conditions. Among changing environmental conditions are for example globalization, increased volatility of markets, shortened innovation cycles, intensified competition and increasing complexity (Spath et al., 2013). Future industrial production needs to be flexible, efficient, and adaptable to respond to these challenges (Spath et al., 2013). The purpose of this study is to give a general understanding of the challenges manufacturing SMEs are facing in regard to the Smart Industry revolution.

In the Smart Industry and Industry 4.0 literature the specific position of SMEs and the challenges they face regarding these revolution are an underlying factor. Only a few studies specifically focus on SMEs (Mittal, Khan, Romero, & Wuest, 2018). SMEs often lack the resources to look outside their core competencies. In most cases, they are not “early adopters,” mainly because of the fear of investing in the wrong technologies or adopting inapt practices and SMEs usually don’t have the manpower to look ahead and beyond their own product and production range. However, SMEs have to learn fast about the emerging technologies and digital practices to compete with the multinationals who have already started their Smart Industry journey (Faller & Feldmuller, 2015; Mittal et al., 2018). Because of the lack of awareness (Smetsers, 2016) and the importance of SMEs for the Dutch economy (CBS, 2019) the challenges for SMEs will be the core domain where a contribution is provided.

This research paper is constructed around the research question: *How do SMEs anticipate on Smart Industrial Revolution and deal with the challenges accompanied by it?* This question will be answered by conducting a literature review to look at the anticipation and challenges already described. The Smart Industry Maturity Scan (SIMS) provided by the University Twente will support the literature and help to answer the research question with empirical evidence. A selected focus-group will be used for the SIMS. The focus-group is selected in accordance with the EU regulation set for SMEs and in consultation with the supervisor. The literature used in this research will be primarily focused on SMEs in the manufacturing industry.

The aim for this study is to contribute to the anticipation among SMEs in regard to the Smart Industry Revolution and to outline the challenges SMEs are facing with this revolution. Next, it should give SMEs a direction on how to tackle these challenges. There is not much SMEs specific knowledge in the Smart Industry research domain and could therefore add new knowledge to this specific research domain.

First, the literature review will consist of an extensive review of a number of existing researches and a table with the challenges SMEs are facing described in these papers. Next, the methodology part will describe the process of the executing the Smart Industry Maturity Scan (SIMS) and the follow-up workshop conducted at company X. After this the results of the SIMS and the workshop will be discussed in chapter 4 Results. Finally, the discussion chapter where the limitations, recommendations and final conclusion are outlined discussed.

2. Literature review

In the literature review the focus will be on the problems SMEs are facing in regard to the Smart Industry revolution and how SMEs deal with these problems at the moment. Smart Industry or it’s synonyms are a growing research topic. In this literature review the focus will be on non-country

specific research (with exception of Dutch and German research) and on SMEs, according to the EU definition of a SME (EuropeanUnion, 2004).

2.1 SME requirements

This section discusses a set of SME specific requirements that differentiate their business from multinationals and other forms of enterprises. To develop such a set of SME specific requirements, *Table 1* defines the requirements of an SME.

Enterprise	Max. employees	Max. annual turnover	Max. Annual balance sheet value
Small	< 50	≤ € 10 million	≤ € 10 million
Medium	<250	≤ € 50 million	≤ € 43 million

Table 1 (EuropeanUnion, 2004)

According to the European Union, enterprises can be defined SMEs when employed with less than 250 employees, have an maximum annual turnover of 50 million Euros and an annual balance sheet total of maximum €43 million Euros. During this research this definition of the European Union will be followed.

2.2 The problems SMEs are facing in regard to the Smart Industry revolution.

The current literature discusses various opportunities and challenges faced by SMEs in regard to the Smart Industry revolution. Sommer finds that SMEs can be ready and capable to meet Industry 4.0 challenges however they strongly depend on the size of the enterprise. The smaller SMEs are, there is a higher risk they become victims of this revolution (Sommer, 2015). Radziwon et al states that there is a lack of research on the effects of the Smart Industry revolution on SMEs. Even though, they state lack of automation and the insecure future perspectives as boundaries for SMEs to participate at a same rate as large companies (Radziwon et al., 2014). Deloitte AG studied 50 Swiss manufacturing companies and found that challenges are most often related to cyber security and lack of financial resources and talent. These cyber security challenges are withholding companies setting important steps in the development of new or improved IT systems (Schlaepfer, Koch, & Merkofer, 2015).

In the study conducted by Sevinc, Gur and Eren the challenges faced by SMEs adopting Industry 4.0 innovations are discussed in 4 terms: innovation, organization, environmental and cost dimensions. They use the analytical hierarchy process (AHP) and analytic network process (ANP) to evaluate the challenges faced by SMEs in adopting these practices. “The aim of this study was to determine the main and sub-criteria for determining the factors that will serve the transition of SMEs to Industry 4.0 by using analytic hierarchy process (AHP) and ANP methods.” (Sevinc, Gur, & Eren, 2018) The hierarchical structure of the criteria where evaluated by 15 SME experts and management officers. The results of the AHP and the ANP where that the terms where ranked after they where giving weights by the 15 SME experts. This resulted in Organization (.411), Cost (.285), Environmental (.190) and Innovation (.114). This was concluded that SMEs are not convinced by the Industry 4.0 transition, because the main results where that Organization and Cost have the biggest weight. The auteurs mentioned that the results of this research area would be better when conducting research with SME executives and/or managers in stead of field experts as used in this research. (Sevinc et al., 2018).

