The role of Dynamic Capabilities in the Industry 4.0 transition of manufacturing SMEs.

Author: Julius Kooistra
University of Twente
P.O. Box 217, 7500AE Enschede
The Netherlands

ABSTRACT,
The fourth industry revolution is currently in full swing, combining manufacturing and information technologies together. Although much research has been conducted on Industry 4.0, little of it takes SMEs in consideration. The goal of this research is to find whether there exists a relationship between the Dynamic Capabilities (Teece, 2007) and the Industry 4.0 maturity level of a SME. This possible relationship could allow for a new way of looking at the enhancement of the Industry 4.0 maturity level and could stretch beyond Industry 4.0 related practices. By applying the Dynamic Capabilities scale (Kump et al., 2018) and the science based Smart Industry Maturity Scan (Ungerer, 2018), consisting of seven dimensions, on a manufacturing firm in the East of the Netherlands, their performance on the two paradigms is measured. Based on the outcomes of the surveys a workshop which focuses on improving certain aspects is given by the researcher. From the surveys a possible relationship between two dimensions of the SIMS scan and the Dynamic Capabilities was found. The results can be resourceful for further investigation and useful for managers as it is made clear that the Industry 4.0 maturity level has an origin, which could lie in their Dynamic Capabilities, making the enhancement of the maturity more tangible.

Graduation Committee members:
dr. R.P.A. Loohuis
drs. P.Bliek

Keywords
Industry 4.0, strategy, Small and Medium Enterprises, Industry 4.0 maturity level, Dynamic Capabilities, Smart Industry Maturity Scan, Business Model Canvas

TABLE OF CONTENTS

1. INTRODUCTION

1.1 Topic relevance

Currently, the Industry 4.0 transition is at full blast in many organizations operating across many sectors (Liao et al., 2017; Luco et al., 2019), and much research has been done which considers Industry 4.0. Only a small part of this research considers Small and Medium Enterprises, also known as SMEs. Most research considering SMEs lacks in giving practical implementations of Industry 4.0 technologies and lives at a high levels of abstraction (Masood & Sonntag, 2020). The complication lies in the fact that there are many SMEs, all with different goals, organizational strategies, and business models (Moeuf et al., 2018). The research available found hurdles and barriers for SMEs to start the Industry 4.0 transition (Luco et al., 2019; Moeuf et al., 2018; Whysall et al., 2019). This research will focus on manufacturing SMEs, as manufacturing SMEs are likely to benefit of Industry 4.0 related technologies (Zhong et al., 2017).

The Industry 4.0 transition can be very costly, especially for smaller firms with less money to spend (Masood & Sonntag, 2020; Mittal, Khan, et al., 2018). Also, with Industry 4.0 requiring a lot of highly specific, technical knowledge to implement correctly, there is a huge lack of knowledge, especially in smaller firms (Mittal, Khan, et al., 2018; Stentoft et al., 2017; Yu & Schweisfurth, 2020). A solution to this problem may be to hire a consultant who guides the SME in implementing Industry 4.0 practices (Masood & Sonntag, 2020; Moeuf et al., 2020). This solution can result in a very expensive project for a firm of this size, which is undesirable. The problem does not necessarily lie in the lack of knowledge in SMEs about what Industry 4.0 consists of, but rather how to implement it in a cost-effective way that fits their organization and goals, failing to move towards an Industry 4.0 vision (Mittal, Khan, et al., 2018). Many of the successful Industry 4.0 use cases were the low costs and simple implementation of IoT and cloud solutions (Hansen & Bøgh, 2021; Moeuf et al., 2020).

In the current research little attention has been given to the cause of these barriers. Industry 4.0 is a paradigm that is already exploited in many Large Enterprises but to a lesser degree in SMEs. A potential cause of this matter can be the fact that SMEs have fewer absorptive capacities than LEs (Müller et al., 2020; Yu & Schweisfurth, 2020). Absorptive capacities are focused merely to the external environment the company is in, while Dynamic Capabilities are focused towards the external as well as the internal environment (Senivongse et al., 2019). This research will focus on the Dynamic Capabilities of a SME as the employees, thus the internal environment, are determinate for the success of the Industry 4.0 transition (Orzes et al., 2020), and the drivers of adoption of IoT and AI primarily come from inside the organisation (Hansen & Bøgh, 2021).

1.2 Research objective

The goal of the research is to find whether there exists a relationship between Dynamic Capabilities (Teece, 2007) and the Industry 4.0 maturity level of a SME. If this is the case, the Dynamic Capabilities can be exploited to enhance the Industry 4.0 maturity level. The implications could stretch beyond Industry 4.0 specific adaptations, as a company might need a substantial change in their business model (Müller, 2019), or organizational culture (Mittal, Khan, et al., 2018; van de Vrande et al., 2009) to allow for a successful implementation of Industry 4.0 technologies.

As previously stated, adopting Industry 4.0 practices can be very costly and knowledge intensive for many SMEs. This research aims to lower the barriers of using Industry 4.0 practices by investigating to what extent the Dynamic Capabilities influence the Industry 4.0 maturity level. This allows managers of SMEs a better understanding of their strengths and weaknesses and provides a new way of looking at their Industry 4.0 transition. Consecutively, improving the Dynamic Capabilities also has effect on other matters beyond the Industry 4.0 transition which might be carried throughout the entire SME, but that is beyond the scope of this research.

1.3 Research question

The following research question comes forth from the objective:

"To what extent exists a relationship between the Dynamic Capabilities of a company and their Industry 4.0 maturity level?"

To be able to answer the research question the following sub question should be answered:

- *How can Dynamic Capabilities be developed to enhance the Industry 4.0 maturity level of SMEs?*
  This research question will allow for a better understanding of the Dynamic Capabilities framework and how this can be used in practice. Answering this question helps build the bridge between the Industry 4.0 paradigm and the Dynamic Capabilities framework.

1.4 Structure of the thesis

The structure of the thesis is as follows. Firstly, the topic relevance, research objective, and research questions have been discussed. Secondly, the theoretical framework will be explored and sketched, focussing on the key elements of Industry 4.0 and what Dynamic Capabilities consist of. Thirdly, the methodology of the research will be explained. Fourthly, the results of the research will be shown and analysed. Fifthly, theoretical implication, managerial implications, and limitations and further work of the research will be discussed. Finally, the conclusion will be given.

2. THEORETICAL FRAMEWORK

In order to be able to investigate the previously named possible relationship between Dynamic Capabilities and Industry 4.0, it is important to have a strong knowledge base about the two paradigms. This will be further explored in this chapter. It is also important to have a clear definition of SME, as this helps distinguishing useful research articles. This research uses the definition of SME as provided by the European Commission (2020). A firm is classified as a SME when it has less than 250 employees, and either a turnover of lesser than or equal to €50 million or a balance total of lesser than or equal to €43 million.

2.1 Industry 4.0

Firstly, a clear definition of Industry 4.0 should be selected, as Industry 4.0 has been defined by many papers in many ways (Bidet-Mayer, 2016, as cited in Moeuf et al., 2020). This research will use the definition by Rüßmann et al. (2015): "a transformation that is powered by nine foundational technology advances.", these nine foundational technology advances being: autonomous robots, simulation, horizontal and vertical system integration, the Industrial Internet of Things (IIoT), cyber security, the cloud, additive manufacturing, augmented reality, and big data and analytics (Rüßmann et al., 2015).

2.1.1 General

Industry 4.0 originated from a huge application pull in combination with a huge technological push in industrial practice (Lasi et al., 2014). The fundamental concepts of Industry 4.0, as defined by Lasi et al. (2014), are: Smart Factories, Cyberphysical Systems, Self-organization, New systems in distribution and procurement, New systems in the development of products and services, Adaptation to human needs, and Corporate Social Responsibility.

Currently, these Industry 4.0 concepts are implemented in SMEs with the largest presence in the construction and customer service sectors, to a lesser extent in the Food preparation sector, the Agricultural Labour and Driving sector, Sales sector, and to the least in the Cleaning sector (Luco et al., 2019). An interesting case study in the food preparation sector has been conducted by Konur et al. (2021). They studied a SME which uses age old machinery to produce their goods, having a quality problem after a product switch on the machine. The Industry 4.0 implementation made tacit knowledge explicit, reduced the waste and makes maintenance predictable. Most importantly, the Industry 4.0 implementation was not a huge investment which enabled the business to innovate and brought a culture change within the company. Konur et al. (2021) designed a generic system architecture to Industry 4.0 implementation which can be helpful in other cases.

Yu and Schweisfurth (2020) investigate the reason behind the lag of implementation of Industry 4.0 technologies in SMEs when compared to MNEs. They found that the overall interest for Industry 4.0 is low in the German-Danish border region. SMEs have very little interest in augmented reality, IoT and big data. The interest in Industry 4.0 technologies related to information systems and communication technology are higher, yet only moderate. They find that on the technology level, companies are significantly more likely to implement a technology when they recognize the benefits of the technology and have high knowledge in a specific technology. If companies lack the knowledge and the absorptive capacity for specific Industry 4.0 technology, they are much less likely to invest and implement a specific Industry 4.0 technology. Another finding is that companies with higher automation within production and a higher variety of products are more likely to implement new Industry 4.0 technologies. Additionally, they find that the higher the regulatory pressure on technology implementation, the lower the likelihood that they actually implement the technology. They state that a clear framework that could guide the company through the journey of implementation would be very helpful for SMEs.

