

UNIVERSITY OF TWENTE.

Faculty of Behavioural, Management and Social Sciences

Master of Science (M.Sc.) Business Administration

Digital Business & Analytics

Case study about industry 4.0 in the internal supply chain of a defense company: are we ready for industry 4.0?

Introduction

According to the literature the industry is facing various economic, social and technological challenges. Think of increasing competition, new technologies (Ghadge, Er Kara, Marilou, & Goswami, 2020), personalized products and services and a shorter product life cycle (Oztemel & Gursev, 2020). Because of this, the concept industry 4.0 is receiving more attention. The main topic of this thesis is industry 4.0 in the defense industry. A presentable company in the defense industry is aware of these developments and wants to continue to make strides in the future to remain competitive. However, a gap exist between the current way of working and industry 4.0 aspects. The aim of this thesis is to identify which factors hinder the implementation of industry 4.0 in the internal supply chain of a company which is operating in the defense industry. The main topic and the purpose of this thesis results in the following research question:

How does the context influence the hindering factors and how can the most important hindering factors be solved so that the internal supply chain of a company in the defense industry can implement industry 4.0?

This thesis aims to aid with the challenges the internal supply chain in the defense industry face regarding the implementation of industry 4.0. On one hand, this thesis contributes to the literature by identifying the current situation of the defense industry with specific characteristics regarding industry 4.0. Current literature focuses more on industries where processes and products are more standardized in contrast to the defense company in this research (Bibby & Dehe, 2018; Ferreri, 2003). On the other hand, this thesis investigates which factors hinder the implementation of industry 4.0 which contributes to the literature. Most scientific literature, including Bibby & Dehe (2018) and J. M. Müller et al. (2018), show that the automotive industry, for example, is further along in terms of industry 4.0. This research shows by means of a single case study which factors are perceived as hindering in a different type of industry.

Besides the theoretical contributions, this thesis also contributes to practice. The practical contribution of this study is to provide management positions in the internal supply chain of complex industries a framework that show in which different broader dimensions the hindering factors occur, what these factors are and which have the most impact. This thesis also includes practical recommendations to the most important factors. By providing these insights, it could help executives in the defense industry to not only consider implementing new digital technologies but also using them (Lineberger et al., 2019). The recommendations could serve as a first step.

Theoretical framework

About three hundred years ago, the agricultural industry changed to the mechanic industry with help of steam power (Rojko, 2017), which later changed in an industry of mass production with help of electrical energy (Rojko, 2017). These revolutions respectively are also known as the first and second industry or industry 1.0 and industry 2.0. These staged were followed up by the third revolution (industry 3.0), the digital transformation (Oztemel & Gursev, 2020). The current revolution, called industry 4.0, focuses on the shift from machine manufacturing to digital manufacturing whereas physical devices/machines are connected to the internet so they interact with each other and can operate autonomously without the intervention of humans (Kamble et al., 2018; Oztemel & Gursev, 2020). Research shows that industry 4.0 is more difficult to implement in industries where companies with a low degree of standardized processes, flexible but less automated production equipment and resource limitations operate (Müller, Kiel, & Voigt, 2018).

This research takes into account the definition of industry 3.0 and industry 4.0 because this may influence the factors that are perceived as hindering.

Literature describes that the Dutch defense and security market contain large, medium and small sized companies but also knowledge institutions and startups with a turnover of 4.5 billion euros (Ministerie van Defensie, 2018). This industry is also characterized by the production of high tech, low-volume and customer specific products which results in little standardization. These characteristics are reflected in an internal supply chain strategy. To make it clear, the internal supply chain focuses on the activities/functions within the company to provide a product to the customer (Basnet, 2013). Out of the four supply chain strategies: Build to Stock (BTS), Assemble to Order (ATO), Make to Order (MTO) and Design to Order (DTO), the DTO strategy fits the internal supply chain of the defense industry best. This type of supply chain makes it possible to completely customize the whole product (Stavrulaki & Davis, 2010). Besides, the products in this strategy are mostly low volume, high variability and high prices. These characteristics require an agile supply chain strategy (Stavrulaki & Davis, 2010). As mentioned above, industry 4.0 is more difficult to implement in industries with such characteristics.

To determine in which categories hindering factors could occur, different readiness and maturity models regarding industry 4.0 are used. The PWC-model, IMPULS-model and Acatech Maturity Index are compared. These models all use different categories and scales to determine the readiness/maturity of the company. The categories of the IMPULS-model fit best to the purpose of this research because this model considers both soft and hard factors related to industry 4.0. Lastly, according to Bibby & Dehe (2018) the IMPULS-model is scientifically well-established in contrast to PWC and Acatech Maturity Index.