Muller and Voigt did research at the integration strategies for small and medium-sized enterprises. There research is based on an exploratory and qualitative case study research design based on 68 in-depth expert (38 where CEO’s) interviews. These interviews are conducted with leading personnel of enterprises in the sector mechanical and plant engineering, electrical engineering, and automotive suppliers. The interviews where based on impacts of Industry 4.0 on business models of SMEs, the business model used in this research is the Business Model Canvas designed by Osterwalder and Pigneur. It consist of 9 “building blocks”. During the interviews the difference between users and providers of Industry 4.0 for SMEs where taking in consideration. The group of 68 experts was distributed as two-third users and one-third providers. The key findings for the two perspectives on Industry 4.0 where *that* providers expect large impact on their business models, except for the blocks Key Partners and Customer Relationships. For users this is exact the opposite, users expect small impact on their business model through Industry 4.0 except for Key resources, Key Partners and Customer Relationships. Key resources are the most named building block, this can be reasoned because SMEs have to obtain competencies regarding automation and digitalisation. Key Partners are named to be especially important for

operation and control of Industry 4.0-based systems. And SMEs will most likely require Key Partners due to their limited size. Customer Relationships are important for the long-term, intensified relationships between manufacturers and providers of Industry 4.0 services. The other 6 building blocks are from high to low: Value proposition, Revenue streams, Cost structure, Customer segments, Key activities and Channels. The research conducted by Muller and Voigt primarily focusses on the impact of Industry 4.0 on business models (Muller & Voigt, 2017). But when the impact is described there are no further implications or challenges described. This would be an opportunity for further research and will be partly used in this thesis report.

The Dutch chamber of commerce did research about the progress of the Smart Industry developments among Dutch SMEs. The research is conducted among 1.194 SMEs and gathered their data through an online survey. The main goal was to identify the state of awareness and to find out if SMEs considered the Smart Industry revolution as an opportunity or as a challenge. Only 15% of the respondents where familiar with the terms Smart Industry or Industry 4.0 and out of this group, 58% consider Smart Industry an opportunity for their company. While out of people that is not familiar with the term Smart Industry only 24% consider it as an opportunity. After these questions participants received clear explanation about Smart Industry to complete the further survey. This research developed 17 challenges divided in 5 topics and asked at the participants in which condition they expect to have problems in the next three years with applying Smart Industry in their companies. The five topics are: Investment, Organization, HR, Technology and Partners. The most affecting challenges are Investment and Organizational. The three investment challenges are defined as: None or too small investment budget (26%), large investments that are due to Smart Industry developments need to be faster depreciated (24%) and unclear which financial benefit Smart Industry can have (21%). The four organizational challenges are: Too many applications which is hard to define (23%), not knowing how to start implementing (19%), lack of time due to continuing operational activity (15%), resistance against change while employee are afraid to lose their jobs (13%). Other larger challenges are: Anxiety larger partners abuse their position (25%), not knowing a partner that could help with knowledge or resources (22%), afraid of becoming dependent of external parties (16%), cooperation with other enterprises require difficult legal contracts (15%). Furthermore this research focusses on the Smart Industry applications SMEs do use, out of the 7 different applications an average of 76% never used any of these applications. (Smetsers, 2016)

Commissioned by the Friedrich Ebert Foundation, C. Schroder did research at the challenges German SMEs are facing for the implementation of Industry 4.0. The research in constructed out of previous research and is focussed on advising the German government to take action to help overcome the challenges as described. Schroder describes four main challenges, lack of a digital strategy, resource scarcity, lack of standards and poor data security. The lack of digital strategy is due to the IT-systems, machinery and processes tends to have been acquired over time at SMEs, this results in different operating systems and it would be expensive to create a universal operating system throughout the manufacturer. At top of this SMEs often do not have their own IT department, which results in managers have to asses IT opportunities and challenges. This frequently results in none or the wrong IT solution for a SME. The resource scarcity is applicable on knowledge and financial resources. Both factors have influence on the overall capability of adopting to the Smart Industry revolution. The lack of standards at SMEs has influence on the ability to connect with other organizations and to connect internal systems. Connecting with both internal and external systems can be seen as economic potentials of Smart Industry revolution. Cloud based solutions could be seen as a solution for this problem but the worry that sensitive company data are not really secure in a cloud environment is preventing SMEs for working in the cloud. In 2014 just under 5% of German SMEs used fee-based cloud computing services. While the European average was at about 8% and Dutch SMEs where listed fourth where about 17% used cloud services. (Schroder, 2015, 2016).

A survey conducted by students of the Fontys Hogeschool Netherlands, in cooperation with EasyStep2 among 96 manufacturing SMEs in the Netherlands gave an insight about the relation between the revenue of a SME and the relevance of Smart Industry challenges. The research shows that the three most important challenges among SMEs are: knowledge base of employee, high costs and the unfamiliarity of Smart Industry. The three other significant challenges that are mentioned in the research are: the return on investment (ROI), the maturity of the technology and change. In *figure 3 (Appendix)* the results of the survey are displayed.