Attempts to develop a generic framework or toolkit have been done by some researchers. Mittal, Romero, et al. (2018) have developed a modular Smart Manufacturing toolkit for SMEs which consists of seven toolboxes, of which six are technical, building forth on the foundational technology advances as defined by Rüßmann et al. (2015), and the other is managerial-oriented. The toolbox is based on maturity levels: novice, beginner, learner, intermediate, and expert. Consecutive research by Mittal et al. (2020) recognizes the need for a framework for SMEs to select the right Smart Manufacturing tools and practices. The proposed framework consists of four steps: identifying the manufacturing data present in the SME, assessing Smart Manufacturing readiness of the SME among the data hierarchy steps, developing a Smart Manufacturing tailored vision for SMEs, and identifying the appropriate tools and practices that will lead towards the Smart Manufacturing tailored vision. They also state that SMEs are not aware of the potential impact data analytics can have on their business and advice SMEs to look beyond the financial data when making innovation decisions.

Further attempts to develop a generic framework are made by Moeuf et al. (2018). They propose an Industry 4.0 analytical framework that illustrates the close relationship between the targeted objectives, the levels of managerial capacity sought, and the technical resources required to achieve them. The performance indicators on SMEs are flexibility, costs, productivity, quality, and lead times. They define four distinct managerial capacities that are aligned with the concept of Industry 4.0, namely: monitoring, control, optimization, and autonomy. These managerial capacities can be realised through the implementations of various technologies as described by Rüßmann et al. (2015). They find that flexibility is the most targeted performance objective by researchers, as it is a common characteristic of SMEs that allows them to be differentiated from other firms. Current Industry 4.0 initiatives mainly focus on monitoring industrial processes and the researchers call for accessibility to optimization models for SMEs. Additionally, there is a lack of research to make big data analysis more accessible to SMEs. In order to truly embrace all the potential benefits behind the Industry 4.0 concept, SME managers must stop seeing the production system as a cost but as an opportunity for transforming their business models.

Despite the attempts of Mittal, Romero, et al. (2018), Mittal et al. (2020), and Moeuf et al. (2018), Masood and Sonntag (2020) defined two research gaps: There is a disconnect between current Industry 4.0 technologies and the characteristic needs of SMEs, and there is no clear method to evaluate Industry 4.0 technologies against the needs and requirements of specific SMEs. Based on a survey they conclude that company size and attitude have a positive effect on the benefits of implementation whilst manufacturing complexity has a positive effect on the challenges of implementation. Furthermore, it is suggested that positive Industry 4.0 attitude has an effect on the benefits observed.

2.1.2 Barriers to entry

To get a better understanding of what capabilities a SME needs to have to make their Industry 4.0 transition, the barriers and preparedness for doing so need to be investigated. Sommer (2015) concluded that enterprises, depending on their size, feel well-prepared for Industry 4.0. Large enterprises tend to feel better prepared than small enterprises. The research defined the following practical challenges: insecurities, like for example data security or maturity of Industry 4.0 technologies have to be reduced; the benefit of Industry 4.0 has to be transferred from vision level to reality level; investments in Industry 4.0 technologies have to be encouraged by public funding in order to lower the barriers explicitly for SMEs; internal staff qualification programs and training programs for schools and universities have to be called for; SMEs have to be supported separately as they are less capable of coping with the financial, technological and staffing challenges than large enterprises (Sommer, 2015).

Investigation into the barriers to enter the Industry 4.0 transition was done by Ingaldi and Ulewicz (2020). They found three main barriers to Industry 4.0 in the SME sector. The first barrier is the narrow product portfolio of SMEs, which does not guarantee full use of the efficiency of automated and autonomous production systems. The second barrier is the cost of obtaining money, i.e., the funds for a given investment. An adverse condition is also the turbulence of the environment from the micro and macro aspect. Research by Orzes et al. (2020) confirms twelve previously found barriers to enter Industry 4.0 for SMEs. Namely, High investments required, lack of clearly defined economic benefit, lack of support by top management, preferred autonomy, lack of skilled employees, lack of technical knowledge, complexity, data security concerns, weak IT infrastructure, difficult interoperability/compatibility, lack of methodical approach for implementation, and high coordination effort. They propose to add another eleven barriers and problems to the theory, namely, lack of support from customer/supplier, focus on day-to-day operations, awareness about the potential of robots, lack of support from the IT department, lack of knowledge of Industry 4.0 technologies and technical providers, factory layout constraints, state of machine park, required time for implementation, changes requires for implementing Industry 4.0, difficulties in demand forecasting, and product characteristics. Masood and Sonntag (2020) showed that respondents from the industry suggested that there is a need for training and support on Industry 4.0 topics in SMEs and financial barriers persist as the greatest issue. This is supported by other research that found that the lack of knowledge is one of the main barriers for SMEs (Amaral & Peças, 2021; Yu & Schweisfurth, 2020). Research states that, to overcome this barrier, technology providers should pay more attention to knowledge transfer and value to address the needs of SMEs more specifically (Yu & Schweisfurth, 2020).

In addition to research into the barriers to enter the Industry 4.0 transition, Moeuf et al. (2020) investigated the risks and critical success factors of Industry 4.0 implementation in SMEs and find that there exists an improvement of competitiveness within companies that are using Industry 4.0. The risks found are the lack of expertise in SMEs, the short-term strategy of SMEs, the risk of obsolescence of an investment in technology, and the fear of employees that may perceive Industry 4.0 as a means of increasing surveillance of their work. The critical success factors are the importance of employee training, the conductance of a study prior to embarking upon any Industry 4.0 project, and the regular use of company data that is available.

Another subject that might accelerate the adoption of Industry 4.0 technologies, by lowering a previously mentioned barrier, is that of industrial standards (Liao et al., 2017). The study confirms and emphasizes the huge gap between Industry 4.0 laboratory experiments (95.1%) and industrial applications (4.9%). Research by Zhong et al. (2017) emphasizes the importance of standards when it comes to Industry 4.0 and suggest the development of a generic Industry 4.0 framework for standards. They state that platform technology is able to reduce cost by using flexible and reconfigurable manufacturing systems, this will help with the increasing amount of highly customized products. To achieve this, they present a framework for Industry 4.0 Intelligent Manufacturing Systems with the research topics smart design, smart machines, smart monitoring, smart control, and smart scheduling.

2.1.3 Maturity

An effective way of assessing where a firm stands in its Industry 4.0 transition is by using a maturity model. However, most maturity models, roadmaps, and frameworks currently available consider mainly the needs and resources of MNEs (Buer et al., 2020; Mittal, Khan, et al., 2018). The main issue is that every production system is unique, and it requires significant effort and expertise to transform these into digital production systems (Buer et al., 2020). Mittal, Khan, et al. (2018) propose to add a level 0 to these models to allow for inclusion of those SMEs that are not yet aware of the market or do not yet have level 1 technologies, like a wireless network, in place, for better coverage. The transition from level 0 to level 1 may include a drastic organizational culture change. They also recognize the need for an easy-to-use self-assessment tool and maturity model, and the need of a company-specific Industry 4.0 vision.

Such an Industry 4.0 maturity level self-assessment tool is the Smart Industry Maturity Scan (Ungerer, 2018). This scan consists of seven aspects, with each five questions to determine the Industry 4.0 maturity level of a SME. The seven aspects are: Strategy and Organisation, People and Organisation, Products and Customer service, Customer interfaces, Value chain, Technology and IT management, and Institutional awareness. These aspects all contribute equally to the Industry 4.0 maturity level of an organisation.

Stich et al. (2020) developed an Industry 4.0 roadmap for digital transformation. To achieve this, they first define measures to Industry 4.0 and attach an Industry 4.0 maturity level to these measures. The first step of the roadmap consists of analysing the corporate strategy, objectives and environment. It is necessary to determine which core objectives a company is pursuing and what contribution digital transformation can make to the efficient and effective achievement of these objectives. The second step consists of the determination of the desired level of Industry 4.0 maturity level. A company should self-assess their current Industry 4.0 maturity level. The gap between the two should be closed by assigned measures. During the third step, the maturity-specific digitization measures are selected. The company should focus on measures that have not been implemented yet. The fourth step assigns the measures to the objectives and puts them in chronological order. The interdependency between measures is determined by the respective maturity level that is reached after implementation. The measures build on each other, and thus care must be taken the measures are developed harmoniously.

From research, it becomes clear that the higher the Industry 4.0 maturity level, the more expensive and complex implementations it naturally entails (Amaral & Peças, 2021). The maturity level is generally low for SMEs; thus, the increase of maturity level might not be tremendously expensive or inherently complex. Amaral and Peças (2021) propose two digitalization propositions of which the first streamlines a process through its digitalization and the second generates six previously non-existent indicators, of which four in real time, that allow several decisions to be grounded on data instead of experience. Both propositions are relatively easy to implement, affordable, or even free.