The IMPULS model provides insight and improvements on the preparations for industry 4.0. The readiness model contains six key dimensions; strategy and organization, employees, data-driven services, smart factory, smart operations, smart products (Grufman & Lyons, 2020). The focus on this research is on the factors: strategy and organization and employees. It is important that these dimensions be considered first because this is at the front end of implementing an innovation (Kotter, 1997). To support the IMPULS-model, the research of Paulussen (1994) distinguished four categories of hindering factors. These are: characteristics of the innovation

strategy, characteristics of the adopting unit, characteristics of the innovation, social- political context. Both the readiness model and the scientific research are combined to design the categories in which the hindering factors could occur.

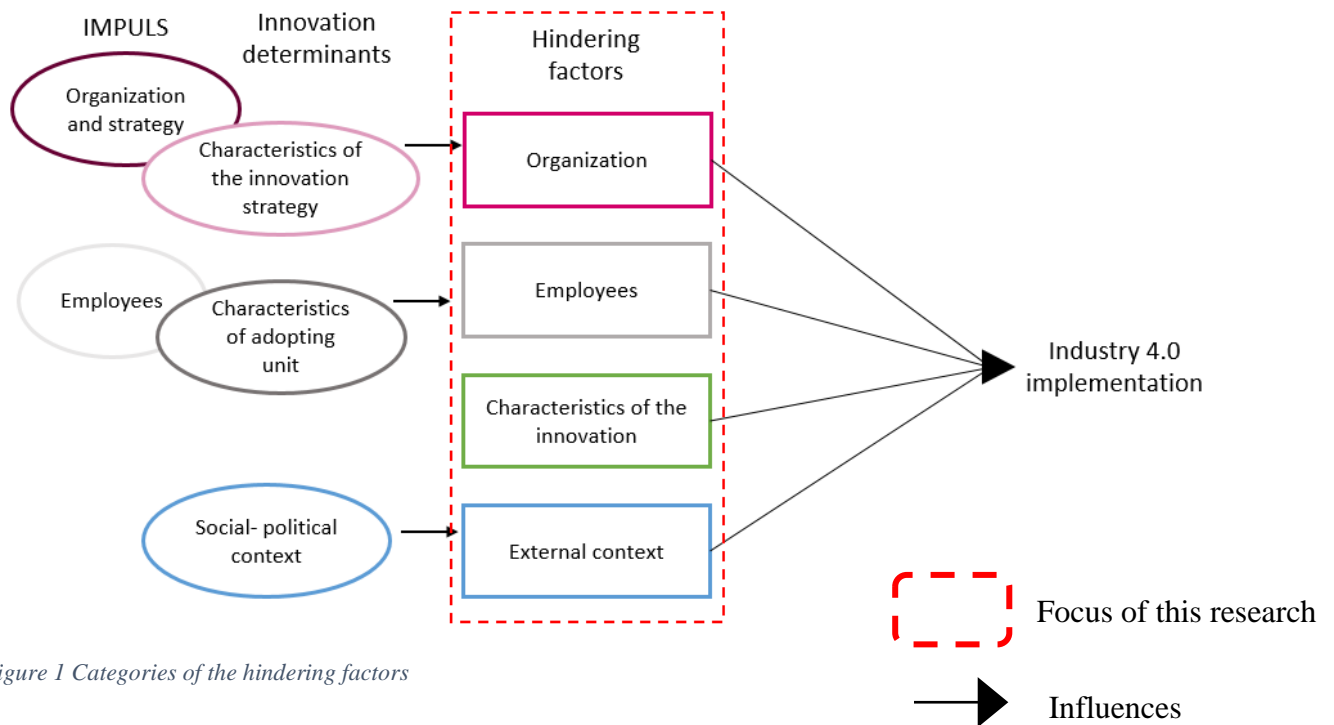


Figure 1 Categories of the hindering factors

As shown in Figure 1, the categories of the IMPULS-model and the innovation determinants are combined in the factors: organization, employees, characteristics of the innovation and external context. These factors are the focus of this research. After defining the core categories, specific factors found in the literature are linked to the core categories. Together with the definition of industry 3.0 and industry 4.0, the following research design was conducted (Figure 2). On the left side, the context that the participants will be referring to is visualized. This could have an influence on the hindering factors. In the middle, the core categories with the hindering factors are visualized which could have an influence on the implementation of industry 4.0.