Authors	Participants are SMEs	Challenges described
(Sevinc et al., 2018)	Yes	Innovation, organization, environmental and cost
(Muller & Voigt, 2017)	Yes	Key resources, Key partners, Customer relationships, Value proposition, Revenue streams, Cost structure, Customer segments, Key activities and Channels.
(Smetsers, 2016)	Yes	Investment, Organization, HR, Technology and Partners
(Schroder, 2016)	Yes	Lack of a digital strategy, resource scarcity, lack of standards and poor data security.
(EasyStep2, 2019)	Yes	Knowledge base of employee, high costs, the unfamiliarity of Smart Industry, return on investment, the maturity of the technology and change.
(Sommer, 2015)	Yes	Size; the smaller SMEs are, more change of not overcoming the challenges ahead.
(Radziwon et al., 2014)	Partly	Lack of automation and insecure future perspectives.
(Schlaepfer et al., 2015)	No	Cyber security, lack of financial resources and lack of talent

Table 2 - Literature overview

3. Methodology

In order to be able to answer the research question this research is constructed in 3 parts; extensive literature review, Smart Industry Maturity Scan and the interactive workshop. The literature review is described in the sections above and give an overview of challenges SMEs are facing in regard to the Smart Industry revolution. The Smart Industry Maturity Scan will be used to gather practical data from a company. An interactive workshop with the company will be organized based on the results of the scan. During this workshop the results will be presented to the company and a discussion between the involved employees will be held to find internal improvements together with the company representatives.

3.1 Smart Industry Maturity Scan

To collect data about the challenges SMEs are facing in regard to the Smart Industry revolution I used the Smart Industry Maturity Scan (SIMS) developed by Luc Ungerer in cooperation with the University of Twente. For this thesis I collected the data at a company in the woodworking materials sector a niche sector in the Netherlands with 1 or 2 national competitors. The company has around 25 employees with an annual turnover between 10 and 25 million euro's. Regarding the information in Table 1 this company fits the requirements of a SME. Hereafter the company will be named "Company X".

The SIMS is an questionnaire with 35 questions equally divided over seven dimensions. Each question can be answered with a score from 1 to 5 (1 is the lowest score and 5 the highest) to indicate the maturity grade of the company regarding to the question. The questionnaire will be distributed online to the company persons and will collect the results at an online database. The database with the results can be exported to excel for further analysis. The seven dimensions are: Strategy & Organization, Products & Customer Services, People & Organizational Culture, Customer Interfaces, Value Chain, Technology & IT Management and Institutional Awareness. Each dimension will receive a separate score based on the five questions and there will be an overall score based on all the questions. This overall score can be used to rank the maturity of the company regarding the Smart

Industry revolution. The ranking of the maturity levels is the following:

Maturity level	Implementation	Score
Level 1 "newcomers"	Poor implementation	1 – 1.49
Level 2 "learners"	Moderate implementation	1.5 – 2.49
Level 3 "leaders"	Semi-advanced implementation	2.5 – 3.49
Level 4 "leaders"	Advanced implementation	3.5 – 4.49
Level 5 "leaders"	Full implementation	4.5 – 5

Table 3 - Five stages of Maturity according to SIMS

3.2 Interactive workshop

The workshop is constructed with guidance from a book section of Gottesdiener. This book section describes so called "ground rules" that have to be considered when organizing and facilitating a workshop. Those ground rules give guidance to how participants should cooperate and participate and helps defining decision making policies (Gottesdiener, 2002). During the introduction meeting where I presented my research strategy and SIMS I discussed which decision making policy was regular at company X and used this during the preparation of the workshop.

The workshop is split in two parts, I will begin with an overview of the results and then based on these results we will start the discussion to come to conclusions what the results mean for company X, what the challenges are for company X to improve their results and start with a base to improve the dimensions. The results will be shown both digital and on a handout so they will be constant available during the workshop. After all the results are discussed at the participants I will start with addressing anomalies to start the discussion between participants. These discussion will be crucial for data collection while they explain why the respondents of the SIMS felt about some topics. It is designed to not only define the challenges but to find the reasons for this challenge and to discuss the possibilities to tackle the challenges and increase the anticipation of company X regarding the Smart Industry revolution.

4. Results

The results are based on both the literature review and on the results of the SIMS and workshop at company X. The literature is used to set a base level during this research and to find similarities among various researchers. Next to this, the literature will be used to compare it with the practical case, to see whether those support or contradict each other. Final, the results of the workshop will be explained and visualized with diagrams.

4.1 Similarities in previous work

As can be seen in *table 2* the mentioned challenges are most of the times company wide issues and therefore it will be hard to find challenge specific solutions. High costs/investments are the most (6/8) described challenges. Further mentioned challenges are difficulties with IT and with cyber security and the lack of knowledge employee (both 4/8). As last the insecurity/unfamiliarity of the Smart Industry future and the organizational challenges that are accompanied by it are mentioned by multiple researchers (both 3/8). The research done by EasyStep2 among Dutch SMEs shows that smaller enterprises (0 to 2 million revenue) have more difficulties with the challenges as mentioned above than SMEs with more than 2 million revenue. This is supported by Sommer, he stated that the smaller SMEs are, there is a higher risk of becoming victims of the Smart Industry Revolution. This is supported by the research of EasyStep2.