2.1.4 Business Model

As Industry 4.0 technology enables SMEs to change their business model, for example from product based to service based, this is a promising research area. The business model can be mapped in a canvas, which is then called the Business Model Canvas (Osterwalder & Pigneur, 2010). This canvas exists of nine building blocks: Key Partners, Key Activities, Key Resources, Cost Structure, Value Propositions, Customer relationships, Customer Segments, Channels, and Revenue Stream. Müller (2019) has done research in this area in the context of Industry 4.0 and aims to create an understanding of which specific characteristics regarding user and provider perspectives of Industry 4.0 towards Industry 4.0 triggered business models exist in SMEs. Key resources are named most often by the providers of Industry 4.0-based solutions. The main challenge is the integration of the current workforce into Industry 4.0. This is especially difficult for SMEs as there is no one available for the daily business when the team is training for Industry 4.0. Value proposition is also named often by the providers of Industry 4.0-based solutions. This includes the individualized products meeting customer requirements. Key partners are named most often by the users of Industry 4.0. As SMEs have a limited size, often a key partner is required in order to develop new Industry 4.0 based solutions. Customer relations are also mentioned often by the users of Industry 4.0. Customer segments are named comparably often by both the providers and the users of Industry 4.0, as Industry 4.0 is predicted to open the usage of products and services in new segments. Industry 4.0 opens the possibility for new revenue streams, which is mainly mentioned by the providers of Industry 4.0-based solutions. This includes dynamic pricing and pay-per-use payment models.

2.2 Dynamic Capabilities

Dynamic Capabilities are the dimensions of firm-specific capabilities that can be sources of advantage, and explain how combinations of competences and resources can be developed, deployed and protected (Teece et al., 1997). Dynamic Capabilities exploit existing internal and external firm-specific competences to align a firm with a changing environment. Firms that respond timely and have rapid and flexible product innovation, as well as the management capability to coordinate and redeploy internal and external competences effectively, are the winners in the global market. Dynamic comes forth from the capacity to renew competences according to the changing business environment. Capabilities refers to the key role of strategic management in adapting, integrating, and reconfiguring internal and external skills, resources, and functional competences according to the needs of a changing environment. The Dynamic Capabilities view suggests that particular behaviour and performance of a firm is hard to copy, even if its connection and rationality can be observed. In one of his later works Teece (2007) refined dynamic capabilities into generic sensing, seizing, and transforming capacities, which need to be closely aligned with a firm's strategy. Sensing includes identification, development, codevelopment and assessment of technological opportunities in relationship to customer needs. Seizing involves mobilization of resources to address needs and opportunities, and to capture value from doing so. Transforming means continued renewal.

For the Dynamic Capabilities in a firm to be measured, Kump et al. (2018) present a 14-item scale based on the previously described, well-established dynamic capability framework by Teece's (2007), assessing sensing, seizing, and transforming capacities. The scale is based on a six-point Likert scale ranging from "strongly disagree (1)" to "strongly agree (6)". The statements which build up the scale are found in appendix A, table 5.

Further work on the Dynamic Capabilities framework applied in the Industry 4.0 paradigm by Lin et al. (2020) recognizes the impact the Dynamic Capabilities of a firm can have on its ability to implement Industry 4.0. To appropriately attain a position in the market they should rethink their Dynamic Capability strategies. Organizations should adjust their internal structure, and thus be flexible, to overcome external bottlenecks. Dynamic Capabilities sustain the organisations competitive advantage in a rapidly changing industrial environment. They design a conceptual framework consisting of four capabilities that influence the smart manufacturing transformation: technology capability, process capability, organisation capability, and transformation capability. Research by Müller et al. (2020), focussed on the absorptive capacity, finds that the higher the ability of an organization to acquire and utilize new information, the higher its capacity to launch innovations. This applies to both exploratory and exploitative innovation strategies. Also, absorptive capacity leads to both exploitative and exploratory innovation strategies. SMEs require an exploratory innovation strategy to approach Industry 4.0, this reflects in the efficiency-oriented business models, as exploring novel business models remains difficult for many SMEs because of limited resources. They encourage companies to implement mechanisms to support their absorptive capacity and to further elaborate on the realized absorptive capacity by cooperation with partners that can help them to transform and exploit external knowledge related to Industry 4.0. SMEs should consider the potential of novelty-centred business models.

The theoretical framework suggests that there exists a relationship between the Dynamic Capabilities and the Industry 4.0 maturity level of a SME (Lin et al., 2020). This is further supported by the fact that an organisation with a high absorptive capacity has a higher innovation potential (Müller et al., 2020), and one of the main barriers to enter the Industry 4.0 transition, the turbulent environment (Ingaldi & Ulewicz, 2020) to which a solution could lie in the Dynamic Capabilities. The relationship needs further investigation to be confirmed.

3. METHODOLOGY

3.1 Research setting

A qualitative analysis of a SME will be conducted. This will take place in the form of an exploratory case study, consisting of three parts: firstly, the participants will fill in a Dynamic Capabilities survey, secondly, the participants will fill in an Industry 4.0 maturity level scan, and, thirdly, the researcher will give a workshop based on the outcomes of the previous parts. The research has an exploratory origin, as the goal is to develop an Industry 4.0 focused vision based on the targets of the company are and why the targets are as is. All data collection methods are obtrusive and verbal. The first two parts, the Dynamic Capabilities survey and the Industry 4.0 maturity level scan, are self-completion methods. The first being on paper and the latter web based. The workshop is based on a focus group analysis.

The company in which the research takes place is a B2B company located in the East of the Netherlands. They operate in the industrial automation business and they produce mobile-, process-, and machine control solutions. The company has a revenue of 5 to 10 million euros and in between 50 and 100 employees. Their assembly is fully manual. They can be classified as an industry 4.0 provider (Müller, 2019).

3.2 Research design

The research population is a manufacturing SME in the East of the Netherlands. The research sample is the specific company described in the previous section. The subjects are a set of five managers and key employees of this specific company.

This research used the convenience sampling method. This method is a nonprobability sampling method in which the sampling is based on convenient selection of samples from a population, the convenience coming forth from the limited time and resources this research was done with. It is of subjective nature and is thus not capable of representing the population, reducing the generalizability (Etikan, 2016). As the goal of this study is to gain an in-depth understanding of the relationship between Dynamic Capabilities and the Industry 4.0 maturity level of a SME, generalizability is not the main purpose.

The time dimension of the study is that of a cross-sectional study, as it was carried out once and it represents a snapshot in time (Cooper & Schindler, 2014).

3.3 Data collection

3.3.1 Dynamic Capabilities scale

In order to measure the Dynamic Capabilities of the company, the generic dynamic capabilities scale, as designed by Kump et al. (2018), is used. The scale is based on the Dynamic Capabilities theoretical framework by Teece (2007), which builds further on Teece et al. (1997). This framework defines Dynamic Capabilities into generic sensing, seizing, and transforming capacities, which need to be closely aligned with a firm's strategy. Sensing includes identification, development, codevelopment and assessment of technological opportunities in relationship to customer needs. Seizing involves the mobilization of resources to address needs and opportunities, and to capture value from doing so. Transforming means continued renewal in this theoretical framework. The scale consists of fourteen questions, on a six-point Likert scale. The outcome of the dynamic capabilities scale is used to find potential weaknesses and opportunities in the Dynamic Capabilities of the company. The original scale is in English, but as the company's main language is Dutch, the researcher translated all the questions carefully. Much attention was given to ensuring a perfect translation. The original scale, including the answers from the company can be found in appendix A, table 5. The survey was filled in with the researcher present to allow for questions in the case of uncertainties.

3.3.2 SIMS scam

The SIMS scan is a multidimensional Industry 4.0 maturity level scan in the form of an online survey. The survey was conducted with the researcher present, giving the respondents the possibility to ask questions about the Industry 4.0 maturity scan. The SIMS scan was provided by the company IXIA smart insights. The scan was developed by Ungerer (2018) and is based on theory. It measures the Industry 4.0 maturity level of cooperating SMEs. This scan is based on seven aspects that together define the Industry 4.0 maturity level of a SME. The seven aspects are: Strategy and Organisation, People and Organisation, Products and Customer service, Customer interfaces, Value chain, Technology and IT management, and Institutional awareness. Each of these aspects has five questions to be answered by the participant that are relevant for the aspect. The participant gives a score on a five-point Likert scale and the average of the scores is the level the aspect is situated in. The scan gives a maturity level between one and five, one being the lowest and five the highest. This maturity level is decided based on the levels of the average of all the aspects (Ungerer, 2018). Throughout the research, there was communication between the researcher and the author of the scan to ensure that results were correctly interpreted. The scan was conducted amongst a sample of five managers and key employees within the company.