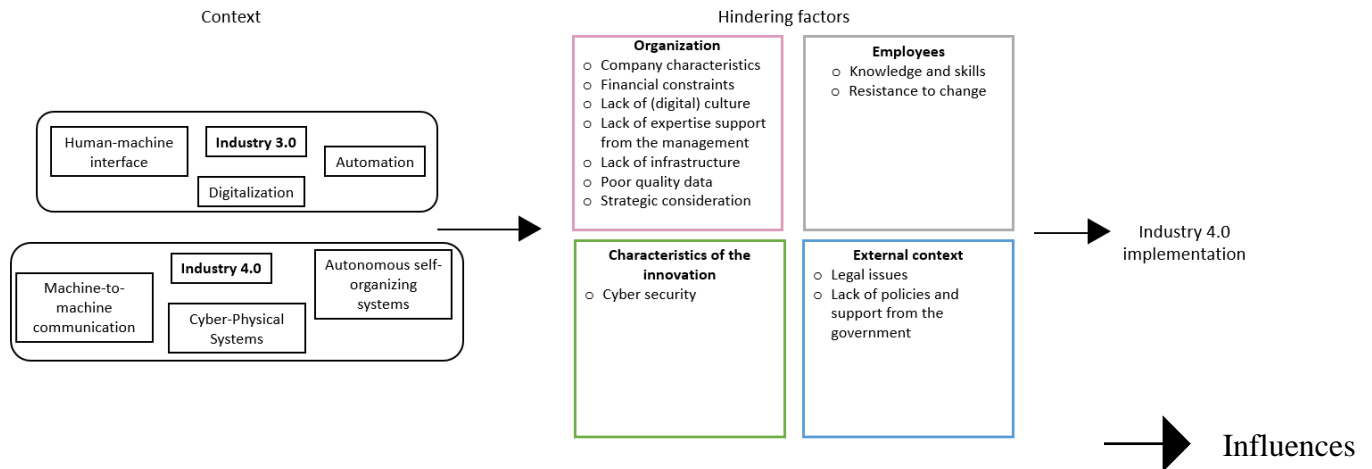


Figure 2 Research model

Method

As mentioned the objective of this research is to identify which factors hinder the implementation of industry 4.0. Because the research question is a so called “how” question, this research has a qualitative approach in which interviews are the main method used. To acquire data, both semi-structured individual and group interviews and a peer-session is used. To get an overview of the current situation, the context of the interviewees and the hindering factors eleven interviews were conducted. The interviewees were selected by non-probability sampling.

The interview questions are based on the research model. It starts with a knowledge question, to define the context of the interviewee. Then questions were asked about each category. In order not to steer the interviewees toward an answer, the questions were as open as possible. When there is no or little response to the first question, an additional question will be asked to verify that there are indeed no answers to the first question.

The first category that will be discussed is the Organization because the third step in an innovation process is to develop a vision and strategy (Kotter, 1997). Second, the Employees because this is related to the organization on a more specific level. After looking internal, the interview discussed the external factors. This is done to make a clear distinction between the Organization and factors related to other categories. Last, the characteristics of industry 4.0 are discussed. After discussing the categories, an open question to investigate whether there are more factors perceived as hindering. Second, a ranking question is asked to have input for the peer-

session. This peer-session is used to come up with the top 3 most important hindering factors to which recommendations are given.

When conducting research, validity is essential to consider. To achieve this, the interview questions are based on the literature review. Besides, to decrease bias, the interviewees are mostly interviewed separately, and the questions were asked in the same order and way. Next to validity, reliability should also be considered. To ensure this, the number of participants is considered, and the peer-session is used to test whether the interview outcomes are consistent.

The interviews were recorded and transcribed in order to be able to analyze the data. After transcribing the interviews, the transcripts were shared with the interviewees to increase reliability. When the transcript was approved, the transcript was coded. This is done by open coding, axial coding and selective coding. The code scheme is used to extend or modify the theoretical framework. After transcribing, and coding it was possible to analyze the data and draw a conclusion.

Findings

The interviews and available documents were examined to draw a conclusion about the current situation. The internal supply chain of the defense company is currently focusing on the digital transformation. This is done by creating a digital backbone that interconnects different networks and provides a path for the exchange of data. More in detail, this means the integration of ERP (Enterprise Resource Planning), PLM (Product Lifecycle Management) and a DSI (Digital Shop floor Interface). This will be the basis for further industry 4.0 developments. Beside the available documents, also the interviews show that the focus is currently on data, digitalization and the digital backbone. This indicates that the internal supply chain of the company is currently working on the transformation from industry 2.0 to industry 3.0.