4.2 Literature vs practical case

The practical case at company X did not only provided the digital answers of the SIMS but did also provide valuable information through informal interviews and discussions. In comparison to the literature company X does not find investments or high costs a challenge for implementing Smart Industry features. This is supported by Easystep2 and Sommer, company X has a revenue between 10 and 25 million Euros and therefore it can be seen as a medium sized company. And in relation with the literature it can be stated that because of the revenue of company X it will be facing less financial challenges. In relation to the other frequent mentioned challenges in the literature company X did suffer from problems in IT management and found organizational challenges. These organizational challenges where caused by the lack of Smart

Industry skilled employees and with the constant focus on day-to-day operations. Research done by the Chamber of Commerce in the Netherlands highlighted that only 15% of SMEs where familiar with the terms Smart Industry / Industry 4.0. At first instance company X was one of the 85% that was not familiar with the terms but after explaining the definition to the participants they were able to substitute to the terms and where able to give examples that were already implemented at company X.

In *figure 3 (Appendix)* an analyses of the survey conducted by EasyStep2 and Fontys Hogeschool Netherlands shows the ratio between revenue and the challenges that are indicated by the company. I divided the group in two parts, the part under 2 million revenue and a part above 2 million revenue. The 0-2mil group represents a total of 76.96% of all the challenges described. To identify for every challenges how many percent is described in this 0-2mil group I divided the percentages of 0-2 mil group to the total and this gave a conclusion on which challenges are more likely to occur to 0-2 mil revenue SMEs in comparison with 2-50 mil revenue SMEs. The results are coloured red or green, whereas red indicate that this challenges is more influenced by 2-50 mil SMEs than by 0-2 mil SMEs. At *figure 3* can be seen that knowledge of employees and the change in the organization is more related to 2-50 mil SMEs and costs, insecurity and maturity of technology are more related to 0-2 mil SMEs. This is supported by Sommer (2015) and especially during the practical case at Company X. While company X had a revenue between 10 and 25 million Euros and did not indicate to have issues in financing or insecurity.

4.3 Workshop results

The workshop took place on 11th June 2019. From company X all four respondents that filled out the SIMS where available to attend the workshop. This included the managing director, head of operation, sales manager and export manager. During the one and a half hour session I briefly presented the results using spider plots, an overview from the seven dimensions and each of the seven dimensions separate where the average answer for each question had been used. The results immediately generated an discussion among the participants to address possible improvements and to substantiate the answers. The decision making policy that was described by the company beforehand and used during the workshop could be best described as "Decision Leader Decides after Discussion". This involves the decision leader (at company X the managing director) making a decision after consulting with other stakeholder (Gottesdiener, 2002). This was best noticed at the point an new digital stock control system was brought to attention by a participant. The managing director asked about everybody his opinion about the system and after consulting with everybody he gave the executive order to start up the project.

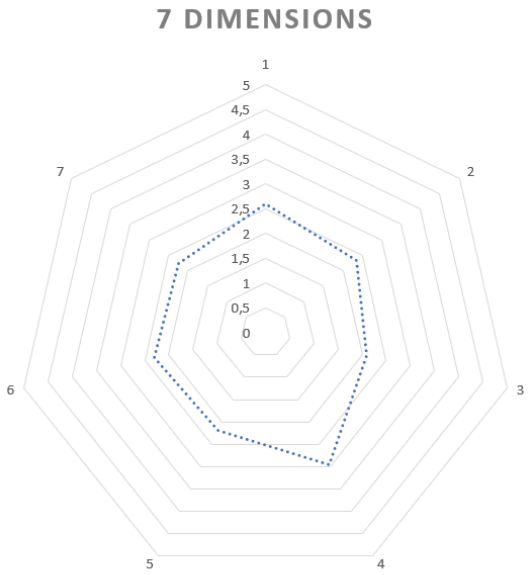

Figure 1 - Overview 7 Dimension

The average maturity score of company X is 2.39, this would indicate that company X can be seen as "learners" with a moderate implementation of Smart Industry features. The scores of all 7 dimensions are between two and three, this indicates company X has an average score in throughout the organization. The highest scoring dimension is dimension 4: Customer interface with a score of 2.95, followed by dimension 1: Strategy and Organisation with a score of 2.6. The lowest scores are dimension 3: Products and Customer services (2.1), dimension 5: Value Chain (2.2), dimension 7: Institutional awareness (2.25) and dimension 6: Technology and IT management (2.3). An overview of the results can be seen in *table 4*.