3.3.3 Workshop

Following up on the dynamic capabilities scale and the SIMS scan, the researcher discusses the results of these with the managers and key employees who filled in the survey and scan. After the results are discussed the group of managers and key employees try to find, together with the researcher, opportunities to grow in their dynamic capabilities and possible solutions for aspects from the Industry 4.0 maturity scan that ranked below average. With the outcomes of the questions in mind, a Business Model Canvas (Osterwalder & Pigneur, 2010) is made for the company's desired state. A Business Model Canvas consists of nine blocks which help to form a holistic and nuanced view of a company and is proven to be a helpful tool for business models (Wirtz et al., 2016). Focus will be given to the building blocks Key resources and Value proposition as these building blocks tend to be the most affected for providers of Industry 4.0 during their Industry 4.0 transition (Müller, 2019). The process of filling in a Business Model Canvas should help with creating an Industry 4.0 vision for the company.

4. RESULTS

In this chapter, the results of the dynamic capabilities scale, the SIMS scan, and the workshop will be presented and analysed.

4.1 Dynamic capabilities scale

The average of the individual items of the scale can be found in table 1, the averages of the three aspects can be found in table 2.

Average of all dynamic capabilities aspects	*3.78*

The average of the dynamic capabilities aspects is 3.78. The company scores best on the seizing aspect, as can be seen in table 1. The difference between the three aspects is low, but seizing is the company's highest ranking dynamic capability.

Table 1; The average of the three dynamic capabilities

Aspect	Score
Sensing	3.64
Seizing	4.35
Transforming	3.72
Average of aspects	**3.78**

The statements the company scored far above average, more than one standard deviation, on are SZ2 and T5, respectively; "We recognize what new information can be utilized in our company.", scored a 4.8, and the statement "In our company, change projects can be put into practice alongside the daily business.", scored a 4.6. The statements the company scored far below average, more than one standard deviation, are SE3 and T2, respectively; "Our company systematically searches for information on the current market situation", scored a 2.6, and the statement "Even when unforeseen interruptions occur, change projects are seen through consistently in our company", scored a 2.8. The other scores can be found in table 2 below. The full list of statements and a table of individual scores can be found in appendix C, table 6.

Table 2; All averages of the individual items

Item	Score
SE1	4
SE2	4.2
SE3	2.6
SE4	3.8
SE5	3.6
SZ1	4.2
SZ2	4.8
SZ3	4.4
T1	3.4
T2	2.8
T3	3.6
T4	4.2
T5	4.6

4.2 SIMS scan

The maturity level of the company is level 3, which is classified as a "leader" (Ungerer, 2018).

Maturity level	*2.83*

A summary of average scores per aspect can be found in table 3. A visualization of the average of each aspect can be seem in the radar chart of figure 1. A larger version for improved readability can be found in appendix C, figure 6.

Table 3; Summary of the SIMS scan

Aspect	Score
Introduction questions	3.22
A1. Strategy and organisation	3.52
A2. People and organisational culture	3.08
A3. Products and customer services	3
A4. Customer interfaces	2.56
A5. Value chain	2.68
A6. Technology and IT management	2.56
A7. Institutional awareness	2.44
Average of aspects	**2.83**

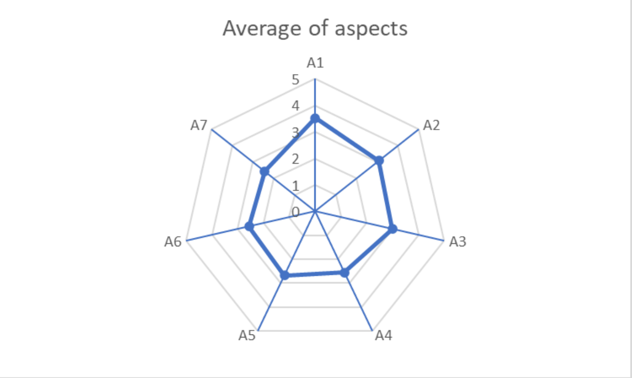

Figure 1; Visualization of the average of aspects

4.2.1 Introduction questions

The introduction questions give the user of the scan an idea of the environment the company is operating in. It gives an idea of the amount of change in the environment and shows whether the company must address these changes.

Average of introduction questions	*3.22*

The industrial sector of the company is changing rapidly, there are many technological breakthroughs and competitors often enter the markets with innovative products. There are unpredictable important innovations in the sector occasionally which causes the boundaries of the sector to redefine. It is important for the company to adapt to the changing environment to stay competitive.

4.2.2 A1. Strategy and organisation

The strategy and organisation questions give a general overview of the strategy and to what extent the strategy contributes to an environment within the organisation in which Industry 4.0 is of great importance (Ungerer, 2018).

Average of strategy and organisation question	*3.52*

Industry 4.0 is a core component of the strategy of the company, and innovation is a key part of the strategy of the organisation. Digital functions, products, and services add value to the company. Progress of the implementation of Industry 4.0 is periodically reported to a lesser extent, and collected data is barely used to create value in the company.

4.2.3 A2. People and organisational culture

The people in an organisation, including management, can be of great importance in the success or failure of digitalization attempts in an organisation. Culture uses norms and values to determine the way things are done in an organisation (O'Donnell & Boyle, 2008).

Average of people and organisational culture	*3.08*

Employees are educated to comply with future Industry 4.0 jobs to a low extent. Management focusses to implement Industry 4.0, and occasionally discusses the implications of Industry 4.0 with their staff. The employees are willing to adjust to changes within the company and to apply new knowledge. The organisational culture within the company is motivated and able to change toward digitalisation of the company.

4.2.4 A3. Products and customer service

Products are defined as the offerings of an organisation, services included. Customer service includes service before, during, and after the purchase of the product (Baines, 2012). Customer feedback is also part of this aspect.

Average of products and customer services	*3.00*

The company's products are equipped with smart technologies from the Industry 4.0 paradigm, and it is the main added value of most of the company's products. As most of the products are tailored to the customers wishes and are unique, the production process is mainly manual. Customer feedback is only collected in a limited way.

4.2.5 A4. Customer interfaces

Customer interfaces are the way customers interact with the company and how the company meets the customers (Gonzales, 2015).

Average of customer interfaces	*2.56*

Customer contact is digitalized to a high extent and multiple communication channels are used. This allows the organisation to cooperate in a more effective way with their customers. There is little to no user data analysis to get a better understanding of customer needs. The customer journey is only digitalised to a low extent.

4.2.6 A5. Value chain

The value chain can be seen as a chain of which each link adds value to a certain product (Porter, 1985). This aspect is about the entire chain, not only the analysed company, but it is essential to measure the digitalisation of a company.

Average of value chain	*2.68*

Devices, hardware, and software in the process of ordering to delivery are connected to high degree. The organisation is improving the digitalization in the value chain to a moderate degree. Collecting data in the horizontal value chain is done to a lesser degree. There is also a low amount of data collected during the production process. The degree to which smart technology is used to find disruptions in the value chain is low.

4.2.7 A6. Technology and IT management

Technology can be defined in many ways, but the underlying concept can be seen as developing tools and machines to solve people's problems (Reisman, 2005). IT management is using these tools to manage data.

Average of technology and IT management	*2.56*

The company focusses their attention on Industry 4.0 related technologies to actively contribute to the work in the company to a moderate extent. The IT department has enough knowledge to implement new Industry 4.0 technologies within the decided time, quality, and cost. ICT security measures to protect company data are taken to a somewhat lesser extent. There is no real-time autonomous decision making in place. The production environment is not able to adapt to new product composition by using automated technology.

4.2.8 A7. Institutional awareness

Institutional awareness exists of compliance, laws, risks, security, taxes, and rules and regulations (Ungerer, 2018).

Average of institutional awareness	*2.44*

The company's digital policies are up-to-date and sufficient, and their intellectual property is sufficiently protected. Relevant employees are aware of rules and regulations around Industry 4.0 to a lesser degree. The awareness of fiscal effects of Industry 4.0 in the company is relatively low. The company is not able to automatically deal with AVG requests from customers.

4.3 Workshop

The workshop focused on improving the Dynamic Capabilities the company scored lowest on and exploiting the Dynamic Capabilities the company scored highest on. Radar charts were used to visualise the stronger and weaker points in the company, these can be found in Appendix B. The lower scoring items of the scale led to little discussion as the company representatives realised and recognised the issues discussed. The higher scoring items are already a key part of the company's strategy and well exploited.

The results of the SIMS scan led to interesting insights for the company. They realised that not capturing and using data that could be collected during the production process, and, most importantly, during the operational time of the machines they produce, is a missed opportunity. Also, not using customer data to improve the service is a missed opportunity that could improve the business significantly. The company expressed their wishes for a full integration of the horizontal value chain but stated that despite previous efforts this couldn't get off the ground as this desire does not live across the horizontal value chain yet. Also, customer requests to access all the data the company holds about them, according to the GDPR, is done fully manual. The company does not see the need to automate this, as there have only been a few requests, and automating the process would be more expensive than manually finding all the relevant data, as the company's administration is not fully digitalised.

Consecutively, the participants filled out a Business Model Canvas for the desired state of the company. During this exercise the researcher ensured the focus was on the most impacting blocks, Key resources and Value proposition (Müller, 2019).