After identifying the current situation, the context of the interviewees was discussed. Industry 4.0 knows no unanimously agreed definition. Therefore, employees could have different definitions of industry 4.0 which influences the hindering factors. Out of eight interviews, six mention digitalization in their definition. Often, this definition is used in combination with AR, VR, IoT, blockchain, mobile devices and robots. Two interviewees also mention, besides digitalization, automation of processes. One interviewee mentioned the interconnection between human and machines. In Figure 3 the context is visualized, it can be seen that most of the aspects

mentioned are more in line with industry 3.0. Overall, definitions vary among interviewees, but it can be argued that data and/or digitization predominate, and the context has no effect on the experienced hindering factors.

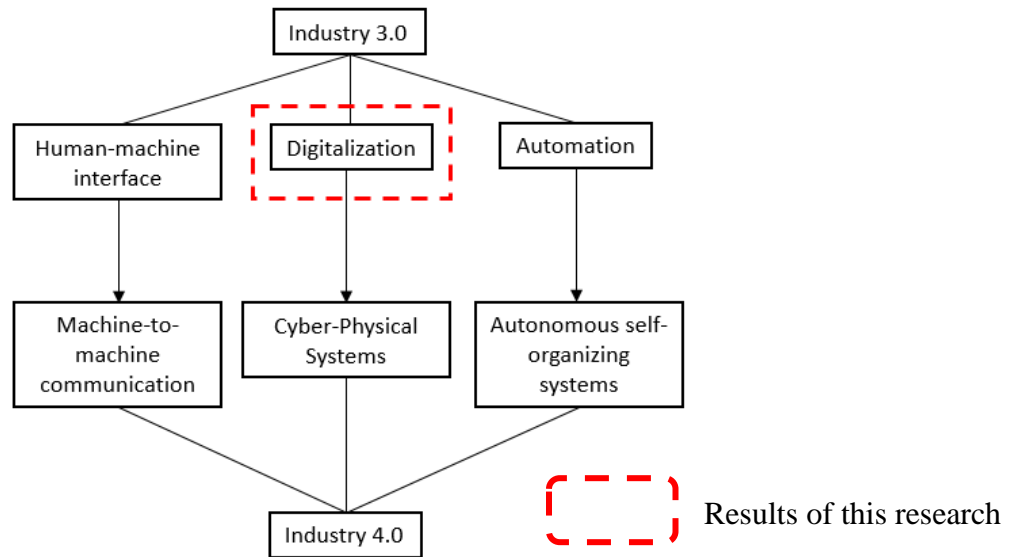


Figure 3 Results of this research: context of interviewees

After identifying the definition and technologies among the interviewees the hindering factors were the second subject of the interviews. The hindering factors mentioned during the interviews fit the core categories found in the literature. The interviewees experience the most hindrance in terms of Organization and Employee.

During the analysis of the transcripts several themes according to the organization emerged. The category Organization consists of a total of eleven hindering factors, which is the most among the categories. Generally, the interviewees focus on ten different themes: different departments, definition of I4.0, governance, processes, initiatives, ICT infrastructure, knowledge, nature of the company, resources, vision, and strategy. The factors definition of I4.0, initiatives and knowledge were mentioned less often than the other factors (by less than two people). The lack of ICT infrastructure and resources are mentioned seven times. The fact that employees have to deal with complex processes and a lack of vision and strategy are mentioned five times. The interviews reveal that most of the hindrance is experienced within the organization.

In the category Employee there are five hindering factors mentioned. The factors that are mentioned in the context of Employees are: integral view, interest, willingness to change, profession, skills and knowledge. Because some factors are highly related to each other, these are merged. The factors interest, profession, and willingness to change. These three factors overlap, and it can be concluded that the willingness to change and seek the full breadth of the profession begins with the degree of interest. The lack of skills and knowledge around industry 4.0 is mentioned five times, the lack of interest is mentioned four times and the lack of an integral view is mentioned three times. It became clear that there is a need for employees with certain skills and knowledge to take steps towards industry 4.0.