The scores of the individual 35 question related to the seven dimensions can be found below here in *figure 2*. Statistically the questions with the lowest answers should be the biggest challenges of company X, but after the workshop and talking with the participants this was unjustified. Due to seize and industry specifics certain questions does not reflect the reality of the company

1. Strategy and organisation	2.6
2. People and organisational culture	2.35
3. Products and customer services	2.1
4. Customer interfaces	2.95
5. Value chain	2.2
6. Technology and IT management	2.3
7. Institutional awareness	2.25
Total average	**2.39**

Table 4 - Results SIMS company X

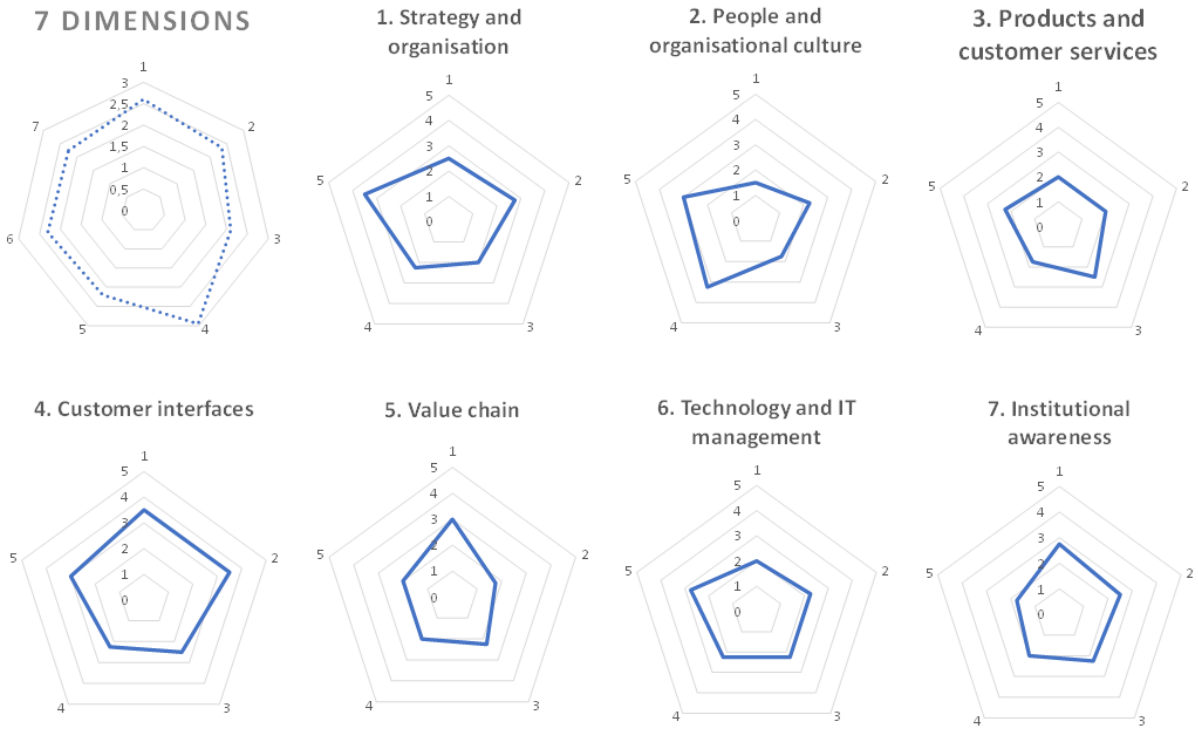

Figure 2 - Results SIMS at company X

After discussing the various answers during the workshop there were some question that reflected challenges company X was facing in regard to the upcoming Smart Industry revolution. These questions will be described below including explanation. Question six regarding whether employees receive skill training to stay up to date to meet future Smart Industry needs. This scored a 1.5 and indicated skill training was not common at Company X. After discussing it could be concluded that due to being constant occupied with the day-to-day operations skill trainings were neglected. In order to stay up-to-date the managing director decided he would free up time for the employees to start working on skill training. Question eight regarding the frequency of discussing the influences of Smart Industry scored a 1.75. All participants agreed this was mainly influenced by the lack of knowledge about the topic and therefore lacking the ability to discuss the influences. The managing director pointed out that workshops like the one I was presenting were useful and would stimulate discussing the topic on a frequent base. An average between 1.75 and 2.25 between questions 21 and 26 in the dimensions "Value chain" and "Technology and IT management" was considered remarkable. During the workshop the general opinion about these results were they were caused by a lack of knowledge and not having an inhouse IT department. Company X stated it was hard for small companies to be up-to-date on IT solutions and the newest technology innovations. The four participants agreed a possible solution for this challenge would be to hire an intern to work on an IT related assignment.

5. Discussion

In this part, the findings of the literature research and practical case at company X are described. Next to that, the limitations and the possibilities of future research will be explained. Further, some recommendations will be mentioned, this with the focus on more SME specific research on the Smart Industry revolution to provide SMEs with practical solutions for the challenges they are facing. Lastly, a conclusion on the research and research question will be provided and an acknowledgement is provided.