Value proposition was the first block to be filled out, as it helps to have an idea of what you want to deliver when deciding what capabilities you need to develop to be able to deliver. The Value proposition was extended based on the data collection possibilities the company currently has. There exists a desire to map the use of a machine by the end user. This allows for feedback to the customer, but also gives sales opportunities as one can say how much the machine can help a potential customer. Further, the company wishes to build a dashboard around the data to allow for comparison between different instances of a specific machine type and error comparison. This would also help create an understanding of how the performance of a machine could be defined. The data collected from the end user, or a service that gives these insights, could also be sold to the customer.

The Key resources the company needs to obtain are mostly human and intellectual resources. There is already a lot of knowledge inhouse with which most of the value proposition can be developed. The company expressed their concerns about the data side of the Value proposition and would need an experienced data analyst to empower the solution. The intellectual side of the resources would need to be complemented with a dashboard that they can sell to their customers and their end users. They would also need to attain the correct data at the machine level, based on the recommendations of the data analyst.

Further interesting blocks in the Business Model Canvas are the Customer relationship block. The company stated that it is essential to have long term customer relationships, as their focus is to provide full unburdening of the total control question to the end customers. They also stated that previous attempts to push their technology to the market have failed because the market was not ready for the technologies. Currently, there is an increase in Industry 4.0 awareness at potential customers, thus the focus lies to establish relationships in that field. With all the technology implemented, the company could also change their Revenue streams, as it allows for a pay per value or a pay per use business model. In both cases the machines remain property of the company and the end users pay to what extent the machines deliver value or pay for their usage of the machines, respectively. This is, again, possible by extracting the right data from the machine.

4.4 Statistical analysis

As an implication of a statistical relationship between the Dynamic Capabilities and the Industry 4.0 maturity level, correlation is used. The correlation coefficient between each capacity of the Dynamic Capabilities and each aspect of the Industry 4.0 maturity level scan is calculated. This was done by taking the average of each capacity and aspect for each of the respondents and applying the correlation formula to the groups of averages. This leads to a matrix of coefficients as seen in table 4.

4.5 Analysis of results

As seen in Table 4, there seems to exist a strong positive correlation between People and organisation and Sensing as well as Seizing. In the case of Sensing, it seems most logical that the people in the company allow for the identification, development, and assessment of technological opportunities, and that the inverse is not possible as the origin lies in the people in the organisation. The investigated company has a dedicated Research and Development team which allows them to find these opportunities parallel to the daily operations, as implied by Müller (2019). In the case of Seizing, the results indicate that the capability to mobilize resources to address needs and opportunities could lead to a higher degree to which Industry 4.0 has been implemented with relation to the People and organisation aspect. The investigated company does this by keeping all their employees up to date with recent innovations, as innovation is the core of their business, using an exploratory innovation strategy (Müller et al., 2020). People and organisation and Transforming are moderately positively correlated. As Transforming is defined as continuous renewal (Teece, 2007) and the People and organisation aspect is one of the aspects that enables the Industry 4.0 transformation, it could be very well that a high Transforming capability leads to a higher score on the People and organisation aspect on the SIMS scan. In the observed company, this is a result of appointing a manager of the Research and Development team, as it is his responsibility that innovation happens continuously.

Table 4; Correlation coefficients between the Dynamic Capabilities and Industry 4.0 maturity aspects

	A1	A2	A3	A4	A5	A6	A7
SENSING	-0,42844	0,884464	-0,15451	-0,37359	-0,79178	-0,10133	0,035472
SEIZING	0,193494	0,788253	0,185535	0,259453	-0,61934	-0,18412	0,106487
TRANSFORMING	0,30048	0,642857	-0,42592	0,374654	-0,63403	-0,24809	0,18334

Value chain and Sensing seem to have a strong negative correlation. This is an unexpected outcome, as generally identification, development, and assessment of technological opportunities lead to a higher added value throughout the organisation. It is noted that the Value chain aspect of the SIMS scan diverts the scope from organisation to value chain, and measures aspects the company has no immediate impact on. the Value chain and Seizing as well as Transforming seem moderately negatively correlated. Given seizing being the mobilization of resources to address needs and opportunities and capturing value doing so, it is surprising that the company scored low on the Value chain aspect as this is the aspect that includes doing so. Again, this could be caused by the company not having direct impact on the entire value chain but could also be an effect of the small sample, as further discussed in the limitations and further work section of this research. The moderately negative correlation between Transforming, which is the continuous renewal, and the Value chain aspect of the SIMS scan is explained by the same factors as the Seizing capability and the Value chain aspect. The negative correlation between the Value chain aspect and the Dynamic Capabilities could be an effect of the numerous failed attempts of horizontally integrating the value chain, as the company itself has the Dynamic Capabilities to do so, but the rest of the value chain might be lacking these.

5. DISCUSSION

In this chapter the theoretical implications, practical implications, and limitations and further work will be discussed.

5.1 Theoretical implications

To the best of the authors knowledge, this is the first research that examines the relationship between the Dynamic Capabilities as defined by Teece (2007) and the degree of Industry 4.0 implementation in SMEs. The research shows that there might exist a relationship between certain aspects from the SIMS scan and the Dynamic Capabilities framework. As this research used the SIMS scan designed by Ungerer (2018), it contributes to the validation of the scan. During this research, the Business Model Canvas framework by Osterwalder and Pigneur (2010) was briefly touched upon. This is also a fruitful research area in combination with Industry 4.0, as, during the workshop, the participants found it a very useful tool, and research in Industry 4.0 transitions and Business Models is unsaturated.

5.2 Managerial implications

The main managerial implication is the fact that Industry 4.0 maturity levels have an origin. This origin might lie in the Dynamic Capabilities. By improving the Dynamic Capabilities of the firm, one might build a basis from which the Industry 4.0 maturity level can be improved. In order to do so, the current state of the Dynamic Capabilities need to be assessed. The researcher encourages companies to self-asses their Dynamic Capabilities with a tool such as the framework by Kump et al. (2018). The investigated company found the questions rather straight forward and logical, but they made them think about other ways of gathering information. To assess whether this results in an improved Industry 4.0 maturity level, the researcher encourages companies to also self-asses their Industry 4.0 maturity level, with for instance the SIMS scan. Without doing so, it is impossible to design the changes to the organisation, as an unclear starting point makes it terribly difficult to map actions to be taken and toughens the measurement of the results of the implementations.

The Dynamic Capabilities can be improved by assigning someone to closely monitor the market, and systematically search for new and relevant information. It is also important not to lose track of the competition. In some businesses, scientific literature could be of great value but as the focus of the research is on SMEs, and not all business owners and managers of SMEs are used to scientific literature, not much tends to be done with the available knowledge. Human resources are of the utmost importance when attempting to improve the Dynamic Capabilities and these should be managed accordingly, keeping in mind the roles and responsibilities of individual employees. Employees should be trained in coping with change and dynamic environments to enhance their individual skills and capabilities, which should return as capabilities at firm level.

As the Industry 4.0 paradigm is data driven, interesting issues within the Industry 4.0 transition are what data is currently being collected, what data can easily be collected and what can the company do with that data, and what data would be interesting to collect and how the company implements gathering this data, following part of the framework of Mittal et al. (2020).

This research used the Business Model Canvas framework (Osterwalder & Pigneur, 2010) to make the step between vision and strategy more tangible. The possibilities of using data usage should be kept in mind during the process. When filling out a Business Model Canvas, it is important to ask yourself why your answer is the case and find the underlying reason for it. This helps with deciding which changes to make. As many resources in a SME are limited, it is of high importance to carefully weigh the possible changes to implement the best change for the company and reduce the risk associated with the innovations. Also, keep in mind the primary processes of the company, those should always be kept inhouse as they are the sole reason the company exists.

5.3 Limitations and further work

The main limitation of this research is the small sample size. The research was conducted in only one company, with a "leader" Industry 4.0 maturity level. This does not allow for any generalizability, as there should be little variety in the results from the SIMS scan and the Dynamic Capabilities scale. It might be pure coincidence that People and organisation and Value chain were found to be correlated with Sensing, Seizing, and Transforming. It could also be the case that, due to indifferences between the respondents, correlations were not found. Statistics can never give true assurance of results due to its nature, but in this research, it is used to find possible leads for further research. To get more certainty of the relationships, this research should be repeated and applied to many more SMEs.

Furthermore, correlation does not mean that there exists some form of a causal relationship. We also cannot say anything about the direction of the relationship. This requires further investigation that uses different methods, a different research question, and most importantly, a different type of statistical analysis. The correlation coefficients that were found in this research could also be the effect of another underlying factor that causes both the Industry 4.0 maturity level and Dynamic Capabilities of the company.

Another limitation of this research lies in its theoretical framework. Both the SIMS scan and the Dynamic Capabilities scale were selected without further background research which was a choice based on availability of both and the limited time the research had available due to the fact it is a thesis. Because only one dynamic capabilities scale and one industry 4.0 maturity level scan were used, the possible correlations that could exist between other frameworks are not considered. Including other frameworks and assessment methods might lead to interesting new insights. Further research would need to be conducted.