The interviews suggest that the factors in the external context hinder implementation to a lesser extent than the other categories. The factors are: defense industry, law and regulations and low competitive market. The characteristics of the defense industry, as mentioned before, could make the implementation more difficult comparing to other industries. This hinderance is mentioned by two interviewees. Both law and regulations and low competitive market are mentioned once. The industry is developing much quicker than the law and regulations, which is perceived as hindering when it comes to for instance data and security. Besides, it is mentioned that within the company there exist the perception that the defense industry is a low competitive market. Therefore, working more efficient is not seen as something necessary which is experienced as hindering. The fact that these factors are only mentioned by one or two participants confirms that these factors hinder implementation to a lesser extent.

The last category, Characteristics of the Innovation, consists of one hindering factor when it comes to confidentiality and security. This is because industry 4.0 is concerned with a lot of data which is confidential within the defense sector.

After the interviews, the peer session resulted in a top 3 important hindering factors. The lack of a clear strategy and the execution of it (1), multidisciplinary teams (2) and skills and knowledge (3) are experienced as most hindering to take steps towards industry 4.0. These factors are positioned in the overall categories Organization and Employee.

Overall the outcomes of the interviews center around Organization and Employees. The factors External context and Characteristics of the Innovation are not seen as that much hindering. This resulted in the final research model, visualized in Figure 4. As mentioned, the definitions center more around industry 3.0 in terms of digitalization and data. Therefore, the model consists

of the industry 3.0 context with the emphasis on digitalization. In the middle of the model, the hindering factors are listed. The green factors are not found in the literature but mentioned during the interviews. The red factors are found in the literature but not mentioned during the interviews and the black factors are also found in the literature. The factors are listed by category in order of which interviewees considered them most important. The factors with a number (strategy, multidisciplinary team, and skills and knowledge) were named as the top 3 factors as a result of the session.

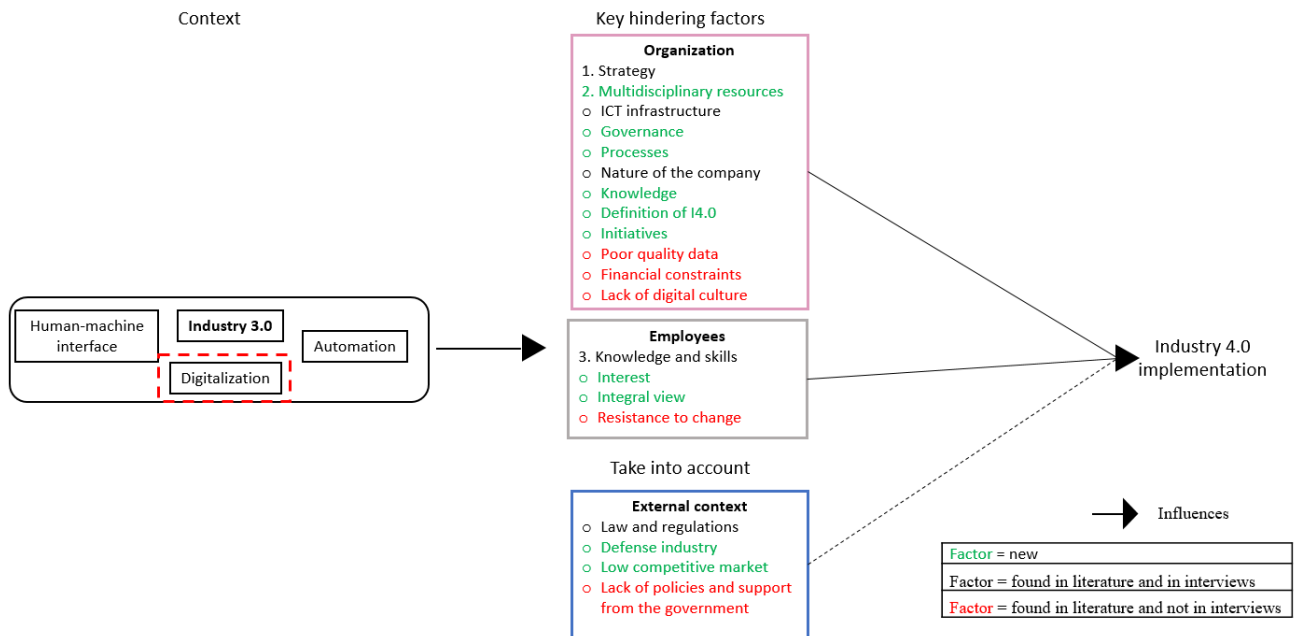


Figure 4 Final research model

Discussion and conclusion

On one hand, this research identifies the current situation of the defense industry with specific characteristics regarding industry 4.0. The case company's internal supply chain is characterized by a make to order and design to order strategy which results in characteristics such as little standardization in product and process, low volume and high product variety. There is a lack of research on the current situation in such companies (Bibby & Dehe, 2018; Ferreri, 2003). This research found that the current situation is formulated as the transition from industry 2.0 to industry 3.0. According to Bibby & Dehe, (2018) and J. M. Müller et al. (2018) industries with more standardized processes and products and more automated machines are better suited for implementing industry 4.0. The characteristics of the defense company could underlie the