5.1 Findings

During the literature review different researchers used different terms to describe the challenges SMEs are facing. This made comparing results difficult. As can be seen in *Table 2* the challenges described by different researchers are in most cases hard to compare. When you consider the challenges less specific it is possible to dedicate them to certain "general challenges". As can be seen in *part 4.1* these challenges are ranked from highest impact at SMEs: High cost/investments, IT and cyber security, skilled employee, insecurity/unfamiliarity of Smart Industry and the organizational challenges. These general challenges are anticipated very different by every researcher but the challenges that need to be overcome are clear. The results of the SIMS conducted at company X are 2.39. Which would give the company the "Level 2, Learners" maturity level. The complete results can be seen in *Table 4* and *Figure 2*. For company X it was a good way to see how employees thought about the topic and to see if they where heading in the right direction. While for me as researcher it was interesting to see the limitations of the SIMS and to talk about the reasons why participants filled out certain answers. This gave an interesting comparison between the literature and the practical case.

5.2 Limitations and future research

One of the limitations in this research is that the case study has only been conducted at one company in a niche market. The results of the SIMS I conducted are therefore difficult to compare with other SMEs in other industries. The limitation of only conducting this at one company does also rule out the possibility to compare different SMEs/industries with each other. Next to this, the scan that was provided by the University of Twente and used during this research is designed for SMEs according to the SME requirements given by the European Union, this means enterprises between 0-250 employees and an annual revenue of 0-50 million Euros. Enterprises that fall within these requirements can differ in terms of investment budget, organizational structure and IT possibilities. During the implementation of the SIMS at company X it came to my attention that the smaller the SMEs the more question in the SIMS are irrelevant, while smaller enterprises most likely do not have an own IT department for example. When implementing the same scan at all these different sized SMEs the total maturity score, and therefore maturity stage, are difficult to compare. At last, this research is mainly focussed on describing and clarifying the challenges SMEs are facing in regard to the Smart Industry revolution. While this will only indicate issues where SMEs can focus on but will not give clear directions on how to proceed from these challenges.

Future research in the topic of Smart Industry will be necessary to solve the limitations as described above. Specific SME research will be useful while the majority of Smart Industry/Industry 4.0 research is conducted with larger enterprises and SMEs are economical important and should not been overruled by larger enterprises. Future research could be based on improving the SIMS. To make this scan more industry and size independent and to be able to compare companies at a better level. Next to this, creating a database with all results based on industry and SME size could improve the accessibility for SMEs to the topic of Smart Industry and could help identifying challenges and focus areas on a large scale. At last, future research into the possibilities to solve the challenges SMEs are facing would be useful in order to strengthen the position of SMEs in the Smart Industry Revolution. Research is currently focussed on providing the benefits and challenges that are accompanied by the upcoming revolution instead of actually focussing on solving challenges and helping the understanding of Smart Industry.

5.3 Recommendations

With the aim of further developing and using the SIMS to gather data about the maturity of SMEs in the Smart Industry Revolution it is recommended to develop the questions more industry and size/revenue based. To improve the ability to compare and to maximize the usability of the output. To be able to have significant amount of results to be able to compare individual SMEs within an industry it is recommended to extend the SIMS to as many SMEs as possible. This could be done by continuing this bachelor circle for next year and to extent the scan to as many enterprises as possible. As mentioned above in the limitations part a recommendation should be

addressed to developing research that is more focussed on overcoming the challenges. At last, improving research on the topic of the connection between revenue/employees to different challenges could be recommended. There is a small amount of research on this topic and the academic relevance could be significant.

5.3 Conclusion

In this study I wanted to create a knowledge base about the challenges SMEs are facing in regard to the Smart Industry Revolution. Some of the general challenges described in the literature are; High cost/investments, IT and cyber security, skilled employee, insecurity/unfamiliarity of Smart Industry and the organizational challenges. These challenges are described in *Table 2* and can give an indication for SMEs what kind of problems they could be facing the coming years. Knowing the possible challenges can help SMEs to anticipate on these challenges and hereby increase the results of Smart Industry. The analysis and other researchers show that smaller SMEs tend to rank challenges different than larger SMEs, this hypothesis is backed by the case study conducted at company X. The SIMS and the workshop that were conducted at company X delivered several challenges the SME was facing. In contradiction with the majority of the literature the SME was not having any difficulties with financially funding new projects. Lack of skilled employees, lack of time and lack of IT knowledge were called the biggest challenges for company X. A solution for some of these challenges was found in working together with local knowledge institutes to have interns working on company specific Smart Industry challenges.

5.4 Acknowledgement

I would like to thank my supervisors Dr. R.P.A. Loohuis and Ms. H.G. Hanna who helped me during this research. During meetings I could discuss issues and would receive feedback what helped me to proceed to this final thesis. Moreover, I would like to thank company X for their time and effort to help me with the valuable results of the SIMS and the workshop. Next to this, I want to thank my fellow bachelor circle student for the useful session and for taking the time to help and support each other.

References

1. CBS. (2019). *Bedrijven; bedrijfstak*. Retrieved from https://opendata.cbs.nl/statline/#/CBS/nl/dataset/81589ned/table?ts=1557387138255.

2. EasyStep2. (2019). Wordt Industrie 4.0 omarmd in het MKB? Retrieved from https://www.easystep2.nl/wordt-industrie-4-0-omarmd-in-het-mkb/

3. EuropeanUnion. (2004). *Definitie van kleine en middelgrote ondernemingen*. Retrieved from https://www.rvo.nl/sites/default/files/bijlagen/Bijlage%20bij%20MKB-toets.pdf.