Additionally, this research is based on the outcome of a one-time use of a scan and scale. It represents the status quo of the researched company at a single moment in time. It would be very interesting to have the same company revisit the scan in a year, to see whether the possibilities for an enhanced Industry 4.0 implementation have been exploited. This would show the value the SIMS scan can provide a company.

6. CONCLUSION

This research provides insight to the relationship between Dynamic Capabilities and the Industry 4.0 maturity level of a company. The research found that there might be a relation between the People and organisation and Value chain aspects and the three Dynamic Capabilities: Sensing, Seizing, and Transforming. Further research is needed to prove the relationship and examine which way the relationships work. This research also found how Dynamic Capabilities can be used to the advantage of an organisation by using them to increase the Industry 4.0 maturity level.

7. ACKNOWLODGEMENTS

Firstly, I would like to thank my supervisor Prof. Dr R.P.A. Loohuis for his valuable input, honest feedback and comments, and flexibility throughout this research. His input made me think out of the box and led to the inclusion of the Dynamic Capabilities framework in this research. I would also like to thank Drs L.V. Ungerer for allowing me to use his SIMS scan and his assistance with analysing the results. Further thanks go out to the company at which the research has been conducted, especially to the managers, who have made this research possible, and allowed me to visit their site despite the pandemic. This has helped enormously with motivation to work a bit extra. Finally, I would like to thank my family and friends for their everlasting support during my bachelor.

8. REFERENCES

1) Amaral, A., & Peças, P. (2021). SMEs and Industry 4.0: Two case studies of digitalization for a smoother integration [Article]. *Computers in Industry*, *125*, Article 103333. https://doi.org/10.1016/j.compind.2020.103333
2) Baines, P. (2012). *Essentials of Marketing*. Oxford University Press.
3) Buer, S. V., Strandhagen, J. W., Semini, M., & Strandhagen, J. O. (2020). The digitalization of manufacturing: investigating the impact of production environment and company size [Article]. *Journal of Manufacturing Technology Management*. https://doi.org/10.1108/JMTM-05-2019-0174
4) Commission, E. (2020). *User guide to the SME Definition*.
5) Cooper, D. R., & Schindler, P. S. (2014). *Business Research Methods* (12 ed.). McGraw-Hill.
6) Etikan, I. (2016). Comparison of Convenience Sampling and Purposive Sampling. *American Journal of Theoretical and Applied Statistics*, *5*(1), 1. https://doi.org/10.11648/j.ajtas.20160501.11
7) Gonzales, K. (2015). Managing the Customer Interface with Best Practice Guidance - and not only in ITIL®! https://www.axelos.com/news/blogs/april-2015/managing-the-customer-interface-with-best-practice
8) Hansen, E. B., & Bøgh, S. (2021). Artificial intelligence and internet of things in small and medium-sized enterprises: A survey [Article]. *Journal of Manufacturing Systems*, *58*, 362-372. https://doi.org/10.1016/j.jmsy.2020.08.009
9) Ingaldi, M., & Ulewicz, R. (2020). Problems with the implementation of industry 4.0 in enterprises from the SME sector [Article]. *Sustainability (Switzerland)*, *12*(1), Article 217. https://doi.org/10.3390/SU12010217
10) Konur, S., Lan, Y., Thakker, D., Morkyani, G., Polovina, N., & Sharp, J. (2021). Towards design and implementation of Industry 4.0 for food manufacturing [Article]. *Neural Computing and Applications*. https://doi.org/10.1007/s00521-021-05726-z
11) Kump, B., Engelmann, A., Kessler, A., & Schweiger, C. (2018). Toward a dynamic capabilities scale: measuring organizational sensing, seizing, and transforming capacities. *Industrial and Corporate Change*. https://doi.org/10.1093/icc/dty054
12) Lasi, H., Fettke, P., Kemper, H. G., Feld, T., & Hoffmann, M. (2014). Industry 4.0 [Article]. *Business and Information Systems Engineering*, *6*(4), 239-242. https://doi.org/10.1007/s12599-014-0334-4
13) Liao, Y., Deschamps, F., Loures, E. d. F. R., & Ramos, L. F. P. (2017). Past, present and future of Industry 4.0 - a systematic literature review and research agenda proposal. *International Journal of Production Research*, *55*(12), 3609-3629. https://doi.org/10.1080/00207543.2017.1308576
14) Lin, T.-C., Sheng, M. L., & Jeng Wang, K. (2020). Dynamic capabilities for smart manufacturing transformation by manufacturing enterprises. *Asian Journal of Technology Innovation*, *28*(3), 403-426. https://doi.org/10.1080/19761597.2020.1769486
15) Luco, J., Mestre, S., Henry, L., Tamayo, S., & Fontane, F. (2019). *Industry 4.0 in SMEs: A Sectorial Analysis* [Conference Paper]. https://doi.org/10.1007/978-3-030-30000-5_45
16) Masood, T., & Sonntag, P. (2020). Industry 4.0: Adoption challenges and benefits for SMEs [Article]. *Computers in Industry*, *121*, Article 103261. https://doi.org/10.1016/j.compind.2020.103261
17) Mittal, S., Khan, M. A., Purohit, J. K., Menon, K., Romero, D., & Wuest, T. (2020). A smart manufacturing adoption framework for SMEs [Article]. *International Journal of Production Research*, *58*(5), 1555-1573. https://doi.org/10.1080/00207543.2019.1661540
18) 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*, 194-214. https://doi.org/10.1016/j.jmsy.2018.10.005
19) Mittal, S., Romero, D., & Wuest, T. (2018). Towards a Smart Manufacturing Toolkit for SMEs. In P.

Chiabert, A. Bouras, F. Noël, & J. Ríos, *Product Lifecycle Management to Support Industry 4.0* Cham.

20) Moeuf, A., Lamouri, S., Pellerin, R., Tamayo-Giraldo, S., Tobon-Valencia, E., & Eburdy, R. (2020). Identification of critical success factors, risks and opportunities of Industry 4.0 in SMEs [Article]. *International Journal of Production Research*, *58*(5), 1384-1400. https://doi.org/10.1080/00207543.2019.1636323
21) Moeuf, A., Pellerin, R., Lamouri, S., Tamayo-Giraldo, S., & Barbaray, R. (2018). The industrial management of SMEs in the era of Industry 4.0. *International Journal of Production Research*, *56*(3), 1118-1136. https://doi.org/10.1080/00207543.2017.1372647
22) Müller, J. M. (2019). Business model innovation in small- and medium-sized enterprises: Strategies for industry 4.0 providers and users [Article]. *Journal of Manufacturing Technology Management*, *30*(8), 1127-1142. https://doi.org/10.1108/JMTM-01-2018-0008
23) Müller, J. M., Buliga, O., & Voigt, K. I. (2020). The role of absorptive capacity and innovation strategy in the design of industry 4.0 business Models-A comparison between SMEs and large enterprises [Article]. *European Management Journal*. https://doi.org/10.1016/j.emj.2020.01.002
24) O'Donnell, O., & Boyle, R. (2008). Understanding and Managing Organisational Culture. *Institute of Public Administration*.
25) Orzes, G., Poklemba, R., & Towner, W. T. (2020). Implementing industry 4.0 in smes: A focus group study on organizational requirements. In *Industry 4.0 for SMEs: Challenges, Opportunities and Requirements* (pp. 251-277). https://doi.org/10.1007/978-3-030-25425-4_9
26) Osterwalder, A., & Pigneur, Y. (2010). *Business Model Generation*. (Wiley)-VCH.
27) Porter, M. E. (1985). The Competitive Advantage: Creating and Sustaining Superior Performance. *NY: Free Press*.
28) Reisman, A. (2005). Transfer of technologies: a cross-disciplinary taxonomy. *Omega*, *33*(3), 189-202. https://doi.org/https://doi.org/10.1016/j.omega.2004.04.004
29) Rüßmann, M., Lorenz, M., Gerbert, P., Waldner, M., Justus, J., Engel, P., & Harnisch, M. (2015). Industry 4.0: The future of productivity and growth in manufacturing industries. *Boston Consulting Group*, *9*(1), 54-89.
30) Senivongse, C., Bennet, A., & Mariano, S. (2019). Clarifying absorptive capacity and dynamic capabilities dilemma in high dynamic market IT SMEs. *VINE Journal of Information and Knowledge Management Systems*, *49*(3), 372-396. https://doi.org/10.1108/VJIKMS-11-2018-0105
31) 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). https://doi.org/10.3926/jiem.1470
32) Stentoft, J., Rajkumar, C., Madsen, E. S., & Syddansk, U. (2017). *Industry 4.0 in Danish industry: an empirical investigation of the degree of knowledge, perceived relevance and current practice*. University of Southern Denmark.
33) Stich, V., Zeller, V., Hicking, J., & Kraut, A. (2020). Measures for a successful digital transformation of SMEs.
34) Teece, D. J. (2007). Explicating dynamic capabilities: the nature and microfoundations of (sustainable) enterprise performance. *Strategic Management Journal*, *28*(13), 1319-1350. https://doi.org/10.1002/smj.640
35) Teece, D. J., Pisano, G., & Shuen, A. (1997). Dynamic capabilities and strategic management [https://doi.org/10.1002/(SICI)1097-0266(199708)18:7<509::AID-SMJ882>3.0.CO;2-Z]. *Strategic Management Journal*, *18*(7), 509-533. https://doi.org/https://doi.org/10.1002/(SICI)1097-0266(199708)18:7<509::AID-SMJ882>3.0.CO;2-Z
36) Ungerer, L. V. (2018). *Constructing A Multi dimensional Smart Industry Scan* University of Twente].
37) van de Vrande, V., de Jong, J. P. J., Vanhaverbeke, W., & de Rochemont, M. (2009). Open innovation in SMEs: Trends, motives and management challenges. *Technovation*, *29*(6), 423-437. https://doi.org/10.1016/j.technovation.2008.10.001
38) Whysall, Z., Owtram, M., & Brittain, S. (2019). The new talent management challenges of Industry 4.0. *Journal of Management Development*, *38*(2), 118-129. https://doi.org/10.1108/JMD-06-2018-0181
39) Wirtz, B. W., Pistoia, A., Ullrich, S., & Göttel, V. (2016). Business Models: Origin, Development and Future Research Perspectives [Article]. *Long Range Planning*, *49*(1), 36-54. https://doi.org/10.1016/j.lrp.2015.04.001
40) Yu, F., & Schweisfurth, T. (2020). Industry 4.0 technology implementation in SMEs – A survey in the Danish-German border region [Article]. *International Journal of Innovation Studies*, *4*(3), 76-84. https://doi.org/10.1016/j.ijis.2020.05.001
41) Zhong, R. Y., Xu, X., Klotz, E., & Newman, S. T. (2017). Intelligent Manufacturing in the Context of Industry 4.0: A Review. *Engineering*, *3*(5), 616-630. https://doi.org/10.1016/J.ENG.2017.05.015