difficulty in implementing industry 4.0. Besides, the current situation is in line with Lineberger et al. (2019), which mention that defense companies are relatively slow in adopting digital initiatives. This may also contribute to the fact that the defense company is still situated in the transition from industry 2.0 to 3.0. Further research could help to identify which steps should be taken to bring the defense industry closer towards industry 4.0.

Besides the current situation, this research had a focus on the context of the participants to assess whether the definition has an influence on the hindering factors. According to Bibby & Dehe, (2018) the lack of a definition could be perceived as hindering for implementing industry 4.0. This is also supported by Culot, Nassimbeni, Orzes, & Sartor (2020), which mentioned that there is a shortcoming in the conceptualization of industry 4.0. The case company has a definition but more in line with industry 3.0. However, this has no influence on the hindering factors. The interviews show that, even though the definition is more in line with industry 3.0, the hindering factors are mentioned with an industry 4.0 vision. So, it is assumed that the definition has no direct influence on the hindering factors. Further research could indicate whether the hindering factors differ when the definition is fixed.

On the other hand, this research shows which factors are perceived as hindering in a different type of industry. Different literature indicates which factors hinder the implementation of industry 4.0 (Čater et al., 2021; Ghadge et al., 2020; Hoyer et al., 2020; Luthra & Mangla, 2018; J. M. Müller et al., 2018; Schuh et al., 2017). This research investigated if these factors are also perceived as hindering in a different type of industry.

First, the Organization category consist of twelve hindering factors. Three factors are derived from literature and the interviews. Three factors are derived from the literature but are not mentioned in the interviews. Six factors are mentioned during the interviews which were not derived from literature. In this category the two most important factors are formulating and executing a strategy and multidisciplinary resources. Within the company it is perceived as hindering that there is no clear strategy regarding industry 4.0. Therefore it is recommended to define a shared strategy. This can be done by designing a roadmap with clear tasks and milestones that is in line with the overall strategy. It is important to make someone responsible for executing the strategy and roadmap, so that is it not optional to work on industry 4.0. The second most important hindering factor is the lack of a multidisciplinary team. On one hand, there are not enough resources in terms of employees available to make industry 4.0 a priority. On the other

hand, industry 4.0 involves many different disciplines and departments. It is perceived as hindering that not all departments see the need. It is recommended to set up a multidisciplinary team in which employees are working full time on industry 4.0 from different departments and not only from the supply chain.

The second category, Employees, contains four hindering factors. One factor is derived from the literature and the interviews. One factor is derived from literature but not mentioned during the interviews. Two factors are mentioned during the interviews but were not found in literature. In this category, the third most important hindering factor is located: skills and knowledge. The lack of skills and knowledge hinders the implementation of industry 4.0. It is recommended to provide basic knowledge and skills by general trainings, information through the intranet and workshops. When the strategy and multidisciplinary team are in place, specific knowledge and skills can be defined and trained.

The third category, External Context, contains also four factors. Here, the same distribution in terms of factors applies as in the Employee category. The External Context category is not seen as a category with a major influence on the implementation of industry 4.0. It contains hindering factors that the organization should take into account.

The Characteristic of the Innovation category has not emerged in practice. This may be explained by the fact that the factor mentioned in this category was in line with the External Context.

In general, it can be stated that the organization and the employees contain the most hindering factors when it comes to the implementation of industry 4.0. In addition, it appears that the defense industry is still in the process of fully implementing industry 3.0. Since these are the beginning steps towards industry 4.0, it can be said that no revolutionary industry 4.0 developments will take place in the defense sector in the near future. This is especially true for technologies that do not focus on data. This is probably partly due to the unique characteristics of the defense sector such as high complexity and little standardization.

To summarize, the insights into the internal supply chain of a defense company this study has given, shows that the hindering factors are situated in the Organization and Employee category. If first the most important hindering factors are eliminated, steps towards industry 4.0 can be taken. In addition, extra effort will need to be made to understand the difference between industry 3.0 and 4.0 in order to identify which technologies bring value to the business. The conducted research has highlighted that literature and practice should pay close attention to the hindering factors that occur in complex sectors.