4. Faller, C., & Feldmuller, D. (2015). *Industry 4.0 Learning Factory for regional SMEs*. Paper presented at the The 5th Conference on Learning Factories 2015, Germany.

5. Gottesdiener, E. (2002). Principles: Ground Rules for the Workshop. In *Requirements by Collaboration* (pp. 24): Addison-Wesley Professional.

6. Mittal, S., Khan, M. A., Romero, D., & Wuest, T. (2018). A critical review of smart manufacturing & Industry 4.0 maturity models: Implications for small and medium-sized enterprises (SMEs). *Journal of Manufacturing Systems*, *49*, 21. doi:https://doi.org/10.1016/j.jmsy.2018.10.005

7. Muller, J. M., & Voigt, K. (2017). *INDUSTRY 4.0 - INTEGRATION STRATEGIES FOR SMALL AND MEDIUM-SIZED ENTERPRISES.* Paper presented at the International Association for Management of Technology.

8. Nieuwenhuize, G. B. (2016). *Smart Manufacturing for Dutch SMEs Why and How?* (Master), Erasmus University, Rotterdam.

9. Radziwon, A., Bilberg, A., Bogers, M., & Madsen, E. S. (2014). The Smart Factory: Exploring Adaptive and Flexible Manufacturing

10. Solutions. Procedia Engineering, 69, 6.

11. Schlaepfer, R. C., Koch, M., & Merkofer, P. (2015). Industry 4.0 challenges and solutions for the digital transformation and use of exponential technologies. Deloitte AG, Zurich.

12. Schroder, C. (2015). Auf dem Weg zur vernetzten Wertschöpfung - Existiert eine Digitalisierungslücke im deutschen Mittelstand? *Ifm-Bonn*.

13. Schroder, C. (2016). *The Challenges of Industry 4.0 for Small and Medium-sized Enterprises*: Friedrich-Ebert-Stiftung.

14. Sevinc, A., Gur, S., & Eren, T. (2018). Analysis of the Difficulties of SMEs in Industry 4.0 Applications by Analytical Hierarchy Process and Analytical Network Process. *Processes*, *6*(264), 16. doi:10.3390/pr6120264

15. Smetsers, D. (2016). *Smart Industry onderzoek 2016*. Utrecht: Kamer van Koophandel Retrieved from https://www.kvk.nl/download/20161810_Rapportage_Smart_Industry_DEF2_tcm109-432829.pdf.

16. Sommer, L. (2015). Industrial Revolution - Industry 4.0: Are German Manufacturing SMEs the First Victims of this Revolution? *Journal of Industrial Engineering and Management*, *8*(5), 21.

17. Spath, D., Ganschar, O., Gerlach, S., Hammerle, M., Krause, T., & Schlund, S. (2013). Produktionsarbeit der Zukunft – Industrie 4.0. *Fraunhoger-Institut fur arbeitswirtschaft und organisation iao*, 155.

18. VDI. (2011). Industrie 4.0: Mit dem Internet der Dinge auf dem weg zur 4. industriellen Revolution. *VDI nachrichten*.

Appendix

Bezwaren	0 t/m 0.5 miljoen	0.5 t/m 1 miljoen	1 t/m 2 miljoen	2 t/m 5 miljoen	5 t/m 9 miljoen	9 miljoen of meer	Onbekend	Totaal
Anders		0,35%				0,35%		**0,70%**
Gebrek aan tijd	1,05%	1,40%	1,05%	0,35%		0,70%		**4,55%**
Industrie of markt niet geschikt	0,35%	0,70%						**1,05%**
Kennisniveau van werknemers	2,45%	3,85%	4,55%	1,75%	0,70%	1,75%		**15,03%**
Kosten	2,45%	5,24%	5,59%	1,40%	0,35%	1,05%	0,35%	**16,43%**
Niet van toepassing	2,10%	1,75%	1,05%	0,70%	1,05%	1,05%		**7,69%**
Onbekendheid	3,85%	5,24%	4,20%	1,75%	0,35%	1,05%	0,35%	**16,78%**
Onbetrouwbaarheid	0,70%	0,70%	0,35%	0,35%				**2,10%**
ROI (Return on Investment)	1,40%	5,59%	1,75%	1,40%	0,35%	0,70%		**11,19%**
Veiligheid	0,70%	2,80%	1,05%	0,35%	0,35%	0,35%		**5,59%**
Verandering	2,45%	1,75%	1,75%	0,35%	0,35%	1,05%	0,35%	**8,04%**
Volwassenheid van de technologie	1,75%	2,80%	4,20%	0,70%		1,40%		**10,84%**
Totaal	**19,23%**	**32,17%**	**25,52%**	**9,09%**	**3,50%**	**9,44%**	**1,05%**	**100,00%**