9. APPENDICIES

9.1 Appendix A: questions and results of the Dynamic Capabilities scale.

Table 5; The questions and results of the representatives of the Dynamic Capabilities scale by Kump et al. (2018)

Code	Question	R1	R2	R3	R4	R5	Average	Aspect scores
SE1	Our company knows the best practices in the market	5	4	4	2	5	4	3,64
SE2	Our company is up-to-date on the current market situation	5	3	4	4	5	4,2	
SE3	Our company systematically searches for information on the current market situation	4	2	2	2	3	2,6	
SE4	As a company, we know how to access new information	5	2	4	2	6	3,8	
SE5	Our company always has an eye on our competitors' activities	5	3	3	3	4	3,6	
SZ1	Our company can quickly relate to new knowledge from the outside	5	4	4	3	5	4,2	4,35
SZ2	We recognize what new information can be utilized in our company	5	4	5	4	6	4,8	
SZ3	Our company is capable of turning new technological knowledge into process and product innovation	5	5	4	3	5	4,4	
SZ4	Current information leads to the development of new products or services	5	4	4	3	4	4	
T1	By defining clear responsibilities, we successfully implement plans for changes in our company	4	5	3	3	2	3,4	3,72
T2	Even when unforeseen interruptions occur, change projects are seen through consistently in our company	4	3	2	2	3	2,8	
T3	Decisions on planned changes are pursued consistently in our company	4	3	3	4	4	3,6	
T4	In the past, we have demonstrated our strengths in implementing changes	4	5	3	4	5	4,2	
T5	In our company, change projects can be put into practice alongside the daily business	4	5	4	4	6	4,6	

9.2 Appendix B: Analysis of Dynamic Capabilities results

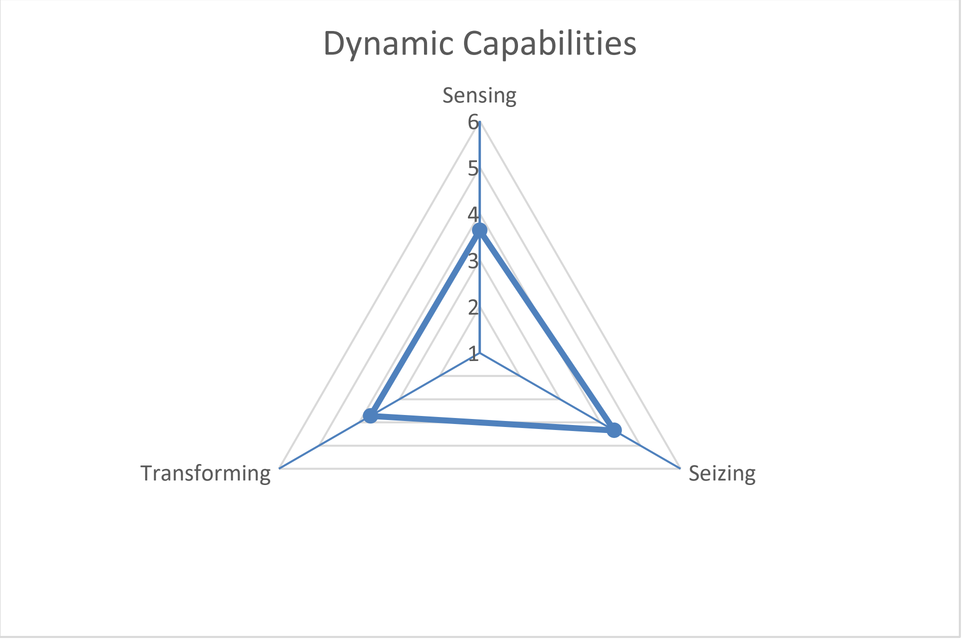

Figure 2; The balance between the Dynamic Capabilities of the company

As one can see in figure 2, the Seizing aspect of the Dynamic Capabilities of the company is slightly better than the Sensing and Transforming aspects. The reason for this will be explored further in this analysis.

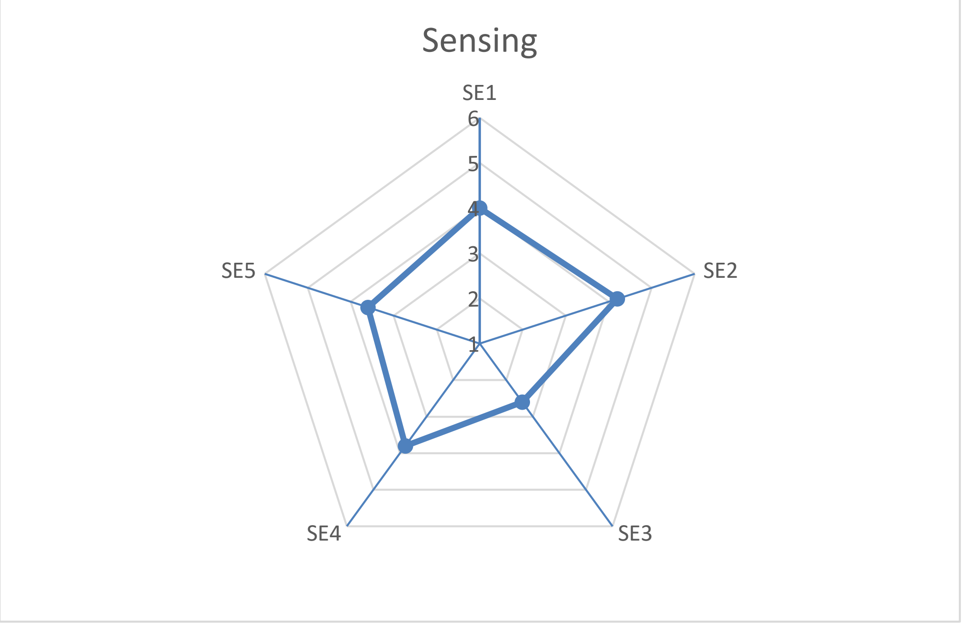

Figure 3; The Sensing aspect of the Dynamic Capabilities of the company

As seen in figure 3, there is only one part of the sensing aspect that lacks behind the rest, which is all around 4 out of 6. This is SE3, with only 2.6 out of 6, or "Our company systematically searches for information on the current market situation". This statement raised awareness at the company that they might be losing out on huge opportunities by not systematically searching for information and measures will be taken to improve this.