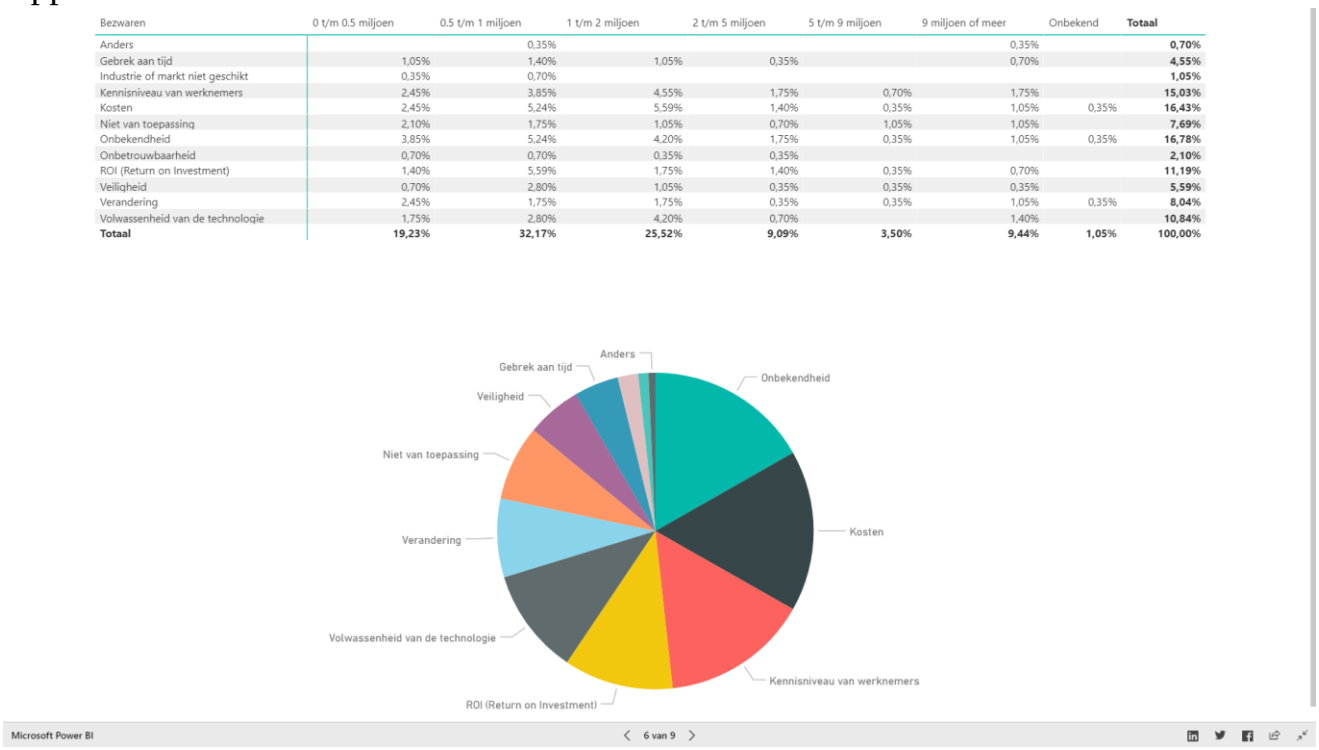

Figure 3 - Wordt industrie 4.0 omarmd in het mkb Source: (EasyStep2, 2019)

Bezwaren	0 t/m 0.5 mil	0.5 t/m 1 mil	1 t/m 2 mil	2 t/m 5 mil	5 t/m 9 mil	9+ mil	onbekend	totaal
Anders		0,35%				0,35%		0,70%
Gebrek aan tijd	1,05%	1,40%	1,05%	0,35%		0,70%		4,55%
Industrie of markt niet geschikt	0,35%	0,70%						1,05%
Kennisniveau van medewerkers	2,45%	3,85%	4,55%	1,75%	0,70%	1,75%		15,05%
Kosten	2,45%	5,24%	5,59%	1,40%	0,35%	1,05%	0,35%	16,43%
Niet van toepassing	2,10%	1,75%	1,05%	0,70%	1,05%	1,05%		7,70%
Onbekendheid	3,85%	5,24%	4,20%	1,75%	0,35%	1,05%	0,35%	16,79%
Onbetrouwbaarheid	0,70%	0,70%	0,35%	0,35%				2,10%
ROI (return on investment)	1,40%	5,59%	1,75%	1,40%	0,35%	0,70%		11,19%
Veiligheid	0,70%	2,80%	1,05%	0,35%	0,35%	0,35%		5,60%
Verandering	2,45%	1,75%	1,75%	0,35%	0,35%	1,05%	0,35%	8,05%
Volwassenheid van de technologie	1,75%	2,80%	4,20%	0,70%		1,40%		10,85%
Totaal	19,25%	32,17%	25,54%	9,10%	3,50%	9,45%	1,05%	100%
Totaal 0 t/m 2 mil t.o.v. totaal	76,96%							
Kennisniveau 0 tm/ 2 mil t.o.v. totaal	72,09%							
Kosten 0 t/m 2 mil t.o.v. totaal	80,83%							
Onbekendheid 0 t/m 2 mil t.o.v. totaal	79,15%							
ROI 0 t/m 2 mil t.o.v. totaal	78,11%							
Volwassenheid van de technologie 0 t/m 2 mil t.o.v. totaal	80,65%							
Verandering 0 t/m 2 mil t.o.v. totaal	73,91%							

Figure 4 - Analysis survey EasyStep Source: (EasyStep2, 2019)