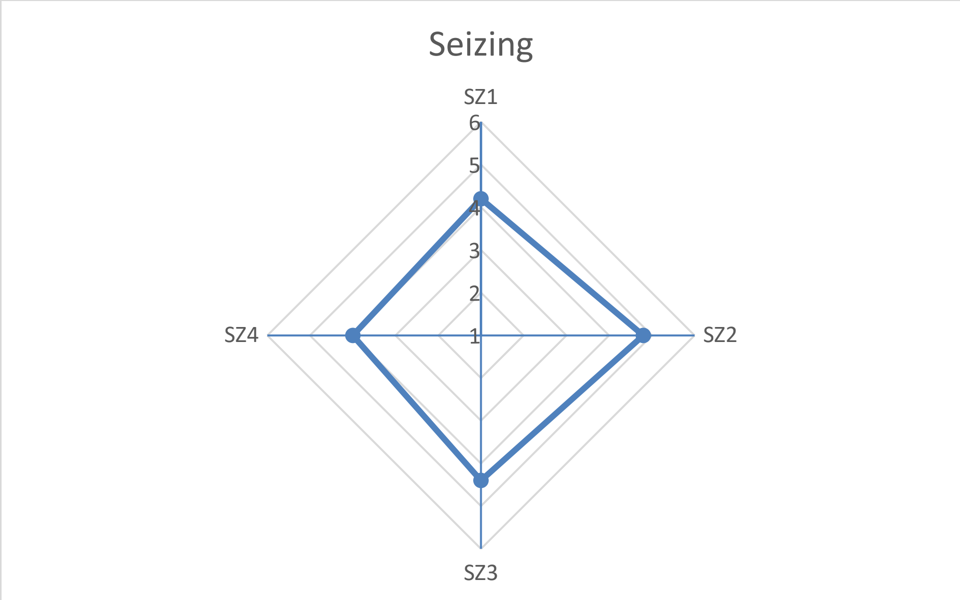

Figure 4; The Seizing aspect of the Dynamic Capabilities of the company

As seen in figure 4, the Seizing aspect of the Dynamic Capabilities is, again, situated around 4, but with an outlier towards SZ2 at 4.8. SZ2 refers to the statement "We recognize what new information can be utilized in our company". Having a strong capability in this statement allows the company to exploit their innovation-based strategy, allowing them to stay ahead of competition in a dynamic market. This allows them to capture value from innovation.

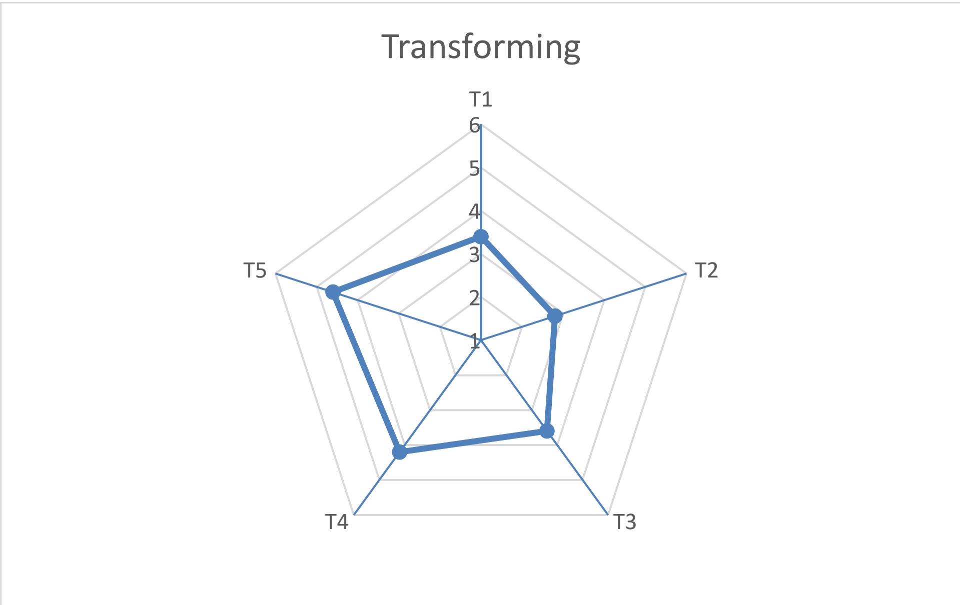

Figure 5; The Transforming aspect of the Dynamic Capabilities of the company

The Transforming aspect has more complications to it than Sensing and Seizing. The lowest value, T2 at only 2.8, being "Even when unforeseen interruptions occur, change projects are seen through consistently in our company." might bring complications along with it. It measures the flexibility in change project throughout the company. This being on the lower side could easily cause for unwanted delays when things do not go as planned. T1 and T3, at, respectively, 3.4 and 3.6, also lie below the average. T1 being "By defining clear responsibilities, we successfully implement plans for changes in our company" could be improved by having more explicit roles, through job descriptions or protocols, and would help in crisis situations when time is limited, and pressure is high. T3 meaning "Decisions on planned changes are pursued consistently in our company". T3 is very related to T2, as both measure the consistency of execution of plans, but in different situations, and thus no surprise of being lower. This issue lies in the culture of the company, employees being rather free to do what they think is right, which is not a wrong matter per se. It could be improved by changing the culture or management style.

9.3 Appendix C: Results of the SIMS scan

Table 6; The complete results of the representatives on the SIMS scan (Ungerer, 2018).

Aspect	Question	R1	R2	R3	R4	R5	Average	Aspect Average
A1	I	4	5	4	4	5	4,4	3,52
	II	4	5	4	4	4	4,2	
	III	1	4	3	2	3	2,6	
	IV	1	3	2	1	3	2	
	V	4	4	5	4	5	4,4	
A2	I	3	3	2	2	2	2,4	3,08
	II	3	3	4	3	4	3,4	
	III	4	2	3	3	3	3	
	IV	4	4	2	2	3	3	
	V	4	3	3	4	4	3,6	
A3	I	4	4	3	3	4	3,6	3
	II	3	5	4	4	4	4	
	III	1	2	2	1	3	1,8	
	IV	1	1	4	2	2	2	
	V	4	2	4	4	4	3,6	
A4	I	4	4	4	3	3	3,6	2,56
	II	1	4	3	3	4	3	
	III	1	2	1	1	2	1,4	
	IV	1	2	2	1	2	1,6	
	V	3	3	3	3	4	3,2	
A5	I	2	3	3	3	3	2,8	
	II	2	3	2	3	3	2,6	2,72
	III	2	2	3	3	1	2,2	
	IV	2	2	3	1	3	2,2	
	V	2	3	4	5	4	3,6	
A6	I	4	3	2	2	4	3	2,56
	II	3	3	3	2	4	3	
	III	3	2	3	3	3	2,8	
	IV	1	1	1	4	2	1,8	
	V	1	1	3	4	2	2,2	
A7	I	3	3	3	3	3	3	2,44
	II	3	2	3	4	3	3	
	III	2	3	2	2	2	2,2	
	IV	1	2	2	2	4	2,2	
	V	3	1	1	2	2	1,8	

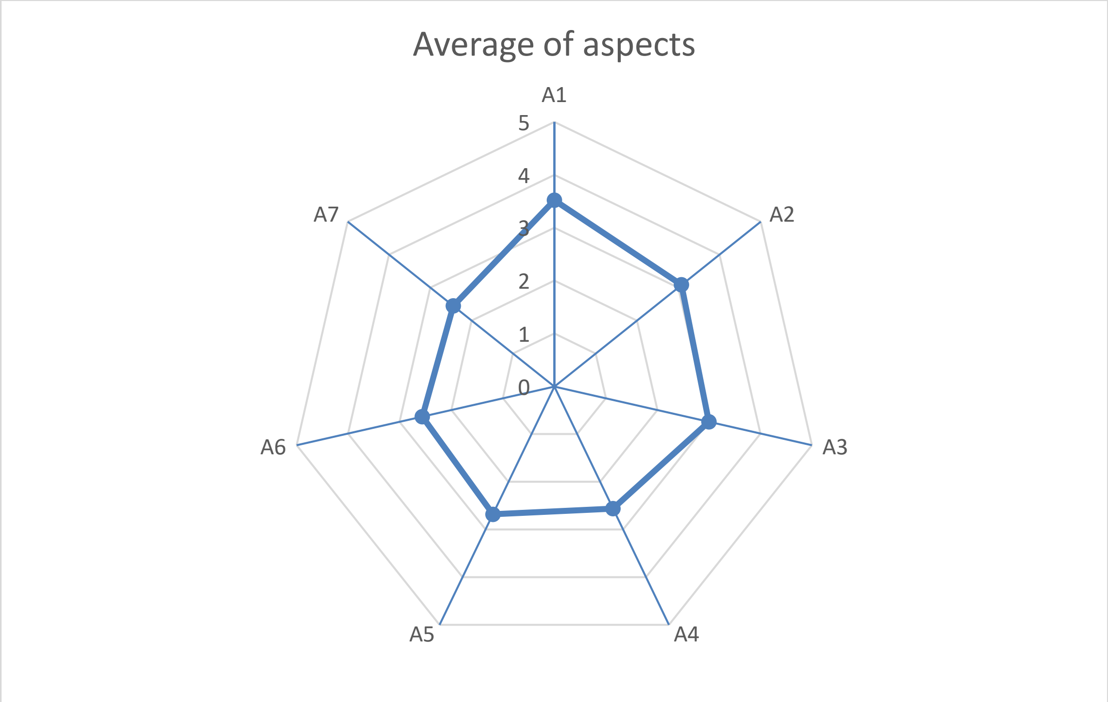

Figure 6; The average of Industry 4.0 maturity aspects (enlarged)